Research Report
2017–2019/20

Max-Planck-Institut für Bildungsforschung
Max Planck Institute for Human Development

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Editorial

Se vogliamo che tutto rimanga come è, bisogna che tutto cambi. This famous quote from Giuseppe Tomasi di Lampedusa's *Il Gattopardo* also applies to our Institute: If we want things to stay the same, we have to make sure that things change. In our case, if we want the Max Planck Institute for Human Development to thrive as it has done since 1963, we have to change.

And this we did: During the last 3 years, a new research center (CHM—Center for Humans and Machines) and four new research groups have been established (iSearch, NeuroCode, the Lise-Meitner Group, and the Emmy-Noether Group). At the same time, Gerd Gigerenzer's research area was closed due to his retirement as a director, and two other research groups finished their projects (REaD; Otto-Hahn Group).

This goes along with a change of personnel. I always find it hard to say goodbye to people I really like. We had to do so quite often, but we also welcomed new colleagues. Those who left obtained positions at other research institutions and universities and, to our great delight, they frequently come back and visit.

There is one person, though, who will, unfortunately, not come back. Former director Wolfgang Edelstein passed away in February 2020. Last year we celebrated his 90th birthday together, and he continued to visit the Institute and take part in its activities (particularly the Dialogue on Democracy, which spoke to his long-term passion for the cultivation of democratic values and habits). We miss him, and will commemorate his life and work with a memorial lecture once the Corona crisis has passed.

The crisis is taking a toll on all of us, but up to now (I am writing this in early May) we have fared rather well. The Institute's administration, service units, and researchers are all functioning remarkably well and efficiently, and our scientific productivity has not slowed down.

During the current crisis, we are not forgetting a far more dangerous and long-term development: climate change. The Institute participated in the global strike for climate in September 2019 and has established a team on sustainability whose recommendations and advice are well received and followed.

We also put considerable effort into career training and counseling for our doctoral and postdoctoral students, especially for those who do not plan to continue scientific work. And we reach out to the public, organizing science slams, participating in the Long Night of Science, writing opinion pieces and articles for major national papers, and being interviewed on TV. Our communications via Twitter and YouTube have also increased, and so have our Open Science activities.

All in all, the last 3 years have been very successful for the Institute and its members. As special honors, both to them personally and to the Institute, Ute Frevert received an honorary doctoral degree from the Finnish University of Tampere in 2018, and Gerd Gigerenzer was appointed to the Scientific Council of the European Research Council in 2019.

This is just a short glimpse of what has happened since the last Research Report was drafted in early 2017. More detailed information on the structure of our programs and findings of the Institute's scientific activities is provided on the following pages, which are supplemented by overviews in the Appendix. Publications are listed separately by each Center or Group. Hence, publications with authors from more than one Center or Group are listed more than once, documenting collaborations across the various research units. But collaboration and communication does not always result in joint publications. There is also much to be gained from interdisciplinary exchange that just serves to challenge each other's approaches and conclusions. Human development happens through learning from one another, and this is our daily experience.

Berlin, May 2020

For the Board of Directors:
Ute Frevert

Overview

The Max Planck Institute for Human Development, founded in 1963, is a multidisciplinary research establishment dedicated to the study of human development. Its inquiries are broadly defined, encompassing evolutionary, historical, social, and institutional contexts of individual human development from infancy to old age. The disciplines of psychology, history, and cognitive science, which reflect the current directors' backgrounds, are enriched by the work of colleagues from behavioral and developmental neuroscience, evolutionary biology, economics, mathematics, computer science, sociology, and the humanities.

The Institute is one of more than 80 research facilities financed by the Max Planck Society for the Advancement of Science (Max-Planck-Gesellschaft zur Förderung der Wissenschaften e.V.), the core support for which is provided by the Federal Republic of Germany and its 16 states. The Institute employs a total of 109 permanent staff, including 33 researchers, supplemented by a varying number of predoctoral, postdoctoral, and affiliated researchers and visiting fellows, as well as student assistants.

Research Centers

The **Center for Adaptive Rationality** (ARC) (Director: Ralph Hertwig) was established in 2012. The Center investigates how people make decisions in complex and uncertain environments. ARC's research focuses on (1) bounded rationality, that is, the simple strategies that people enlist in order to navigate a complex and uncertain world; (2) information search, learning, and experience-based decision-making as key processes for reckoning with uncertainty; (3) the use of collective intelligence to cope with uncertainty; (4) the development of decision-making over the lifespan and the influence of cognitive aging; (5) the neural underpinnings of the cognitive processes of search, learning, and decision-making; and (6) evidence-supported ways to boost individuals' competences and thus enable better decisions. In each of these research areas a variety of methods are employed, including behavioral experiments, computer simulations, mathematical analyses, and neuroscientific investigations (pp. 15–60).

The **Center for the History of Emotions** (HoE) (Director: Ute Frevert), which opened in 2008, examines emotions as a major feature of human development both in an ontogenetic and a phylogenetic sense. The research rests on the assumption that emotions—feelings and their expressions—are shaped by culture and learned in social contexts through social practices. Since these contexts and practices change in space and time, emotions are held to be historically variable. In order to detect and explore this variability, the Center's scope includes different societies within and outside Europe. Special attention is paid to institutions that have a strong impact on human behavior and development, such as the family, school, law, religion, the economy, the military, and the state, as they have developed since the (early) modern period (pp. 61–100).

The **Center for Humans and Machines** (CHM) (Director: Iyad Rahwan) was founded in 2019. Its goal is to understand how machines are shaping human society today and how they may continue to shape it in the future. How can science help us understand, anticipate, and shape the major disruptions that Artificial Intelligence, the Web, and social media cause to the way we think, learn, work, play, and govern? Work at the Center is guided by the proposition that challenges posed by the information revolution are no longer just problems of computer science (pp. 101–118).

The **Center for Lifespan Psychology** (LIP) (Director: Ulman Lindenberger), founded in 1981 by Paul B. Baltes and led by Ulman Lindenberger since 2004, has helped to establish lifespan psychology as a distinct conceptual approach within developmental psychology and cognitive neuroscience. Work at the Center is guided by three propositions: (1) to study lifespan changes in behavior as interactions among maturation, learning, and senescence; (2) to develop theories and methods that integrate empirical evidence across

Björn Blaß, Predoc in the IMPRS Moral Economies, represented the Institute in a science slam at the Max Planck Day 2018.

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domains of functioning, timescales, as well as behavioral and neural levels of analysis; and (3) to identify mechanisms of development by exploring age-graded differences in plasticity (pp. 119–166).

The **Harding Center for Risk Literacy** (Director: Gerd Gigerenzer) envisions a society of informed citizens who are competent enough to deal with the risks of a modern technological world. A key aim of the center is to improve people's risk literacy, and has focused on health care and digitalization. Established in 2009 through a gift from the London-based global investment manager David Harding, the center was affiliated with the Max Planck Institute for Human Development until 2019. Since 2020, the center has been located at the University of Potsdam (pp. 167–176).

The **Max Planck UCL Centre for Computational Psychiatry and Ageing Research** (Directors: Raymond J. Dolan, London, and Ulman Lindenberger, Berlin) was established in April 2014 as a joint initiative of the Max Planck Society and the University College London. The Centre fosters a mechanistic understanding of behavioral aging and psychopathology by developing and applying statistical and computational tools to delineate individual differences in brain-behavior dynamics (pp. 177–184).

The **Lise Meitner Group for Environmental Neuroscience** (LMG EnvNeuro) (Head: Simone Kühn), which was formed in July 2019, investigates how the physical environment impacts brain plasticity in terms of its structure and function. The group aims to gain a detailed understanding of the cognitive and affective processes involved in the acute exposure to natural vs. built environments and to unravel how long-term exposure affects the brain (pp. 185–194).

Research Groups
During the reporting period, several research groups have broadened the scope of the Institute's research agenda.

The **Emmy Noether Group Lifespan Neural Dynamics Group** (LNDG) (Head: Douglas D. Garrett) seeks to understand how and why the human brain fluctuates so markedly from moment to moment. LNDG was established in January 2017 and examines a wide range of brain signal variability phenomena in relation to cognition, network dynamics, neurochemistry, brain structure, and brain stimulation (pp. 195–200).

The **Max Planck Research Group iSearch │ Information Search, Ecological and Active Learning** (Head: Azzurra Ruggeri) takes a novel developmental and computational approach to explore four main themes: (1) the

emergence and developmental trajectory of children's active and ecological learning strategies; (2) the individual factors driving their effectiveness and adaptiveness; (3) the role of active learning to navigate the social environment, with the aim of (4) developing interventions that tap into and boost children's learning potential. iSearch started its work in March 2017 (pp. 201–212).

The **Max Planck Research Group Naturalistic Social Cognition** (Head: Annie E. Wertz) investigates social learning and cognitive development from an evolutionary perspective, with a focus on infancy and early childhood. The group's research program is primarily organized around investigating a learning problem that confronted our ancestors across human evolution: acquiring information about plants. This group was established in January 2015 (pp. 213–226).

The **Max Planck Research Group NeuroCode | Neural and Computational Basis of Learning, Decision Making and Memory** (Head: Nicolas W. Schuck) was established in September 2017 and investigates the foundations of decision-making in humans. To this end, the group studies how the human brain transforms, stores, and retrieves experiences during and after decision-making tasks (pp. 227–244).

The **Max Planck Research Group Reading Education and Development** (REaD) (Head: Sascha Schroeder) investigated the underlying structure of students' reading skills and their development during childhood and adolescence from July 2012 to June 2018. The group aimed at a detailed description of the cognitive processes involved in reading development, including its prerequisites and consequences (pp. 245–252).

Max Planck Fellowship
Several years ago, the Max Planck Society established the Max Planck Fellow Program to further strengthen research collaboration between its institutes and neighboring universities and other research institutions. In June 2008, Gert G. Wagner was appointed Max Planck Fellow at the Institute in order to facilitate collaboration between the Institute's researchers and the Socio-Economic Panel Study group at DIW Berlin. He was re-

appointed as a Max Planck Fellow in 2019 for another 5 years (pp. 253–258).

Research Programs of the Directors Emeriti
The directors emeriti Jürgen Baumert, Gerd Gigerenzer, and Karl Ulrich Mayer continue to pursue their research at the MPI for Human Development.

Jürgen Baumert's work focuses on the reform of the secondary school system in Berlin, schooling and the lifecourse, bilingual education in multicultural societies, and early foreign language learning.

The ABC Research Group under the direction of Gerd Gigerenzer ended its activities on September 30, 2017. Gerd Gigerenzer has continued as Director of the Harding Center for Risk Literacy.

Wolfgang Edelstein's work focused on socio-moral development, democracy education, and democratic school reform. He actively participated in events at the Institute up until his death in February 2020.

Karl Ulrich Mayer continues to work on the German Life History Study (GLHS); his other major research interests are the sociology and politics of science (pp. 259–276).

International Max Planck Research Schools (IMPRS) & Networks
Founded in 2019, the **Max Planck School of Cognition** is a new collaborative initiative between the Max Planck Society and universities in Germany that offers exceptionally broad graduate training in the cognitive sciences. The faculty, which includes Ralph Hertwig and Ulman Lindenberger from the MPI for Human Development, consists of about 45 scientists from all over Germany covering a wide range of research fields.

An important collaborative effort involving three of the four Centers and two of the three Max Planck Research Groups at the Institute as well as universities in Berlin, the United States, and Switzerland is the **International Max Planck Research School on the Life Course** (LIFE). The aim of this graduate school is to provide advanced research training in the study of human behavior and institutional systems over evolutionary and ontogenetic time (pp. 279–282).

The **International Max Planck Research School for Moral Economies of Modern Societies** (MEMS) started in October 2013 and will end in October 2020. Twenty-two doctoral students in four cohorts explored "moral economies" by identifying values, emotions, and habits that have shaped social formations since the 18th century in Europe, North and South America, China, and South Asia. The dissertations and the curriculum focused on analyzing the relationship between the modern history of emotions and the development, consolidation, and transformation of morals (pp. 283–286).

The **Max Planck Research School on Computational Methods in Psychiatry and Aging Research** (COMP2PSYCH) started in April 2016 and is located in Berlin and London. Affiliated with the Max Planck UCL Centre, COMP2PSYCH teaches and trains concepts and methods from computer science and statistics in relation to substantive research questions in psychiatry and lifespan psychology (pp. 287–289).

The Max Planck International Research Network on Aging (MaxNetAging) was a virtual institute for the advancement of research on human aging. At its heart was the **MaxNetAging Research School** (MNARS), a pre- and postdoctoral program devoted to interdisciplinary aging research. The program ended in 2019 (p. 290).

The MPI for Human Development also participates in the **Berlin School of Mind and Brain** at the Humboldt-Universität zu Berlin. The program fosters scientific dialogue among the humanities, behavioral sciences, and the neurosciences and offers career development opportunities ranging from the graduate to the postdoctoral level.

Career Training

As part of its doctoral and postdoctoral education, the Institute offers career training programs, such as workshops on academic writing, presentation, communication, and publishing. Apart from personal counselling by supervisors and directors, students and researchers attend a great variety of seminars on career paths inside and outside of academia as well as on advanced leadership skills.

Scientific Services

The Scientific Services at the MPI for Human Development support the individual Research Centers, their researchers, and other service units at the Institute. The **Library and Research Information Unit** (Head: Sebastian Nix) ensures researchers rapid access to analog and digital information resources and continously develops and provides numerous services, including information research, scientific publishing support, impact optimization, and impact analyses (pp. 293–294).

Research Data Management (RDM) is becoming increasingly important. RDM is about how research data are managed throughout their entire life cycle, from study planning, to data collection, to their publication (either in manuscript form or as Open Data) and possibly their long-term preservation. This is why a research data management working group, established by the Board of Directors in July 2018, elaborated a comprehensive, detailed concept for a sustainable organizational and technical RDM infrastructure at the MPI for Human Development (pp. 294–295). In the reporting period, significant activities at several levels were undertaken in order to implement the fundamental principles of **Open Science at the MPI for Human Development**—transparency, reproducibility, reusability, and open communication (pp. 295–296).

The **Central IT Unit** (Head: Sebastian Lau) provides professional computing and technology support. This includes the central client and server infrastructure, user support, and operation of the Institute's data center, which was completely overhauled in 2018 (p. 297).

The **Magnetic Resonance Imaging Laboratory** operates a Siemens TIM Trio tomograph, which has a field strength of 3 Tesla. It also houses a mock scanner that looks and sounds just like the real one and is used to familiarize research participants with the scanning environment. Various research centers and groups make use of this important infrastructural facility (p. 298).

In addition to the scientific service units, there are also a number of **non-scientific service units** that contribute significantly to the success of the Institute: Administration, Press and Public Relations Department, Tech-

nical Services, and Central Services, which include desktop publishing (DTP) and graphics, reception, chauffeur, mail, and gardening services; and last but by no means least, the Institute's Cafeteria. Staff members within each of the research centers and groups provide administrative and research support. The research staff are indebted to all of these colleagues, who are major contributors to the productivity of this Institute and its special atmosphere.

Interdisciplinarity

With its diversity in methods and research orientations, the MPI for Human Development offers excellent conditions for multi- and interdisciplinary scientific exchange, both within and across its research centers and groups. In addition to specific research collaborations and occasional joint seminars, workshops, and colloquia, the Institute-wide research colloquium that was established in 2011 takes place twice a year and is attended by the entire scientific staff of the Institute. At the colloquium, all pre- and postdoctoral researchers who are beginning the last year of their studies at the Institute present and discuss their current work. Moreover, in 2019,

Tamara Turner (HoE) and Simone Kühn (LMG EnvNeuro) created the Cross-Disciplinary Research Initiative to promote dialogue between our Centers and foster understanding of our diverse methodologies, while Michael Amico (HoE), Kerstin Maria Pahl (HoE), and Indrajeet Patil (CHM) formed an Institute-wide discussion group on morality, emotion, and their relation to decision-making (p. 68).

Teaching Activities and Academic Degrees

The Institute puts great emphasis on close collaboration with universities, including participation in teaching. Scientific staff members—directors, research scientists, and postdoctoral as well as predoctoral fellows—have held seminars and lectures at German universities and abroad. In addition, Institute members were supported by universities in Berlin and elsewhere in completing their degrees. During the reporting period, research staff at the Institute completed 6 habilitations and 29 doctoral dissertations. All these degrees are listed in the Appendix (pp. 299–354), which also provides lists of research colloquia, workshops, and conferences held at the Institute, and includes further information about the scientific staff members.

Long Night of the Sciences 2019: The Institute in dialogue with the public.

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Governance of the Institute

The Institute is governed by a **Board of Directors,** which consists of the members of the Institute who are Fellows (Wissenschaftliche Mitglieder) of the Max Planck Society. The Board of Directors elects one of its members to serve as the Managing Director on a rotational basis, usually for a period of 2 years. In the present reporting period, the Board consisted of the following members:

Ute Frevert (Managing Director as of 07/2019)
Gerd Gigerenzer (until 09/2017)
Ralph Hertwig
Ulman Lindenberger (Managing Director until 06/2019)
Iyad Rahwan (as of 12/2018)

The Board is augmented by one member of the Institute's research staff (Margrit Pernau), the head of the Lise Meitner Group (Simone Kühn [as of 07/2019]), the heads of the Max Planck Research Groups (Azzurra Ruggeri [as of 03/2017], Sascha Schroeder [until 06/2018], Nicolas W. Schuck [as of 09/2017], and Annie E. Wertz [as of 01/2015]), and the head of Administration (Brigitte Merz).

Several in-house committees, composed of representatives either elected by the entire research staff or appointed, advise the Board of Directors on matters of scientific research and policy. One of the major institute-wide committees is the **Scientific Staff Committee** (Mitarbeiterausschuss). Furthermore, all female staff members elect an equal opportunities commissioner and her deputy. Among other things, they are involved in personnel selection procedures. Christin Schulze and Katja Münz are the Institute's current **Equal Opportunity Commissioners.**

The **International Board of Scientific Advisors** offers an important source of external review and advice to both the directors and the scientific staff on research matters at the Institute. Members are selected from an international circle of distinguished researchers and appointed by the President of the Max Planck Society. They meet tri-annually to discuss completed, ongoing, and future research projects at the Institute. In this reporting period, the Board consisted of the following members:

Rajeev Bhargava	CSDS—Centre for the Study of Developing Societies, Delhi, India (until 12/2018)
Joanna Bourke	Birkbeck College, University of London, UK (until 12/2018)
Roberto Cabeza	Duke University, Durham, USA
Nicholas Christakis	Yale University, New Haven, USA (as of 01/2019)
Beatrice de Graaf	Utrecht University, The Netherlands (as of 01/2019)
Ido Erev	Technion—Israel Institute of Technology, Haifa, Israel
Andreas Gestrich	German Historical Institute London, UK (until 12/2018)
Reid Hastie	University of Chicago, USA (until 12/2018)
Matthias Kliegel	University of Geneva, Switzerland
Joachim I. Krueger	Brown University, Providence, USA
Claire Langhamer	University of Sussex, UK (as of 01/2019)
Ruth Leys	Johns Hopkins University, Baltimore, USA
Mike Martin	University of Zurich, Switzerland
Barbara A. Mellers	University of Pennsylvania, Philadelphia, USA (until 12/2018)
David C. Parkes	Harvard University, Cambridge, USA (as of 01/2019)
Katherine Schofield	King's College London, UK (as of 01/2019)
Hans Spada	University of Freiburg, Germany (until 12/2018)
Michael R. Waldmann (Chair)	University of Göttingen, Germany
Anita Woolley	Carnegie Mellon University, Pittsburgh, USA (as of 01/2019)

Center for
Adaptive Rationality

Director: *Ralph Hertwig*

Research Team 2017–2019/20

Ruben C. Arslan, Florian Artinger (as of 10/2019: Simply Rational GmbH, Berlin, Germany, and Berlin International University of Applied Sciences, Germany), Thomas Christophel (as of 11/2019: Bernstein Center for Computational Neuroscience, Berlin, Germany), Mattea Dallacker, Nadine Fleischhut, Stefan M. Herzog, Juliane E. Kämmer, Ralf H. J. M. Kurvers, **Ralph Hertwig,** Sebastian S. Horn (as of 11/2017: University of Zurich, Switzerland), Douglas Markant (as of 07/2017: The University of North Carolina at Charlotte, USA), Lucas Molleman (as of 09/2018: University of Amsterdam, Netherlands), Ana Sofia Morais (Scientific Coordinator), Mehdi Moussaïd, Thorsten Pachur, David Pietraszewski, Timothy J. Pleskac (as of 09/2018: The University of Kansas, USA), Zoe Rahwan, Christin Schulze, Leonidas Spiliopoulos, Bernhard Spitzer, Dries Trippas (as of 10/2018: Red Bull GmbH, Salzburg, Austria), Wouter van den Bos (as of 09/2018: University of Amsterdam, Netherlands), Odette Wegwarth, Jan K. Woike

Postdoctoral Fellows
Joshua T. Abbott (as of 06/2018: The University of Melbourne, Australia), Junyi Dai (as of 08/2017: Zhejiang University, China), Philipp Gerlach (as of 09/2018: Hochschule Fresenius, Hamburg, Germany), Sebastian Grün-eisen, Bertrand Jayles, Elizaveta Konovalova, Anastasia Kozyreva, Corinna Laube (as of 03/2018: Center for Lifespan Psychology), Christina Leuker, Ying Li, Juan Linde-Domingo, Aleksandra Litvinova (until 11/2019), Philipp Lorenz-Spreen, Alan Novaes Tump, Charley M. Wu (as of 10/2019: Harvard University, Cambridge, USA), Shuli Yu (until 06/2017), Veronika Zilker

Predoctoral Fellows
Stefan Appelhoff, Simon Ciranka (COMP2PSYCH), Verena Clarmann von Clarenau (COMP2PSYCH), Ksenija Gumenik, Lou M. Haux, Shahar Hecht-linger, Perke Jacobs, Nikita Kozodoi (as of 04/2018: Humboldt-Universität zu Berlin, Germany), Lisa Reiber (LIFE), Anna Thoma (LIFE), Kyanoush Seyed Yahosseini (as of 01/2020: Robert Koch Institute, Berlin, Germany)

Associate Research Scientists
Florian Artinger (Simply Rational GmbH, Berlin, Germany, and Berlin International University of Applied Sciences, Germany), Thomas Christophel (Bernstein Center for Computational Neuroscience, Berlin, Germany), Larissa Conradt (University of Cambridge, UK), Junyi Dai (Zhejiang Univer-

sity, China), Renato Frey (University of Basel, Switzerland), Philipp Gerlach (Hochschule Fresenius, Hamburg, Germany), Mirjam A. Jenny (Harding Center for Risk Literacy at University Potsdam, Germany), Tomás Lejarraga (University of the Balearic Islands, Palma, Spain), Stephan Lewandowsky (University of Bristol, UK), Aleksandra Litvinova, Jutta Mata (University of Mannheim, Germany), Rui Mata (University of Basel, Switzerland), Björn Meder (University of Erfurt, Germany), Lucas Molleman (University of Amsterdam, Netherlands), Dirk Ostwald (Freie Universität Berlin, Germany), Timothy J. Pleskac (The University of Kansas, USA), Michael Schulte-Mecklenbeck (University of Bern, Switzerland), Renata S. Suter (Kiron Open Higher Education, Berlin, Germany), Wouter van den Bos (University of Amsterdam, Netherlands), Charley M. Wu (Harvard University, Cambridge, USA), Dirk U. Wulff (University of Basel, Switzerland), Kyanoush Seyed Yahosseini (Robert Koch Institute, Berlin, Germany)

Visiting Researchers
Zeynep Akbal (MPI for Human Cognitive and Brain Sciences, Leipzig, Germany), Bahador Bahrami (Ludwig-Maximilians-Universität München, Germany), Matthew Blanchard (University of Sydney, Australien), David Budescu (Fordham University, New York, USA), Marwa El Zein (University College London, UK), Kamil Fulawka (University of Warsaw, Poland), Arend Hintze (Michigan State University, East Lansing, USA), David Johnson (Michigan State University, East Lansing, USA), Monika Keller, Lothar Krappmann, Eva Krockow (University of Leicester, UK), Joachim Krueger (Brown University, Providence, USA), Tomás Lejarraga (University of the Balearic Islands, Palma, Spain), Megan Patterson (The University of Texas at Austin, USA), Kavitha Ranganathan (T.A. Pai Management Institute, Manipal, India), Amnon Rapaport (The University of Arizona, Tucson, USA), Jörg Rieskamp (University of Basel, Switzerland), Sebastian Schäf (MPI for Human Cognitive and Brain Sciences, Leipzig, Germany), Lena Schäfer (Radboud University Nijmegen, Netherlands), Max Schneider (University of Washington, Seattle, USA), Victoria Siegrist (University of Basel, Switzerland), Maarten Speekenbrink (University College London, UK), Kevin Tiede (University of Konstanz, Germany), Claus Vögele (University of Luxembourg), Lavi Wolf (Ben-Gurion University of the Negev, Beer Scheva, Israel), Ilan Yaniv (The Hebrew University of Jerusalem, Israel)

"Human beings viewed as behaving systems are quite simple. The apparent complexity of our behavior over time is largely a reflection of the complexity of the environment in which we find ourselves."

Herbert A. Simon, 1996

Introductory Overview

For Hannah Arendt, people inhabit isolated islands of certainty in an ocean of uncertainty. Consequently, uncertainty is, to borrow another famous phrase from her, *the human condition*— a condition from which there is no escape. Indeed, much of what people do is predicated on forecasts of the uncertain future. Whether choosing a job, an apartment, or a spouse; whether deciding when to travel the world, have children, or start saving for old age; whether voting in an election or deciding between medical treatments, we cannot help but rest our decisions on predictions about what the future holds. Such predictions are often difficult because most future events are inevitably shrouded in uncertainty. To add insult to injury, uncertainty and lack of knowledge bedevil not only our predictions of the future but also our mental constructions of the present and reconstructions of the past. The research program of the Center for Adaptive Rationality (ARC) is about *how* people navigate the high seas, that is, the ocean of uncertainty and often daunting conditions of imperfect knowledge, high complexity, and lack of time. What is the cognitive foundation of our reckoning with uncertainty?

Many scholars of the mind conceptualize cognition in an uncertain world in terms of a single universal, computationally powerful and optimizing prediction machine—whether Bayesian in nature, resting on neural networks, or involving a combination of both as in Bayesian deep learning. This, however, is not our vision. Inspired by Herbert Simon's notion of bounded rationality, we pursue a different kind of cognitive foundation. We focus on three sets of cognitive tools— heuristics, exploration and learning strategies, and strategies for harnessing the knowledge of others—that in our view are indispensable for reckoning with uncertainty. We have set out three major research goals. The first goal is to describe these cognitive tools and understand how they exploit informational structures in the world. The second goal is to reveal the ontogenetic dynamic nature of the adaptive toolbox. Cognitive tools develop in response to changes inside the mind—for example, cognitive resources such as memory grow or decline—and to changes outside the mind such as when environmental demands shift. Therefore, to understand how the mind copes with uncertainty, it is imperative to understand how the mind's "adaptive toolbox" is impacted by and develops in response to these internal and external changes. Our final goal is to help people make better decisions. It is not difficult to demonstrate that people do not consistently make decisions that foster their own or others' welfare. Our objective is to design interventions that foster people's competence and thus to empower them to make decisions in a way that increases their own and public welfare while maintaining autonomy and agency.

The psychologists, economists, biologists, engineers, neuroscientists, computational social scientists, and philosophers in our research group pursue these goals using a variety of methods, including behavioral experiments, computer simulations, mathematical analyses, and neuroscientific investigations. In the following, we outline the theoretical tenets and major research areas and turn to some highlights of the work being carried out therein between 2017 and 2020. The final section of the report highlights how we have contributed, in theory and in practice, to good scientific practices and to important ongoing methodological debates.

The Heuristic Mind

Heuristics are computationally inexpensive and informationally frugal cognitive strate-

gies, each one representing a bet on the structure of the environment at hand. This "gamble" pays off to the extent that the heuristic selected by the decision-maker fits the statistical structure of the given environment. This *ecological rationality* of heuristics has almost exclusively been studied in nonsocial environments—for instance, we have continued our analysis of the ubiquitous risk–reward structure—that are devoid of competitive and intelligent agents. This has led some to speculate that the simplicity of heuristics will fail once they encounter such strategizing agents. In response, we have extended the investigation of ecological rationality to the social and strategic worlds. Our results show this speculation is flat-out wrong. Even in a complex strategic environment, simple heuristics can perform on par with or even outperform complex strategies. In addition, we have analyzed structural properties of social interactions, focusing both on one-off strategic games as well as on repeated strategic interactions, thereby demonstrating how the analysis of ecological structures can be extended to the social domain (e.g., in terms of action space, contact frequencies, and level of environmental uncertainty). Finally, in a collaborative book entitled *Taming Uncer-tainty* (see Box 1), we have further extended the analysis of ecological rationality to decision strategies more generally, including, for instance, strategies of collective intelligence, and have continued our efforts to integrate the framework of simple heuristics with other important modeling frameworks.

The Exploring Mind

Many normative and descriptive theories of choice are mute on how people search for and learn from information. This reticence might be taken to suggest that considering how people search contributes little to comprehending how they cope with uncertainty. But nothing could be further from the truth. People survive and thrive in the ocean of uncertainty by enlisting search processes: visually searching for targets of interest, searching their semantic memory, or looking up information on the Internet. We believe that unless decision science comprehends cognition also as a search process, it will fail to understand key aspects of human behavior. This has become increasingly clear after the discovery of the description–experience gap, that is, the finding that human choice can systematically diverge as a function of whether people are required to actively search

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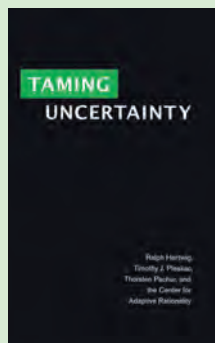
New Book: Taming Uncertainty
Almost every decision you make represents a leap into the unknown. You do not know with certainty what the consequences of your actions will be nor do you know how likely the consequences are or when they will materialize—not to mention whether you and others will like the repercussions of your decisions. Faced with these myriad uncertainties, you may be tempted to throw in the towel. But that is not what people do. In fact, most of the time people are pretty good at navigating the unknown. The mind seems to be equipped with cognitive tools that empower people not only to reduce uncertainties where possible, but also to proceed in light of uncertainties that defy reduction. In *Taming Uncertainty,* teams of authors, often from different disciplines, aim to shed light on the cognitive tools in the mind's adaptive toolbox that help people make the leap into the unknown. We do this across a wide range of topics—from food choice, financial choice, and intertemporal choice to pedestrian navigation and adolescents' risk-taking. We adopt a wide range of methods, including simulation, experimentation, analysis, and meta-analysis. The reader is invited not just to read the chapters, but to experience first-hand some of the material, analyses, and simulation by exploring interactive elements at *https://taming-uncertainty.mpib-berlin.mpg.de*

Box 1.

for information, thereby reducing uncertainty and rendering decisions from experience, or are being presented with all information, rendering decisions from description. We have further studied this gap by, for instance, employing meta-analytic methods and turning to other important tasks such as intertemporal choice. In addition, we have studied the impact of search and how it contributes to important phenomena such as the in-group heterogeneity effect and even systematic allocation of attention in decisions from description. Last but not least, in another book (see Box 2), we have continued our investigations into a fascinating psychological phenomenon, *deliberate ignorance,* according to which people sometimes intentionally decide not to peruse important available evidence, thereby preferring uncertainty over certainty.

The Collective Mind

Other people are a major source of uncertainty. How will they respond to our actions? Will they compete or cooperate? Can we trust them or not? Yet, at the same time, teaming up with others is a powerful tool to reduce uncertainty. Pooling our distributed, incomplete, and uncertain knowledge boosts our power to make accurate predictions. By such pooling, we insure ourselves against the chance of a single individual getting lost in the ocean of uncertainty. But sometimes taking exactly that risk is better than teaming up with others. We have investigated both the challenges and the benefits of socially shared environments and decision-making. To this end, we analyzed—using numerical and analytic modeling—how one can detect and predict high-performing individuals and teams, thus rendering it possible to design better collective decision-making systems. Moving from matters with an objective truth (a tumor is benign or malignant) to matters of taste, we showed—using computer simulations and empirical analysis—that simple social learning strategies can predict people's uncertain tastes. We also investigated the dynamics of information propagation, thus contributing to the understanding of social contagion processes. And, moving from the laboratory to the Internet, we modeled the dynamics of information on social media and beyond. Analyzing Twitter data, we observed an accelerated dynamic of collective attention, meaning that people respond to the increasing rate of production of content by

New Book: Deliberate Ignorance

Western intellectual history of thought abounds with claims that knowledge is valued and (should be) sought, yet individuals and groups often choose not to know. Recently, we (Hertwig & Engel, 2016) have called the conscious choice not to seek or use knowledge (or information) deliberate ignorance. Our new book (Hertwig & Engel, in press) investigates this rich phenomenon in greater depth and asks a series of hard questions: When is this epistemic choice a virtue? When is it a vice? What is the scope of the phenomenon? What can be learned from formal models of deliberate ignorance from economics and psychology? What are the motives behind deliberate ignorance? On what normative grounds can it be judged? Should it be considered irrational or even unethical or could the choice not to know even be ethical and wise? What institutional interventions can either promote or prevent it? Psychologists, economists, historians, computer scientists, sociologists, philosophers, anthropologists, legal scholars, and bioethicists gathered in Frankfurt at a Strüngmann Forum to investigate these and many other questions. Drawing upon the ubiquity of the phenomenon—from the right not to know in genetic testing to individual and collective amnesia in transformational societies; from blinding in orchestral auditions and scientific review to "don't ask, don't tell" policies; from preventing algorithms from using protected attributes in a discriminatory way to the prohibition of research into gun violence—this volume reports on answers and outlines avenues for future research into one of the most elusive and fascinating aspects of human nature.

Box 2.

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an increasingly shorter burst of collective attention.

The Unfinished Mind

Maintaining the mind's adaptive toolbox is a work in progress, a task never completed. The mental tools available to us for dealing with uncertainty are subject to developmental change and rooted in a cognitive architecture that likewise changes constantly. The heuristic mind, for instance, hinges on the flexible and adaptive selection of heuristics and on changes in working memory. Therefore, we investigated heuristics that sample information from memory about one's social network to make inferences about social statistics. In addition, we made much progress in understanding the characteristic trajectory of risk preferences across the lifespan and as a function of key properties of a child's family environment (e.g., birth order). Last but not least, we have gained much more insight into age difference in risk attitudes: For instance, although it may appear (and many have concluded) that older adults are more risk averse than younger adults, we found it depends on the architecture of the stimuli used to measure risk preferences.

The Boosted Mind

According to Thomas Jefferson, democracy depends on an informed and educated electorate. As we experience a worrying array of global problems—including rising incivility, hatred and manipulation in digital environments, the spread of political extremism and of disinformation, climate change, the aging of societies, pandemics, and obesity—an educated electorate is as important as ever. Yet, the currently most influential approach to informing public policy on the basis of behavioral insights has largely abandoned the goal of making citizens competent. Often called "nudging," this approach assumes that people suffer from difficult-to-correct "decisional irrationalities" that lead them to make choices detrimental to their health, wealth, and happiness. Its proposal for containing the fallout from these irrationalities is to let policymakers, for instance, nudge people toward better outcomes by systematically changing external properties of choice architectures (e.g., defaults). Although such interventions can sometimes work, we disagree with the nudgers' portrayal of people as egregiously irrational. We have therefore proposed an alternative class of interventions—boosts— also informed by evidence from psychological and behavioral sciences. Boosting aims to foster lasting competences. Boosts are meant to empower people to make better decisions for themselves in accordance with their own goals and preferences. To better understand the function and efficiency of boosts, we have detailed this approach conceptually and have designed instances of boosts across different contexts, including medical diagnostics and nutritional health.

The Heuristic Mind

Heuristics are computationally inexpensive and informationally frugal cognitive strategies, each one representing a bet on the structure of the environment at hand. This "gamble" pays off to the extent that the heuristic selected by the decision-maker fits the statistical structure of the given environment. In the Center's work on the heuristic mind, we have generalized the analysis of ecological rationality to social and strategic environments in which it has been previously assumed that simple heuristics will fail. In addition, we have begun to study the concrete processes by which the mind can adapt to specific ecological structures such as the risk–reward structures and we have begun to shed light on the content of the adaptive toolbox in the domain of intertemporal choice. Last but not least, we have advanced our push for theory integration.

Ecological Rationality in a Social World

According to the concept of ecological rationality (see Kozyreva & Hertwig, 2019), heuristics are not good or bad per se; instead, there are two key questions (see Gigerenzer et al., 2011; Hertwig et al., 2019): Given a specific heuristic, in what environments does it succeed or fail? And given an environment, what heuristics will succeed or fail in it? In the right environment, heuristics can be as good as, and even better than, computationally much more complex strategies.

One recurrent objection has been that these discoveries predominantly focused on heuristics for individual decision-making. Does the success of heuristics for individuals generalize to heuristics for strategic situations in the social world? There are certainly grounds for doubt. The philosopher Sterelny (2003, *Thought in a Hostile World*), for instance, argued that simple heuristics—despite reaching surprisingly high levels of accuracy in nonsocial worlds—will fail in interactions with other intelligent —and especially competitive—agents. "For it is precisely in such situations that simple rules of thumb will go wrong … Catching a ball is one problem; catching a liar is another" (p. 53). But is it really the case that heuristics will fall apart in competitive interactions?

We (Spiliopoulos & Hertwig, 2020) investigated this question in strategic one-shot social interactions. By means of computer simulations, we investigated the performance of 10 decision strategies, ranging from the very complex Nash equilibrium, to moderately complex boundedly rational strategies, to simple heuristics (e.g., MaxMax). We varied the characteristics of the social environment,

namely, the number of actions available to each player (from 2 to 20 actions), the extent to which the players' interests were aligned or misaligned, as well as the type of uncertainty experienced by the players (i.e., uncertainty regarding either the payoff information or which opponent one is facing). For each environment, we drew 25,000 random games and each strategy played against all other strategies. Counter to Sterelny's (2003) belief, a set of simple strategies—especially one that both ignores opponents' payoffs and assumes that each action is equally likely to be chosen (Level-1 strategy)—performed very well, relative to, for instance, the Nash equilibrium strategy (see Figure 1). These results challenge the received wisdom that social complexity necessitates cognitive complexity because of the additional uncertainty introduced by strategic interactions. They further extend related findings for repeated games, where simple strategies such as tit-for-tat or win–stay, lose–shift perform remarkably well, to the one-shot game scenarios we studied here.

Another important ecological property for decision-making in a social world is the structure of social interactions. When an agent repeatedly interacts with other agents in their social network, how are these interaction frequencies distributed across the network members? In analyses of strategies for cooperation, it is commonly assumed that members interact with all agents in their social networks equally frequently. However, in real social networks most interactions happen in a small circle of two to three members; interactions with other members of the network are rare.

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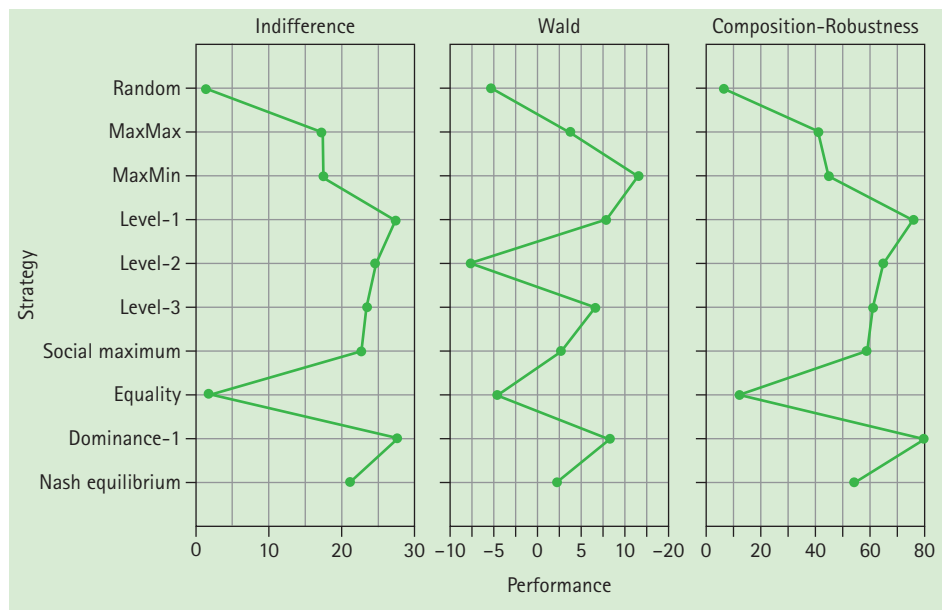
Figure 1. Summary of decision strategies' performance (x-axis: higher means better) pooled across all environments investigated (discordant, neutral, and harmonious) and all levels of payoff uncertainty according to three different performance criteria (panel columns): *indifference criterion* (i.e., all opponent strategies are equally likely), *Wald criterion* (i.e., paired with the worst-case opponent strategy), and *composition-robustness criterion* (i.e., percentile ranking of a strategy's performance averaged across all possible population mixtures). For a given environment, we performed simulations using 25,000 randomly drawn games where each target policy played against all other policies, including itself. Strategies are sorted in increasing order of complexity: *Random:* Choose one of the actions at random. *MaxMax:* Choose the action(s) offering the highest payoff for the player. *MaxMin:* Choose the action(s) offering the highest worst-case payoff for the player. *Level-1:* Choose the action(s) offering the best response to the assumption that an opponent is choosing randomly. *Level-2:* Choose the action(s) offering the best response to the assumption that an opponent is applying Level-1. *Level-3:* Choose the action(s) offering the best response to the assumption that an opponent is applying Level-2. *Social maximum:* Choose the action(s) maximizing the sum of the player's own payoff and the opponent's payoff. *Equality:* Choose the action(s) minimizing the difference between the player's own payoff and the opponent's payoff. *Dominance-1:* Choose the action(s) offering the best response to the assumption that an opponent is choosing randomly over their non-dominated actions. *Nash equilibrium:* Choose the action(s) consistent with the Nash equilibrium (based on data reported in Table 4 in Spiliopoulos & Hertwig, 2020).

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We (Stevens et al., 2018) investigated how assuming uneven versus even contact frequencies changes the success of strategies for deciding whether to cooperate with another agent or defect. Furthermore, we manipulated the quality of agents' memories, that is, how well they correctly recalled whether the currently encountered agent previously cooperated or defected. Several social strategies use this information to make a decision. For example, the tit-for-tat heuristic initially always cooperates with a new interaction partner and subsequently simply copies the other agent's behavior in the previous encounter. How do different cooperation strategies thrive or vanish depending on the pattern of contact frequencies and how well agents can keep track of other agents' previous behavior? How do these ecological and cognitive factors interact and together shape the evolution of cooperation? To address these questions, we used evolutionary simulations, where the extent to which a strategy was passed on to the next generation depended on its success in the previous generation. At the end of the evolutionary process, cooperation rates were higher when agents tended to interact with the same other agents (uneven distribution) rather than equally likely with everybody else (even distribution). Furthermore, an uneven contact distribution buffered the detrimental effect of poor memory: Whereas higher for-

getting generally led to decreased cooperation, this drop was lower when agents tended to interact with the same other agents. This held irrespective of the forgetting rate or the type of memory error. These results are driven by different variants of the tit-for-tat heuristic we investigated. The results exemplify a key lesson of ecological rationality, namely, how characteristics of the mind (including imperfect memory and the strategies for making decisions) interact with the structure of the environment to determine the success of boundedly rational agents.

How Ecological Structures Enter the Mind

In risky choice, the consequence of an action cannot be predicted with certainty at the time of the decision; only the possible consequences and their probabilities are known. In natural environments, large rewards usually come with a low probability of getting them. People can exploit this statistical regularity—a negative association between the size of a reward and its probability—in decisions under uncertainty, where payoffs are known but probabilities are not, and infer the probability directly from the payoff (see Pleskac & Hertwig, 2014). To use such a risk–reward heuristic efficiently, people must be able to learn this relationship but also be sensitive to how it can differ across contexts: Whereas there is a near-perfect inverse relationship between payoffs and probabilities in monetary gambles in casinos, the risk–reward relationship is less reliable in other environments, such as in newly forming markets. To test whether people learn and adapt to different risk–reward environments, we (Leuker et al., 2018) exposed participants to different risk–reward structures in the laboratory using monetary gambles (see Figure 2a). In a subsequent estimation task, most participants exploited the learned association by inferring probabilities from the magnitudes of the payoffs (see Figure 2b). Furthermore, in a subsequent choice task with decisions under

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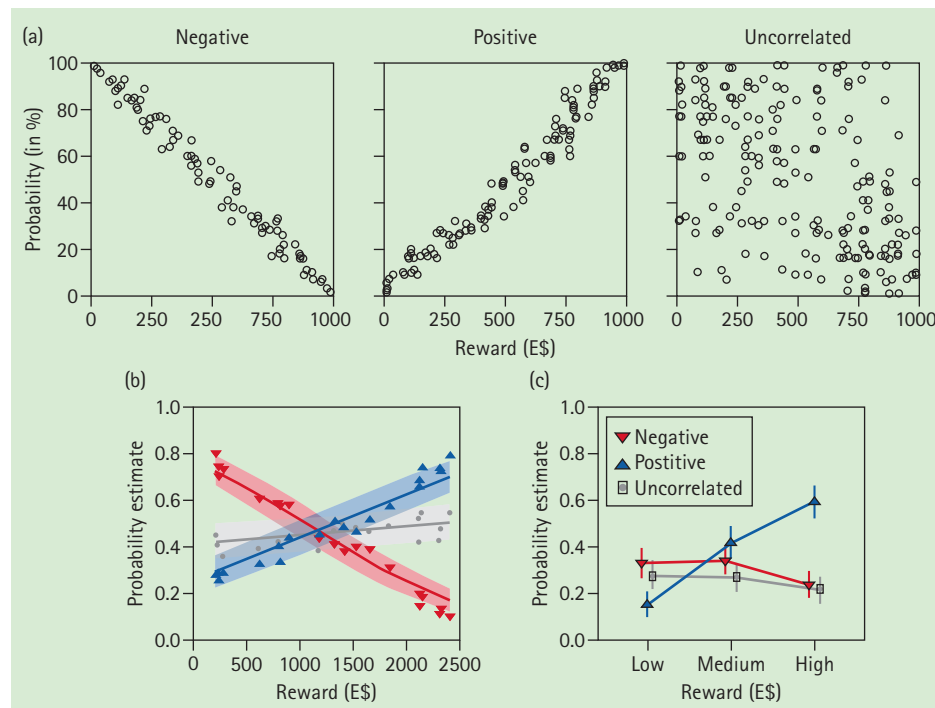
Figure 2. (a) The three experimentally manipulated risk–reward relationships; payoffs refer to a laboratory currency E$. (b) Average probability estimates for each of the payoff levels in the probability estimation task. The solid lines are the posterior predicted means from the respective regression and the ribbons reflect the 95% posterior predictive distribution. (c) Proportion of times the uncertain option was chosen in the decisions under uncertainty task (error bars reflect the 95% posterior predictive distribution; adapted from Leuker et al., 2018).

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uncertainty, participants, previously exposed to a negative risk–reward relationship, tended to prefer the uncertain option over a smaller sure option for low payoffs, but not for high payoffs (see Figure 2c). This pattern reversed in the positive condition and disappeared in the uncorrelated condition. These preference changes are consistent with using the risk–reward heuristic in an adaptive manner. Recently, we (Leuker et al., 2020) harnessed the conceptual work on the risk–reward heuristic to study an important real-world institution, namely, the design of clinical trials and why some people consider high payments for participating in a specific trial to be morally repugnant.

Modeling Intertemporal Choice With Heuristics

Next to decisions about risky or uncertain prospects, intertemporal choices about delayed outcomes are another important type of decision people face: How does the subjective attractiveness of an outcome change depending on how long the decision-maker has to wait until they receive the outcome? Not surprisingly, people find an outcome less attractive the more they have to wait for it (i.e., people discount delayed outcomes relative to more immediate ones). Past research has identified several signature regularities of intertemporal choice. For example, people discount larger outcomes less than smaller ones *(magnitude effect);* and delaying all outcomes by the same amount of time (e.g., changing an immediate outcome to the same outcome in 2 weeks, and another outcome in 3 weeks to the same other outcome in 5 weeks) makes the outcome with the longer delay disproportionally less attractive *(delay duration effect).* Furthermore, the more people prefer the same option in a choice set, the faster they decide between those two options *(fast-and-extreme effect).*

As of now, research has explained all these regularities using decision field theory—a model of dynamic decision-making. We (Dai et al., 2018) demonstrated that these regularities can also be explained by a heuristic decision process, such as a lexicographic strategy that inspects attributes (the magnitude of a

reward, the delay of the reward) sequentially and stops further inspection if one attribute discriminates. Using three large data sets, we also conducted a rigorous quantitative model comparison that involved a total of three different frameworks of probabilistic, dynamic models of intertemporal choice. In this model comparison, a dynamic utility-based model captured the data best, but there were considerable individual differences, with a substantial proportion of participants best explained by a heuristic.

Theory Integration

A final theme of our investigation of the heuristic mind is the question of how models of heuristics relate to other modeling frameworks. The value of such theory integration is that other frameworks provide alternative conceptual lenses to study heuristic principles of decision-making. Here, we highlight one particular form of theory integration: implementing heuristics in the cognitive architecture ACT-R (adaptive control of thought–rational). ACT-R is an integrated theory of cognition and a modeling environment that has been applied to a wide range of human behaviors. ACT-R models consist of a set of production rules and declarative knowledge that interact with core modules representing different cognitive functions.

We (Fechner et al., 2018) implemented heuristics in ACT-R to quantify their cognitive costs and identify where in the cognitive system they occur and how this all depends on the type of decision task. We considered two heuristics: take-the-best (TTB), a lexicographic strategy that inspects attributes sequentially in order of importance and stops inspection as soon as a discriminating attribute is found; and tallying, which counts for each option the number of attributes that support that option. Because TTB often ignores part of the available information and foregoes integrating across attributes (i.e., is a noncompensatory strategy), it is commonly assumed to be cognitively simpler than compensatory strategies, such as tallying, which always inspect all attributes. Using ACT-R, we simulated the response times of TTB and tallying under different amounts of competing

cognitive demands (assuming a concurrent tone-counting task, which was also implemented in the same ACT-R simulation). In the decision task, the search requirements for TTB were manipulated by the position of the first discriminating attribute. The upper two panels in Figure 3 show the resulting response-time predictions for TTB and tallying. Challenging the view that TTB is generally simpler than tallying, the results revealed that TTB can lead to longer response times—and thus higher cognitive costs—than tallying. This occurred, in particular, under high search requirements. Decomposing the response times showed that TTB's high costs stem from higher requirements for updating working memory, restoring information from declarative memory, and coordinating the associated mental actions. We then corroborated these predicted patterns empirically. Participants were presented with a multi-attribute task with five attributes in which they judged—while performing a concurrent tone-counting task—which of two animals has a longer lifespan. Importantly, half of participants were trained and explicitly instructed to use TTB or tallying, respectively. As predicted, under increasing cognitive demands, the response times of TTB exceeded those of tallying. Overall, this study illustrates how theory integration can yield unique insights that would not have emerged from pursuing either theoretical approach in isolation.
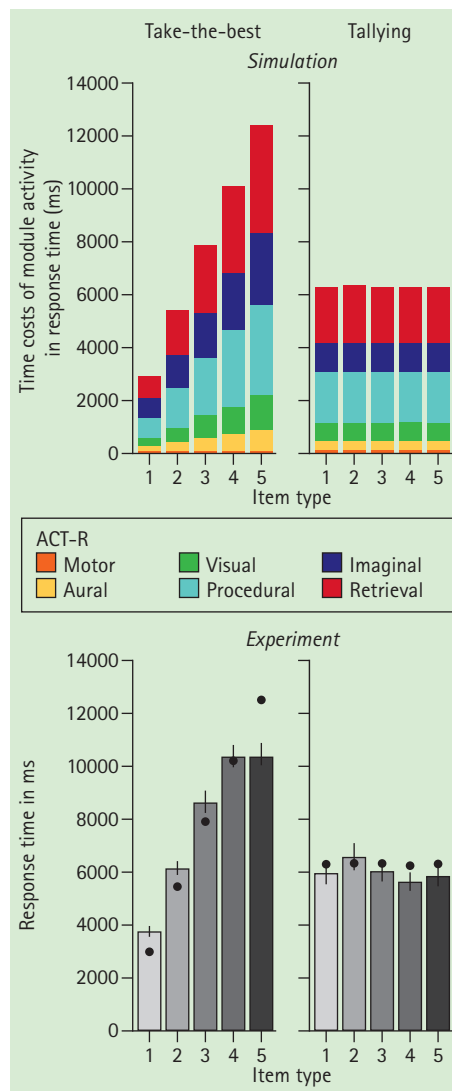
Figure 3. Response times for take-the-best (TTB) and tallying conditions. The upper panels show the predicted response time (based on simulations in ACT-R); the colored subsections of the stacked bars represent the contributions of the different ACT-R modules (based on how long they were active) to the overall response time. The lower panels show the results from the empirical study (for comparison, the dots show the predicted response times from the simulation). Displayed are the results for the condition with the highest working memory load. "Item type" indicates how many attributes TTB users needed to search for to make a decision (i.e., 1–5 attributes). Error bars represent standard errors corrected for within-subject designs (adapted from Fechner et al., 2018).

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The Exploring Mind

We rarely make decisions under risk where all information is provided to us on a silver plate. Rather, in many real-world situations, we find ourselves as explorers of information environments, aiming to find some informational basis on which to make an educated decision. Many normative and descriptive theories of choice are mute on how people search for and learn from information. This reticence might suggest that taking into account how people search contributes little to comprehending how they cope with uncertainty. We full-heartedly disagree with this implication. Consequently, we have continued our work on the description–experience (or, relatedly, the risk–uncertainty) gap and have investigated it with meta-analytic tools, extended its study to other domains such as intertemporal choice, and investigated how information sampling can shape important social perceptions and unfold in vast decision spaces. Finally, we also turned to the question of how search in decisions from description—in terms of attention allocation—can reveal informative signals about process and choice. Below, we illustrate these lines of work.

How Experience Shapes People's Risk Attitudes

The *description–experience gap* refers to the observation of systematic differences between choices based on a summary description of risky options (i.e., the possible outcomes and their probabilities; *decisions from description*) and choices in which the possible outcomes and their probabilities have to be learned from experience, with and without feedback (decisions from experience). Its discovery stimulated a wealth of empirical studies, affording us the opportunity to systematically examine the overall magnitude of the gap but also to quantify the contribution of the various causes of the gap discussed in the literature. In a meta-analysis, we (Wulff et al., 2018) collected 80 data sets with a total of 4,400 participants, making a total of 45,239 decisions from experience in the so-called *sampling paradigm;* here, participants initially explore all options without consequences before committing to a final, consequential decision. Furthermore, the meta-analysis also included 31,353 decisions from description made by a total of 2,208 participants. Our analyses led to the following major observations. First and foremost, the description–experience gap is a robust empirical regularity (also in terms of probability weighting; Hertwig & Pleskac, 2018). We found that depending on the definition of the gap, experience- and description-based choices differed by between 10 and 13 percentage points. Second, the size of the gap

is moderated by various factors, including the structure of the decision problem. More specifically, when a choice involved a risky and a safe option, the gap was 20 percentage points; when two risky options were presented, the gap reduced to 8 percentage points (see Figure 4). Third, people rely on small sample sizes—the median sample size was 14 in decisions with a safe and a risky option and 22 in decisions with two risky options. Small samples can systematically distort experience-based representations due to sampling

Figure 4. The size of the description–experience gap (defined in terms of discrete underweighting [DU]; y-axis) depends on the objective probability of the rare event (x-axis) and the type of the decision problem (a risky vs. a safe option or two risky options; color legend). Error bars show 95% confidence intervals. Diamonds represent aggregate estimates and standard errors based on a random-effects meta-analysis (adapted from Wulff et al., 2018).

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error. Importantly, however, sampling error cannot fully explain the gap. Fourth, experienced-based choices are substantially more consistent w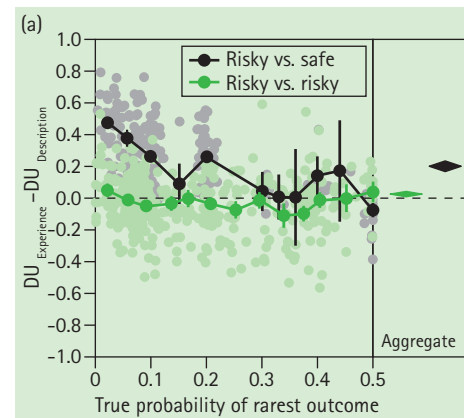ith the maximization of average returns than description-based choices are. Fifth, outcomes experienced later in the exploration phase predict choices better than earlier outcomes *(recency effect)* only when decision-makers can decide themselves when to stop exploring. This suggests that the recency effects reported in some extant studies may actually result from optional stopping and may thus be a consequence—rather than a driver—of the decision-making process. Finally, the experienced relative frequencies of the outcomes in decisions from experience and the stated probabilities in decisions from description prompt different weighting functions for choices involving a risky and a safe option, but more similar functions for choices among two risky options.

A Description–Experience Gap in Intertemporal Choice

The description–experience gap is not a one-trick pony, but generalizes to other important domains. For illustration, we (Dai et al., 2019b) demonstrated that the description–experience gap extends to intertemporal choices, where people choose between options whose outcomes will materialize at different times in the future. In particular, we considered the situation in which the length of the delay is uncertain. As an example, just think of the last time you decided whether to order, say, an acceptable pair of shoes with instant delivery or your dream pair of shoes that would be delivered within the next 10 to 20 days. In our study, we manipulated whether the probabilities of the possible delays of payoffs were explicitly described to people (*timing risk;* description condition) or had to be learned from sequentially sampling from the possible delays (*timing uncertainty;* experience condition). For instance, in the description condition, participants were asked to choose between option A, which paid 100€ in 2 months, or option B, which paid 60€ in 1 month with a probability of 90% or in 11 months with a probability of 10%. In the experience condition, the probabilities of the

different delays were initially unknown, but could be learned by sampling from the respective delay distributions.

Participants in the description condition preferred the lottery (option B in the example above) if it offered the chance for a short delay (even if its chance was low) over a sure option in which they had to wait for longer. However, in the experience condition, the preference was reversed. Similar to in the domain of risky choice, this description–experience gap in intertemporal choice was partly attributable to sampling error: Because participants in the experience condition tended to draw small samples from the distribution of possible delays, they often did not even know that there was the rare possibility of a short, attractive delay. However, a further contributor to the gap was that, even when participants *did* sample the rare, short delay, it received less weight than that given by participants in the description condition.

How Information Sampling Shapes Social Perception

One of the key findings in social psychology is that people tend to perceive their groups as more heterogeneous than groups they do not belong to—on dimensions such as, for example, personality or friendliness. Previous explanations of this *in-group heterogeneity effect* all assume, in one way or another, that its cause resides within people's minds. The explanations range from differential processing of information about in- versus out-groups to different prior beliefs people have about in- versus out-groups' heterogeneity to motivated reasoning.

However, one crucial difference between in- and out-groups is that we usually have more contact with our in-group compared to our out-groups. In other words, we sample more information about people who are similar to us than about people who are different from us (e.g., with respect to ethnicity, gender, social class, or occupation). We (Konovalova & Le Mens, 2020) proposed a new explanation for the in-group heterogeneity effect that starts with this—almost trivial—observation and connects it with the statistical truism that the variability of a sample of observa-

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tions tends to increase with sample size. Using formal analysis, quantitative modeling, and two empirical studies, we show how the differential exposure to in- versus out-groups is sufficient to explain the in-group heterogeneity effect, as the larger sample sizes for in-groups produce larger perceived variance—even if the true variance is the same for both in- and out-groups. Intriguingly, even a Bayesian observer with both unlimited memory and unlimited cognitive abilities, as well as accurate knowledge of the structure of the environment, would produce the in-group heterogeneity effect when exposed more often to the in- than the out-group. This shows how the effect is an inherent consequence of the structure of the environment and not merely a consequence of humans' bounded rationality.

However, we do not claim that differential information sampling is the sole cause of the in-group heterogeneity effect. Rather, we show that differential information sampling is sufficient to predict the effect. More generally, our environmental explanation of the in-group heterogeneity effect is yet another case study in a list of many more important phenomenon about human cognition and behavior, which researchers were quick to explain in terms of processes within individuals' minds, but where an information sampling explanation would be sufficient.

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How Humans Explore Vast Decision Spaces

For Herbert Simon, search was perhaps the key cognitive process of human life. For instance, in his work with Allen Newell, he conceptualized problem-solving as the search for a path through a problem space with the goal of finding a route linking the problem's initial state to the goal state via intermediate steps and subgoals. In a grand metaphor of human life, he depicted our existence as a search through a "life's maze," representing a multiplicity of needs and wants. Following this lead, we (Wu et al., 2018) suggested that many aspects of human behavior—from foraging for food to learning complex games—can be understood as a search problem in a vast space of possible actions, with each corresponding to some reward that can only be observed through ex-

perience. In such complex problems, one must learn to balance the dual goals of exploring unknown options while also exploiting familiar options for immediate returns. This frames the exploration–exploitation dilemma, which is commonly studied using the multiarmed bandit problem.

Using various bandit tasks with up to 121 arms, we studied how humans actively search for rewards under limited search horizons as well as when the spatial correlation of rewards provides traction for generalization (e.g., spatial clustering of rewards). We found substantial evidence for the separate phenomena of directed exploration (toward reducing uncertainty) and noisy, undirected exploration. Both the empirical and the modeling results show how function learning, combined with optimistic search strategies, may provide the foundation of adaptive behavior in these highly complex environments. These studies could be extended in future studies using temporal dynamics and nonstationary environments such as depleting resources. Another direction to pursue is to consider what role heuristics might play in these complex environments and how they could guide search therein toward unexplored yet promising options.

Attention and Decision-Making

Information search is a key factor shaping risk attitudes in decisions from experience. But also in decisions from descriptions, search plays an important role: When acquiring the described information about the options, people have to move their attention across the options' attributes (i.e., possible outcomes and their probabilities). Cumulative prospect theory (CPT), arguably the most prominent descriptive model of decision-making under risk, is commonly seen as being mute about search and attention allocation. We (Pachur et al., 2018) showed, however, that this widespread view of CPT ignores that several of its basic explanatory constructs, such as loss aversion, outcome sensitivity, and probability sensitivity, can be interpreted in terms of attention allocation. For example, loss aversion in choice might be associated with more attention paid to losses than to gains,

and different degrees of probability sensitivity might be associated with different degrees of attention to probabilities. We tested these possible associations in a study using Mouselab, a process-tracing tool that allows, for example, tracking the amount of time people spend on inspecting outcome or probability information. Specifically, we measured participants' relative amount of attention to loss (vs. gain) outcomes as well as the absolute amount of time spent on inspecting probability and outcome information, respectively. These attentional measures were then related to CPT's parameters—estimated from people's choices.

As predicted, there were systematic and meaningful links between CPT's parameters and the measures of attention. To illustrate, consider CPT's probability sensitivity parameter, which governs the shape of a probability weighting function and thus how objective probabilities translate into subjective decision weights. In a strongly curved weighting function, the transformed probabilities do not discriminate much between objectively different levels of probability, implying lower probability sensitivity. As shown in the left panel of Figure 5, participants with a more curved probability weighting function tended to pay less attention to probability informa-

tion. In a further experiment, we provided evidence for a causal effect of attention on choice: Manipulating how long gain versus loss outcomes were visible to participants led to different patterns of choice, which were then picked up as corresponding differences in CPT's loss aversion parameter (see Figure 5b). These results underline the crucial role of attention in understanding decision-making under risk.

Let us conclude with a few words on a new line of ongoing work: Adaptive search, learning, and decision-making involve cognitive processes that are not necessarily easy to investigate using computational modeling of behavioral data alone, such as the internal transformation of objective evidence into subjective decision information or the retrieval of relevant experience from memory. To shed light on this "black box" of neurocognitive processes and understand their role in shaping adaptive behavior, we have recently begun to combine human neuroimaging techniques, such as electroencephalography (EEG) and functional magnetic resonance imaging (fMRI), with newly developed multivariate analysis methods and neurocognitive modeling. We hope to report more on this in the future.
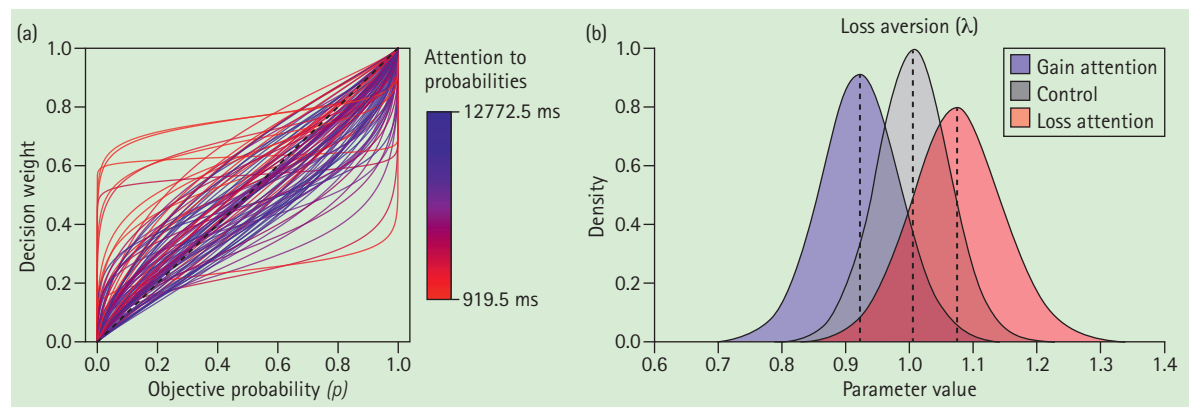
Figure 5. Association between attention and choice. (a) Individual differences in attention to probabilities (measured using a preocess-tracing method) during predecisional information search are related to the curvature of cumulative prospect theory's (CPT) probability weighting function (as estimated from choice data). Redder lines indicate increasingly lower and bluer lines increasingly higher attention to probability information. (b) Manipulating attention to losses over gains leads to shifts in loss aversion in choice and CPT's loss-aversion parameter: Shown are posterior distributions of the group-level mean of CPT's loss-aversion parameter, separately for the gain attention (blue; gains shown for longer than losses), control (gray), and loss attention (red; losses shown for longer than gains) conditions. The dashed lines indicate the group-level posterior means of each condition (adapted from Pachur et al., 2018).

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The Collective Mind

When faced with uncertainty, one powerful strategy to increase the quality of judgments is to rely on the judgments of others (e.g., Herzog et al., 2019; Marshall et al., 2019). However, being open to the influence of others also carries the risk of falling victim to the "madness of crowds," such as the amplification of false information or having to share the blame for others' mistakes (El Zein et al., 2019). In the following, we report our work aimed at better understanding how to identify high-performing individuals and groups in high-stakes contexts; how to harness the "wisdom of crowds" to boost the quality of judgments about matters of taste; the mechanisms underlying judgment propagations across diffusion chains; and the historical development of collective attention to cultural items in the digital world, such as Twitter tweets. Related to our exploration of the collective mind, we have continued to study the inner crowd (Litvinova et al., 2020), where individual decision-makers can partly emulate the wisdom of crowds within their own mind by relying on the same statistical truism that enables the wisdom of crowds: aggregating nonredundant judgments whose errors partly cancel out (Herzog & von Helversen, 2018).

Identifying High-Performing Individuals and Groups

Distinguishing between high- and low-performing individuals and groups is of critical importance for designing better decision-making systems. When decision-makers' accuracy in previous decisions is known (i.e., track records are available) and the environment is stable, it is straightforward to identify high performers: Simply check who performed best previously. However, in many real-world contexts, such track records are either unavailable or unattainable; and even if they are available, in many domains they quickly go out of date. We (Kurvers et al., 2019) investigated whether and when the similarity between different people's decisions *(decision similarity)* can be used to identify high-performing individuals and groups—without knowing the correctness of those decisions at the time.

The intuition for why this approach can work at all is based on a truism and an assumption. First, the truism is that skilled decision-makers necessarily need to make similar decisions in domains with a single, objective ground truth. Consider the extreme case of two decision-makers who always make correct decisions: Their decisions always have to coincide if there is only one correct answer per decision. Second, the assumption is that unskilled decision-makers generally do not always make the same mistakes.

Our analytic and numerical modeling showed—across a broad range of realistic scenarios—that an individual's decision similarity—defined as the mean percentage agreement with the decisions of all others in the population—is a strong predictor of an individual's accuracy level. However, our results also showed that whenever unskilled decision-makers *do* make the same mistakes (i.e., our assumption is violated), decision similarity ceases to be a valid cue for accuracy—in extreme cases it would actually rely completely on the wrong people. Think of the "trick questions" that the audiences in "Who wants to be a millionaire?" get wrong or a nonobvious medical diagnosis based on an x-ray. To check how robust our approach is under realistic conditions, where our "erring-in-different-ways" assumption may be violated, we analyzed several high-stakes decision environments, including breast and skin cancer diagnoses made by medical experts and geopolitical forecasts from the *Good Judgment Project.* We show that an expert's decision similarity is indeed tightly correlated with decision accuracy, allowing us to distinguish between high- and low-performing experts (see upper panels in Figure 6). Whereas high-performing individuals have a high decision similarity to other high performers, low-performing individuals have a low decision similarity to other low performers. Thus, as we assumed, poor decision-makers generally err in very different ways (see lower panels in Figure 6).

Moving to the group level, we also show that selecting individuals based on decision similarity allows us to create high-performing

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(a) Breast cancer (b) Skin cancer (c) Geopolitical events

Figure 6. Top panels show the strong positive relationship between individuals' decision similarity (i.e., mean percentage of agreement with others) and decision accuracy in breast and skin cancer diagnostics and geopolitical forecasting. Each dot represents one individual; lines show linear fits. Bottom panels show, for each data set, a network in which nodes represent individuals and edges connect similar individuals (i.e., edges with above-median similarity). The algorithm used for creating the network layout minimizes the distance between pairs of individuals with high decision similarity. In all data sets, high performers (dark-shaded nodes) cluster in the center of the network, whereas low performers (light-shaded nodes) are scattered at the periphery. Low performers thus make decisions that are dissimilar not only to those of high performers but also to those of other low performers; that is, while high performance necessarily unfolds in a similar way, poor performance unfolds in different ways (adapted from Kurvers et al., 2019).

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groups and thus represents a simple way to boost the "wisdom of crowds": Groups consisting of individuals whose decisions were highly similar to each other outperformed groups consisting of individuals whose decisions were dissimilar to each other. Our findings offer a simple, yet broadly applicable, heuristic for improving real-world decision-making systems that does not require any prior knowledge about the past accuracy of decision-makers.

Harnessing the Wisdom of Others in Matters of Taste

How much will you fancy a new book, movie, or restaurant? Many of our daily choices involve "matters of taste" for which there is no universal correct answer. How can an individual still make use of the judgments of others? We (Analytis et al., 2018) studied how individuals can leverage the experiences of individuals with similar taste who have already evaluated the available options to make better decisions.

We mapped recommender system algorithms to models of human judgment and decision-making about "matters of fact" and recast the latter as social learning strategies for matters of taste. Using computer simulations on a large empirical data set, we investigated the performance of different aggregation strategies in matters of taste. On one end of

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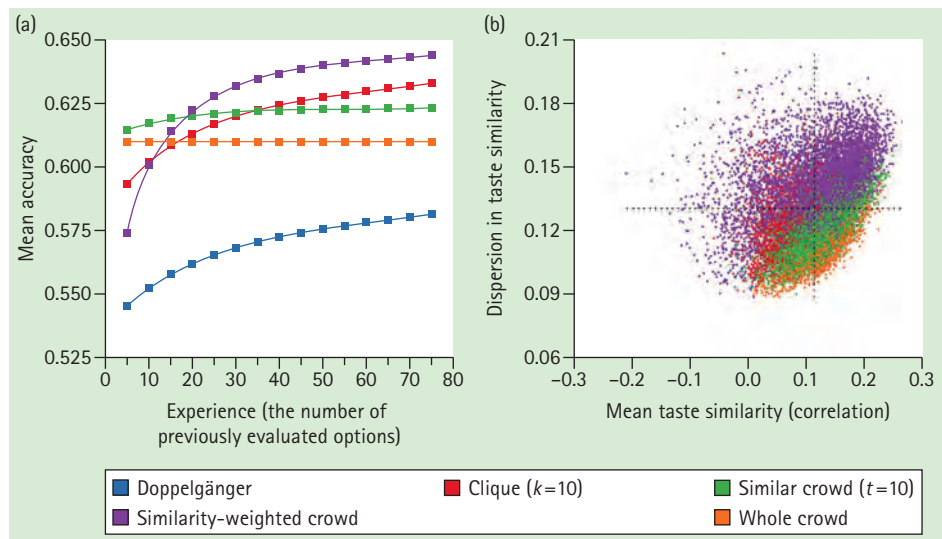
Figure 7. Performance of social learning strategies in predicting which of two jokes a person finds funnier based on ratings of other jokes: The doppelgänger strategy adopts the rating of the one single person that seems most similar to the target person based on other jokes both have rated. The clique strategy uses the average rating of only the 10 most similar people, whereas the similar crowd strategy uses the average rating of all people with a positive correlation. The similarity-weighted crowd weighs the ratings proportional to the correlation to each person. Finally, the whole crowd simply takes the average rating of everybody, thus essentially betting that the target person has a mainstream taste. (a) The y-axis shows how the average performance (across all 14,000 participants in the data set) increases as more ratings about other jokes are available to estimate the taste similarity among any two people (x-axis); the one exception is the whole crowd, which by design does not pay any attention to similarity. (b) The best performing strategy depends on how people's tastes correlate with those of others in the population. The scatter plots show for each individual the best performing strategy when only 25 items are used to estimate similarity. Each of the 14,000 individuals is positioned according to their mean taste similarity with all 13,999 other individuals (x-axis) and the dispersion in taste similarity with other individuals (y-axis). The dashed horizontal and vertical lines show the overall average of the mean correlations (0.11) and standard deviations (0.13; adapted from Analytis et al., 2018).

the spectrum is the *whole-crowd strategy,* where everybody's respective ratings about, say, two different books, are averaged with equal weight—irrespective of how similarly those people and the target decision-maker previously rated other books—and then the decision-maker chooses the book with the higher average rating. On the other end of the strategy spectrum is the *doppelgänger strategy,* which identifies and then copies the one person with the most similar past ratings. We also investigated variations in between those two strategies that are more or less sensitive to people's similarity in previous ratings. Our results show that—even though people's tastes *do* differ—averaging strategies outperform more selective strategies (e.g., similarity weighting) whenever people have only a few previous ratings with others in common (see Figure 7). This is because small samples of

past ratings are only noisy cues about the true similarity among people's tastes. However, when joint past experience increases, more selective strategies do outperform less selective strategies in predicting an individual's subjective taste. Crucially, the level of experience beyond which people should switch to similarity-heavy strategies varies substantially across individuals and depends on how mainstream (or alternative) an individual's taste is and the dispersion in taste similarity with the other people in the group.

An old Roman maxim states: "In matters of taste, there can be no dispute," illustrating the apparent futility of debating taste. However, we show that, although taste is subjective, social learning strategies matter in how well an individual's taste can be predicted, rendering this subjective topic amenable to rational exploration.

Reach, Speed, and Scale of Social Contagion

A large body of research has demonstrated that judgments, feelings, and behaviors can "spread" from person to person in social networks, similar to the propagation of infectious diseases. In recent years, social contagion phenomena have been identified across a wide range of domains, such as risk perception, health practices, violence, political mobilization, and emotional states. The exact behavioral mechanisms underlying such "long-range" social influence processes are, however, still largely unknown.

To address this issue, we (Moussaïd et al., 2017) developed a novel paradigm for experimentally studying the phenomenon of judgment propagation. We created chains of participants who could reconsider their judgment in a visual perception task after observing the judgment of their predecessor. The placement of a very good performer at the first position of a chain (the "initiator") creates a performance gap that triggers a wave of judgment propagation down a chain of otherwise unskilled participants. This setup enables us to gauge the speed, reach, and scale of social contagion. Each chain consisted of six participants who worked together in 15 consecutive rounds of the visual perception task. In each round, we measured the influence of the initiator A (who was very good at the task) on the judgment of all subsequent individuals (B to F, who were all barely better than chance at the task).

The strength of social influence for all rounds and social distances is shown in Figure 9. Waves of judgment propagation are clearly visible: The judgment of the initiator A spread to B after two rounds, to C after four rounds, and even to D after about eight rounds. However, the judgments of individuals E and F remained unchanged. That is, the initiator A influenced the judgments of individuals B, C, and D, but not E and F. This observation is consistent with the three-degrees-of-influence hypothesis suggesting that the social horizon of complex contagion is limited to three degrees of separation. Additional simulations informed by the experimental
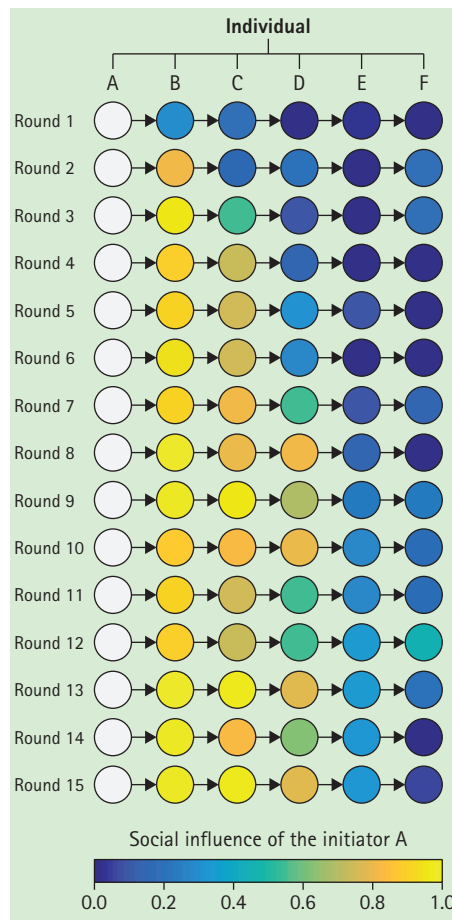
Figure 8. Influence of the initiator A on the judgments of the five subsequent individuals in the chain during 15 consecutive rounds. The judgment of A eventually spread to B, C, and D, but individuals E and F remained uninfluenced (adapted from Moussaïd et al., 2017).

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data indicate that the propagation is undermined by two factors: (1) A's judgments tend to become gradually distorted as they spread down the chain (information distortion); and (2) individuals overweight the errors of others relative to their own errors—eventually stopping the propagation of social information that would have reduced the receivers' errors. Our results contribute to the understanding of social contagion processes and could help practitioners design interventions in domains such as public health, marketing, and social mobilization.

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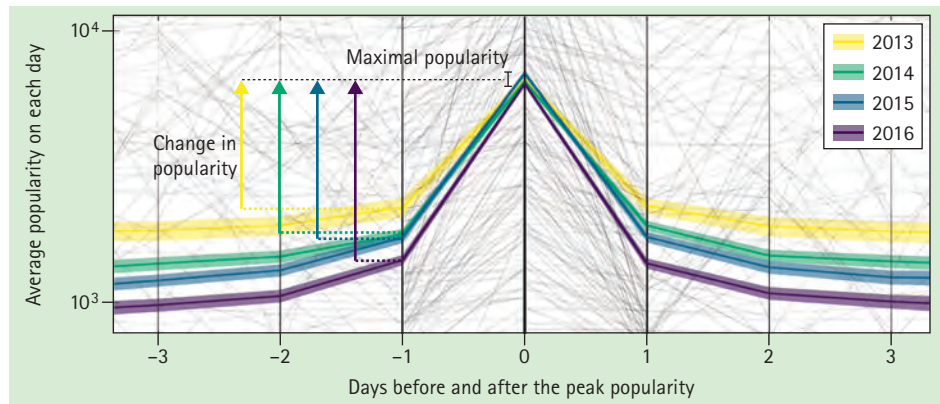
Figure 9. Annual average trajectories of the daily top 50 hashtags on Twitter for the years 2013 to 2016 leading to a local maximum. The shaded areas show the 95% confidence intervals. In the background, a 1% random sample of trajectories is shown in gray. Although the heights of the peaks remain similar over the years, the widths of the peaks narrow, indicating that topics remain for less time in the collective attention (adapted from Lorenz-Spreen et al., 2019).

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Accelerating Dynamics of Collective Attention

The public debate appears to be increasingly fragmented and accelerated. Sociologists, psychologists, and teachers have warned of an emerging crisis stemming from a "fear of missing out," keeping up to date on social media, and breaking news coming at us 24/7. The negative effects of social media and a hectic news cycle on our attention span have been an on-going topic of discussion in recent years—but there has been a lack of empirical data supporting claims of a "social acceleration." We (Lorenz-Spreen et al., 2019) capitalized on digitized, historical behavioral data from social media and other domains to study if our collective attention span is indeed narrowing as commonly claimed. We used data from Twitter (2013–2016), Google Trends (2010–2018), Reddit (2010–2015), Wikipedia (2012–2017), Google Books (last 100 years), movie ticket sales (last 40 years), and citations of scientific publications (last 25 years). Across most of these domains, we found strong evidence of ever-steeper gradients and shorter bursts of collective attention given to each cultural item. For example, looking at the global daily top 50 hashtags on Twitter, we found that peaks of collective attention became increasingly steeper (see Figure 9) and more frequent: In 2013, a hashtag stayed in the top 50 for an average of 18 hours. This gradually decreased to 12 hours in 2016. This trend is mirrored in most other on- and offline domains and across different time periods. For example, we found similar patterns when analyzing the occurrence of five-word phrases in Google Books for the past 100 years (5-grams), the box office success of top movies, Google searches, and the number of Reddit comments per post. However, we did not find this pattern for daily online traffic to individual Wikipedia articles or citations of scientific publications—presumably because these are more curated knowledge communication systems.

To investigate what mechanisms could drive the behavior we observed in most domains, we developed a model to study this attention economy. Our model is inspired by models from mathematical biology and has three basic ingredients: collective proportional growth, aging, and the thirst for something new. We picture topics as "species" that compete with "each other" for human attention. The model results suggest that the accelerating vicissitude of popular content is driven by increasing rates of production and consumption of content and, therefore, is not confined to the domain of social media. The cognitive and behavioral consequences of our limited collective attention to individual topics across a broad range of domains is an exciting and important avenue for future research.

The Unfinished Mind

People make countless judgments and decisions throughout their lives. As children, we decide whom to trust and where our preferences lie. As adolescents, we juggle doing schoolwork with hanging out with friends; as young adults, we decide on a career path and how to spend our newly earned money. In later adulthood, we may need to choose which medical treatment to undergo or when to retire. In older age, we decide how to spend our free time, for example, caring for grandchildren, traveling, or volunteering. We have sought to understand how people's ability to make adaptive decisions and their preferences develop by investigating—taking a comparative approach—the phylogenetic as well as ontogenetic origins of social and risk preferences and by studying the development of risk preferences in the family and the complexities of the measurement of risk in aging decision-makers. We were also concerned with how memory biases grow in older age. Finally, we investigated how children harness their social environment to make smart inferences about the social statistics of their environment.

Evolutionary Origins of Decision-Making Under Risk and Uncertainty

Inferring the evolutionary history of adaptive choice strategies requires both computational models that simulate evolution in action (see also *The Heuristic Mind section*) and comparative approaches to the study of decision-making (Herrmann et al., 2019). Relative to our closest primate relatives, the chimpanzees, humans exhibit a suite of species-unique sociocognitive skills that are often argued to foster prosocial, rational, and cooperative human decisions. One manifestation of this so-called human "ultra-sociality" is the tendency to engage in social comparison.

While social comparison studies typically focus on cooperative behavior, we (Herrmann et al., 2019) investigated the competitive dimension of social comparison: a preference for getting more than what others get. Chimpanzees and human children (5–6 and 9–10 years old) engaged in the social decision-making task illustrated in Figure 10. In this task, participants decide between two options: one yielding two rewards for the subject and one for the partner; the other yielding three rewards for the subject, but six for the partner. That is, the first option maximizes the participants' relative payoff compared with their partner—the "I get more" option—whereas the second option maximizes the participants' own absolute payoff, but simultaneously puts them at a disadvantage compared with their partner—the "you get more" option. We found that chimpanzees and young children consistently selected the payoff-maximizing option even though this gave their partner a higher payoff. Older children, in contrast, chose the "I get more" option and thus paid a cost to reduce their partner's payoff below their own payoff. These findings demonstrate that social comparison can manifest positive consequences—for example, fairness considerations, a hallmark of human social life—but also more negative emotions, such as envy or schadenfreude. Uniquely human social skills and motivations thus do not necessarily lead to more prosocial, rational, and cooperative decision-making.

Birth Order Does Not Shape Life-Long Risk Preferences

Where do preferences, such as one's feelings about risk, come from? One possibility is that the foundation of preferences is laid in the family and the specific dynamics within the family are caused by an important structural property: birth order. Charles Darwin, Alexander von Humboldt, and Rosa Luxemburg were the youngest children in their families and had character traits that are often attributed to lastborns: They were intrepid, adventurous, and rebellious. The idea that birth order influences personality has been a topic of heated discussion in psychology and beyond for some time. It came to the fore in the 1990s, with the work of science historian and Darwin expert Frank Sulloway. In trying to pinpoint why people become political or scientific revolutionaries, Sulloway found that lastborns are statistically more likely to take these routes. According to his family dynamics model, first-

Figure 10. Schematic representation of one experimental condition. Participants (children or chimpanzees) were located in front of two options and could choose one: an option maximizing the participant's absolute payoff (three rewards for the participant and six rewards for the partner; "you get more") or an option maximizing the participant's relative payoff (two rewards for the participant and one reward for the partner; "I get more"; adapted from Herrmann et al., 2019).

borns can be sure of their parents' undivided attention, whereas younger siblings have to fight for a "family niche." That leads the latter to take risks that in turn shape their personality. Sulloway's family dynamics model is now viewed more critically, and recent studies have found no relationship between birth

order and personality in general. But does the same apply to the willingness to take risks? To find out, we (Lejarraga et al., 2019) examined data from one of the most comprehensive scientific surveys in Germany, the Socio-Economic Panel (SOEP). Each year, the SOEP surveys around 30,000 people on a variety of topics, including their self-assessed willingness to take risks in contexts such as driving and financial decisions. We compared the responses of firstborns with those of their younger siblings. In 96% of the comparisons between first- and laterborns (specification curve analysis), no relationship was found between birth order and risk-taking propensity. We also did not find any reliable differences in a reanalysis of the large data set from the Basel–Berlin Risk Study, which featured a wide variety of different behavioral and self-report elicitation methods for risk preferences. Finally, we also investigated the birth order of almost 200 famous explorers and revolutionaries. Again, we found no birth-order effects. Thus, findings from these three qualitatively different sources of data and analytic methods point unanimously in the same direction: We found no birth-order effects on risk-taking.

The Complexities of Investigating Aging Decision-Makers' Risk Preference
Current demographic developments across the globe indicate that we live in aging societies. Therefore, it is a good time to ask how older adults differ from younger adults when it comes to dealing with risk and uncertainty and how age-related declines in core cognitive abilities affect the quality of people's decisions and the processes that underlie them.

The Role of Option Complexity in Shaping Age Differences in Risk Attitude
When asked to choose between a safe and a risky gain, most people prefer the safe option. This tendency is even more pronounced in older compared to younger adults. Hence, the canonical conclusion from research on age differences in risky choice is that older adults are more risk averse than younger adults. Yet, when offered a choice between two risky prospects, we (Pachur et al., 2017) found that

older adults were more likely than younger adults to choose the more risky prospect. But why should age differences in apparent risk attitude depend on the availability of a safe option? Recently, we (Zilker et al., 2020) offered a novel explanation: Safe and risky options differ not only in the degree of risk but also in their complexity, that is, the amount of information that needs to be processed. Specifically, safe options can be fully described by a single outcome and its probability (e.g., "100% chance to win 66€"), whereas risky options consist of multiple outcomes and probabilities (e.g., "40% chance to win 30€ and 60% chance to win 90€"; see top row in Figure 11a). In contrast, two risky options do not differ (much) in complexity. Comparing choices between simple safe and risky options—that differ in complexity—to choices between similarly complex safe and risky options, we showed that differences in option complexity are a key driver of age differences in risky choice. Figure 11a illustrates how safe options were rendered similarly complex as risky ones by expressing the safe outcomes as a mathematical term (e.g., "100% chance to win [0.6 × 90€] + [0.4 × 30€]") rather than a single number (e.g., "100% chance to win 66€"). Figure 11b shows that when the options differed in complexity, older adults were more likely to choose safe gains than were younger adults. When the complexity of the safe option was increased, and options were thus similarly complex, differences between younger and older adults in risky choice were eliminated. Age differences in choices between safe and risky options thus seem to reflect a stronger response to option complexity in older age, rather than genuine age differences in risk attitude.

We also tested the psychological mechanism underlying older adults' stronger response to differences in option complexity using computational modeling based on cumulative prospect theory (CPT). Older adults were not merely averse to complexity, and increasing the complexity of safe options did more than simply making responses noisier—higher complexity also affected the sensitivity to differences in outcomes and probabilities. In sum, these findings imply that much of the evidence for apparent age differences in risk attitude, obtained using choices between simple safe and more-complex risky options, may instead reflect older adults' stronger response to option complexity.

Declining Core Cognitive Abilities and an Increasing Memory Bias

Beyond the ability to process the complexity of decision environments, judgment and decision-making taps into numerous cognitive functions. Many core cognitive functions, however, display marked declines from around

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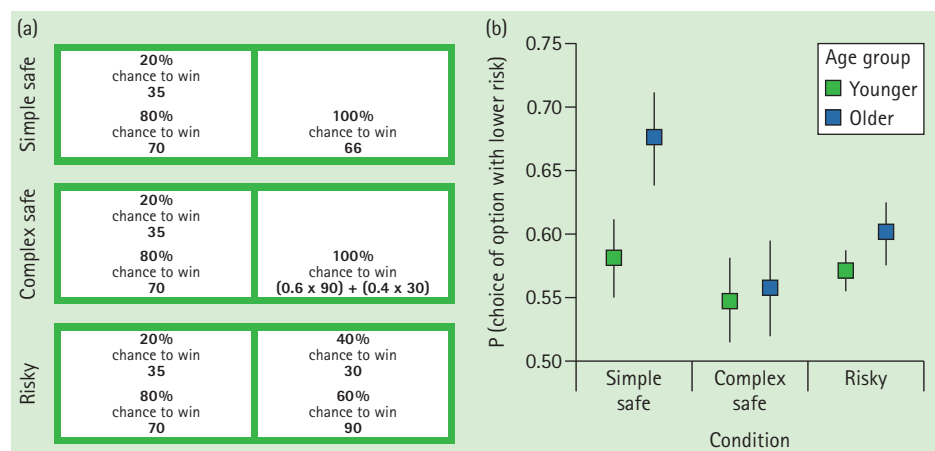
Figure 11. (a) Illustration of the experimental design used to disentangle riskiness from complexity. (b) Results show that differences between younger and older adults in the proportion of risky choices disappeared when the complexity of the safe option was increased (adapted from Zilker et al., 2020).

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age 60 years onward. How do these changes affect people's decision-making and when do declines in cognitive functions lead to corresponding decrements in decision quality? In addressing these questions, we have found that some judgmental distortions indeed seem to be more pronounced in older age.
In a recent meta-analysis, we (Groß & Pachur, 2019) examined differences between younger and older adults in *hindsight bias.* Hindsight bias refers to the phenomenon that after being informed about the correct answer to a factual question (e.g., "What is the height of the Eiffel tower?" "324 meters"), people's report of their knowledge prior to having learned the correct answer is distorted toward that correct answer. In other words, people typically respond as if they "knew it all along." Summarizing across nine data sets, we concluded that hindsight bias is larger for older than for younger adults. In addition, computational modeling revealed that this age difference is due to older adults failing to recall their initial response more often than younger adults and therefore needing to reconstruct it more frequently. Moreover, older adults' reconstruction process was more strongly influenced by the correct response, possibly due to age-related declines in inhibitory control.

Ontogenetic Development of Search and Decision-Making
How does the ability to make boundedly and ecologically rational judgments and decisions develop from childhood to adulthood? Which strategies are already present at a young age and which emerge over time with life experience, potentially undergoing changes during this period? We (Schulze et al., in press) considered these questions in the context of

judgments about the relative frequency of people's behaviors, preferences, and beliefs. In everyday life, people generally do not have access to summary tables of such social statistics, but need to infer them. One way of inferring population-wide social statistics is to sample—from memory—relevant instances of events experienced by the members of one's own social network. There is considerable evidence that children can generalize beyond what they already know and thus make many types of judgments and decisions by, for example, recruiting knowledge from memory, including information about benefits and costs in value-based decisions.
With respect to social sampling, we (Schulze et al., in press) have shown that children as well as adults can exploit structures of the external social environment to limit information search in internal social memory. To examine this thesis, we asked children (8–11 years old) and adults (20–35 years old) to judge the relative popularity of vacation destinations among German vacationers (e.g., "Which destination is visited by more German vacationers: Italy or France?"). Participants were then asked to recall how many people they personally knew who had recently made a vacation at each destination. Using a hierarchical Bayesian latent-mixture approach to model each participant's relative frequency judgments, we found that children, like adults, consulted their social memories by relying on sequentially ordered and limited search to make inferences about social statistics (e.g., starting with themselves, then family, then friends, and finally, acquaintances). These findings demonstrate that children aged 8 to 11 years are already able to systematically exploit their social memory in a bounded and ecologically rational fashion.

The Boosted Mind

In recent years, policy-makers around the globe have shown increasing interest in using behavioral science to make government simpler, less expensive, and more effective. However, to date, much of the discussion of behaviorally informed approaches has emphasized "nudges," that is, interventions designed to steer people in a particular direction while ostensibly preserving their freedom of choice. The nudging approach assumes that people suffer from difficult-to-correct "decisional irrationalities" that lead them to make choices detrimental to their health, wealth, and happiness. Its proposal for containing the fallout from these irrationalities is to let policy-makers, for instance, nudge people toward better outcomes by systematically changing external properties of choice architectures (e.g., defaults).

Figure 12. Boosting people's competences for making better decisions for themselves in accordance with their own goals and preferences.

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Although such interventions can sometimes work, we disagree with the nudgers' portrayal of people as egregiously irrational. We have therefore proposed an alternative class of interventions—boosts—also informed by evidence from behavioral science. Boosting aims to foster lasting competences. Boosts are meant to empower people to make better decisions for themselves in accordance with their own goals and preferences. To better understand the function and efficiency of boosts, we have detailed this approach conceptually and have designed instances of boosts across different contexts, including nutritional health, medical diagnostics, and emergency decision-making. Furthermore, we have started to engage more directly with policy-makers, such as consumer protection organizations (Herzog & Hertwig, 2019).

Empowering Good Decisions Using Insights From Behavioral Science: When Should Policy-Makers Consider a Boosting Approach?

In a recent conceptual paper, we (Hertwig & Grüne-Yanoff, 2017) elaborated on how boosts are conceptually distinct from nudges: They differ with respect to (a) their immediate intervention targets, (b) their roots in different research programs, (c) the causal pathways through which they affect behavior, (d) their assumptions about human cognitive architecture, (e) the reversibility of their effects, (f) their programmatic ambitions, and (g) their normative implications (see Table 1). Furthermore, we provided an initial taxonomy of boosts:

(1) *Risk literacy* boosts establish or foster the competence to understand statistical information in domains such as health, weather, and finances.

(2) *Uncertainty management boosts* establish or foster procedural rules for making good decisions, predictions, and assessments under uncertain conditions.

(3) *Motivational boosts* establish or foster the competence to autonomously adjust one's motivation, cognitive control, and self-control through interventions.

Finally, we addressed three possible misconceptions and clarified (1) why boosting is not the same as school education, (2) why boosts need not be costly, and (3) why the use of boosts and nudges is not mutually exclusive. Importantly, conceptually clarifying the differences between boosting and nudging is not merely a dry, intellectual exercise; rather, it has tangible consequences for policy decision-making: Because the two approaches fundamentally differ in how they affect citizens' behavior, depending on the policy issue at hand, one or the other approach—or even their combination—may be more effective. To aid policy-makers in assessing which approach (nudging, boosting, or their combination) is likely to be more effective given specific conditions, Hertwig (2017) suggested a set of rules (see the list below). The first four rules address what can be seen as necessary requirements for boosting or nudging to succeed; if any of these requirements are not met, this shortcoming cannot be offset by any other advantage an intervention may have otherwise. The remaining fifth and sixth criteria do not eliminate either approach, but should be considered in a cost–benefit calculation aimed at balancing an intervention's other costs and benefits.

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Table 1. Seven dimensions on which the (noneducative) nudging and (long-term) boosting approaches to public policy can be distinguished (adapted from Hertwig & Grüne-Yanoff, 2017)

Dimension	Nudging	Boosting
Intervention Target	Behavior	Competences
Roots in research programs and evidence	Show decision-maker as systematically imperfect and subject to cognitive and motivational deficiencies	Acknowledge bounds, but identify human competences and ways to foster them
Causal pathways	Harness cognitive and motivational deficiencies in tandem with changes in the external choice architecture	Foster competences through changes in skills, knowledge, decision tools, or external environment
Assumptions about cognitive architecture	Dual-system architecture	Cognitive architectures are malleable
Empirical distinction criterion (reversibility)	Once intervention is removed, behavior reverts to preintervention state	Implied effects should persist once (successful) intervention is removed
Programmatic ambition	Correct momentous mistakes in specific contexts ("local repair")	Equip individuals with domain-specific or generalizable competences
Normative implications	Might violate autonomy and transparency	Necessarily transparent and requires cooperation—an offer that may or may not be accepted

(1) If individuals lack the cognitive ability or motivation to acquire new skills or competencies, then nudging is likely to be the more efficient intervention.

(2) If policy-makers are uncertain about people's goals, if there is marked heterogeneity of goals across the population or if an individual has conflicting goals, then boosting is the less error-prone intervention.

(3) If the working of a nudge requires it to be nontransparent or even invisible to the person being nudged, then it fails the easy-reversibility test and is paternalistic.

(4) If governments do not (always) act benevolently, or if they permit the private sector to create "toxic" choice architectures, then boosting will provide better protection for individuals.

(5) If the policy-maker aims to foster generalizable and lasting behaviors, boosting seems, ceteris paribus, to be more expedient.

(6) If there is substantial danger of unanticipated (unpredictable) and undesired consequences of a nudging or boosting intervention, then consider the respective alternative.

Self-Nudging as a Way to Avoid the Ethical and Practical Problems of Nudging

Along with the rising popularity of nudging, several ethical and conceptual problems of nudging have been pointed out (for a review, see, e.g., Reijula & Hertwig, 2020; see also the list of rules above), including concerns about autonomy, the actual reversibility of nudges in practice, unintended side effects of nudges, the limitation of the scope of nudges to public choice contexts, figuring out how to accurately identify citizens' preferences, and the challenge that one-size-fits-all nudges cannot account for heterogeneous preferences in the population. Intriguingly, there is a way to both harvest the power of nudging and simultaneously circumvent—for the most part—the ethical and practical problems of nudging.

We (Reijula & Hertwig, 2020) argued that nudges can often be turned into *self-nudges:* interventions that empower people to design and structure their own decision environments—that is, to become their own citizen choice architects. Self-nudging applies insights from behavioral science in a way that is both practicable and cost-effective but also sidesteps many concerns about nudging, including paternalism and manipulation. It can potentially expand the scope of application

of behavioral insights from the public to the personal sphere (e.g., homes, offices, families). It provides a tool for reducing failures of self-control and enhancing personal autonomy. Here is an initial taxonomy of self-nudges:

(1) *Self-deployed reminders and prompts* ("notes to self"; e.g., writing a reminder on your shopping list not to buy meat to reduce your environmental footprint).

(2) *Self-deployed framing* (e.g., using mental accounting: framing donations as "exceptional" to yourself so you are more likely to donate).

(3) *Self-deployed changes in accessibility and defaults* (e.g., rearranging the refrigerator and kitchen cupboards to control cravings for sugar and promoting healthier food choices).

(4) *Self-deployed social comparison and social pressure* (e.g., commitment devices that enlist social help, say, having to donate to a political party one dislikes if you fail to deliver on a promise you made publicly).

Policy-makers could promote self-nudging by sharing knowledge about nudges and how they work—which boost citizens' competences to act as their own choice architects. Self-nudges may even permit people to see through the operation of commercial nudges that maximize profits and not individuals' well-being, empowering them to withstand them.

Having conceptualized boosting, self-nudging, and rules that can inform the use of these competence-enhancing interventions, let us now turn to a series of investigations of boosts in specific domains.

Boosting Decision-Making With Simple Decision Trees

There is both increasing interest in using artificial intelligence to aid human decision-making (i.e., mostly machine learning algorithms, such as deep learning neural networks) and increasing worry about the sociotechnical consequences of using such "black-box" tools in various domains, such as medicine, forensics, law, and finance (e.g., with respect to discrimination and robustness in practice). In our view, simple heuristics are one answer to the mounting call to use decision algorithms

that are inherently interpretable. Rudin (2019, *Machine Intelligence*), a computer scientist, makes a convincing case for this call in her forceful article aptly titled "Stop explaining black box machine learning models for high stakes decisions and use interpretable models instead."

Many important decisions we make are classifications (e.g., is this emergency room patient in immediate danger of dying without extensive medical attention?). One type of simple heuristic for classification is the *fast-and-frugal decision tree* (FFT). FFTs are very simple decision trees that can make accurate classifications based on limited information (see Figure 13). To foster the conceptual understanding of FFTs, we (Woike et al., 2017) related natural frequency representations of cue–criterion relationships to fast-and-frugal heuristics for inferences based on multiple cues and clarified how FFTs can be modeled as lexicographic strategies but also as linear classifiers with noncompensatory weights. Furthermore, we (Woike et al., 2017) proposed new construction algorithms for building FFTs and compared the performance of different variants of FFTs with naïve Bayes and *profile memorization* in 11 medical data sets. The results show that the two heuristic approaches, naïve Bayes and FFT, generally outperform the model that is normative when fitting known data, namely, classification based on natural frequencies (or, equivalently, profile memorization).
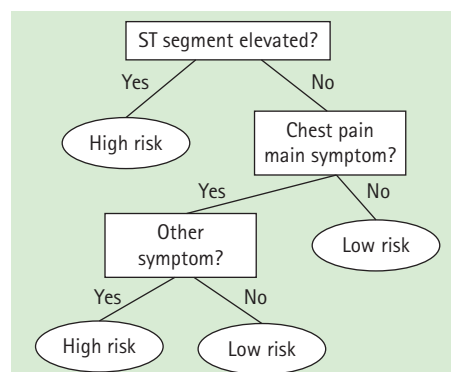
Figure 13. Example of a fast-and-frugal classification tree for predicting whether a patient with severe chest pain is at high or low risk for myocardial infarction. Questions in rectangles specify which cues are consulted for each patient (adapted from Woike et al., 2017).

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🔓Fundel, V. J., **Fleischhut, N., Herzog, S. M.,** Göber, M., & Hagedorn, R. (2019). Promoting the use of probabilistic weather forecasts through a dialogue between scientists, developers and end-users. *Quarterly Journal of the Royal Meteorological Society, 145*(S1), 210–231. https://doi.org/10.1002/qj.3482

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To make it easier for data scientists and practitioners to develop and use FFTs in practice, we (Phillips et al., 2017) developed a software package called FFTrees, implemented in R, a popular, free software environment for statistical computing and graphics. The package is available at https://github.com/ndphillips/FFTrees

Boosting the Understanding of Probabilistic Forecasts of Extreme Weather Events

Today's ensemble weather prediction systems provide reliable and informative probabilistic forecasts—yet these probabilities are still rarely communicated to users outside of weather services. There are two likely worries underlying this phenomenon: the presumed difficulty of communicating probabilities to lay audiences and the latter's presumed reluctance to use probabilistic forecasts. In joint projects with meteorologists at the Freie Universität Berlin and the German Weather Service (DWD), we (Fundel et al., 2019) made initial progress in overcoming this deficiency.

Using our experience in introducing probabilistic forecasts to user groups widely varying in their technical sophistication, we came up with three key points for successful and useful communication of probabilistic forecasts in high-stakes domains.

(1) To make informed decisions, users need access to probabilistic forecasts because converting probabilities into deterministic warnings presumes a particular trade-off in benefits between avoiding false-negative and avoiding false-positive warnings. And, as meteorologists themselves emphasize, meteorologists are simply not in the position to know what trade-off their users (e.g., emergency managers) should make.

(2) Forecast uncertainty can be understood if its visual representations follow validated best practices from risk communication and information design. Figure 14 shows our implementation of probabilistic warnings in the online information system FeWIS operated by the DWD, which is
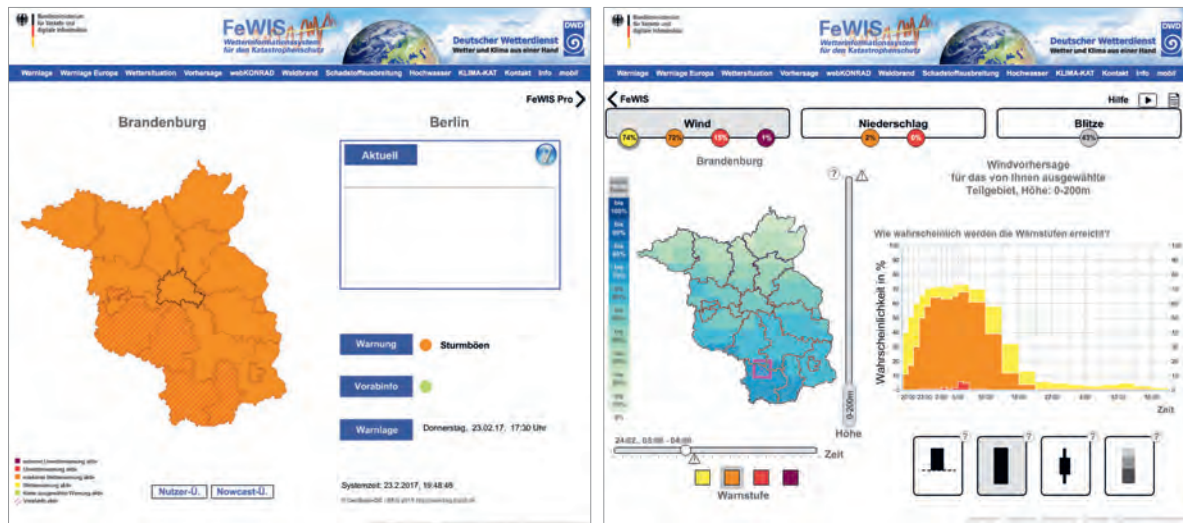
Figure 14 Emergency managers in Germany currently receive deterministic warnings and forecasts through an online information system (FeWIS) operated by the German Weather Service (DWD). It provides weather information tailored to user regions on various temporal scales, from general early warning information a week ahead to "nowcasting" information. The left panel shows an official deterministic warning in FeWIS and the right panel the corresponding probabilistic forecast in the new system, FeWIS Pro, which we developed. The probabilistic system allows the user to select one of three variables of interest (wind, precipitation, or thunderstorms) and display the forecast in five different representations. The map centers on the area of responsibility of each user (here Berlin) as well as the surrounding region and shows exceedance probabilities. The colors convey the probability of exceeding a selected warning threshold (here orange) for wind at a particular time, which can be adjusted using the slider below. By clicking on the buttons at the bottom right, the user can choose between four representations that give a temporal overview for a selected grid point on the map (pink square). Here, the diagram on the right shows the probabilities for exceeding the yellow, orange, and red thresholds, respectively, within the next 48 h (adapted from Fundel et al., 2019).

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used by emergency services across the whole of Germany.

(3) To appreciate the value of probabilistic forecasts for their decisions, users need the opportunity to experience them in their everyday practice.

To bridge the gap between the forecasts available from weather services worldwide and their use in day-to-day decision-making, interdisciplinary collaborations among scientists, developers, and end users are necessary. With these insights and practical pointers, we hope to support future efforts to integrate probabilistic forecasts into everyday decision-making.

Boosting Parents' Competences to Instill Healthy Nutritional Habits in Their Children

The worldwide increasing prevalence of overweight and obesity, especially in children, is one of the public health challenges of our times. Because an unbalanced diet is one of the major drivers of obesity and two thirds of children's daily calories stem from food prepared at home, family meals offer a promising entry point for changing the current obesity trajectory of children. We (Dallacker et al., 2018a) recently meta-analyzed 57 studies investigating the relationship between the quantity of family meals and children's nutritional health. The results show that a greater frequency of family meals was reliably associated with lower body mass index (BMI; $r = -.05$), more healthy eating ($r = +.10$), and less unhealthy eating ($r = -.04$) in children. Although these results are promising in that they suggest that family meals may indeed be an entry point for intervening in child obesity, the documented associations appear to be quite small. Furthermore, it remains unclear what qualitative components of family meals contribute to these positive effects. Therefore, as a next step, we (Dallacker et al., 2019) synthesized studies on social, environmental, and behavioral attributes of family meals and aimed at identifying those components of family meals that are related to better nutritional health in children. A systematic literature search (50 studies;

49,137 participants; 61 reported effect sizes) identified six different components of healthy family mealtimes, which were then investigated in separate meta-analyses (see Figure 15). Positive associations consistently emerged between the six components and children's nutritional health: turning the TV off during meals ($r = +.09$), parental modeling of healthy eating ($r = +.12$), higher food quality ($r = +.12$), positive atmosphere ($r = +.13$), children's involvement in meal preparation ($r = +.08$), and longer meal duration ($r = +.20$). Importantly, no moderating effects were found for age (children vs. adolescents), outcome type (BMI vs. diet quality), and socioeconomic status (SES).

Thus, although the cross-sectional nature of the synthesized studies precludes a strong causal interpretation, the lack of moderation with plausible confounders (especially SES)—and results from other studies on family systems and eating behavior—suggests that the six identified components of family meals may be beneficial for children's nutritional health. Therefore, investigating the effectiveness of introducing these family mealtime practices as interventions in randomized trials seems a promising next step to further explore this potential entry point for curbing child obesity. This work is currently underway. However, in addition to family mealtimes, other contributors to obesity need to be explored, such as the association between parents' considerable underestimation of sugar in common food items and their children's risk of being overweight (Dallacker et al., 2018b). Let us conclude by highlighting that the work on specific boosts in domains important for our health, wealth, and happiness is ongoing and, for instance, involves studying the use of "simulated experience" to better communicate the risks of overutilizing opioids among both patients and physicians (Odette Wegwarth) and the use of boosts to empower citizens in the digital world to reckon with manipulative choice architectures and interventions such as microtargeting (Lorenz–Spreen et al., in press).

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Author, Date	r [95% CI]
TV off (N = 14,298)	
Coon et al., 2001	0.33 [0.17, 0.47]
Horodynski et al., 2010	0.19 [0.09, 0.28]
Wenhold & Harrison, 2018	0.18 [0.07, 0.28]
Roos et al., 2014	0.15 [0.10, 0.20]
Berge et al., 2014	0.14 [−0.08, 0.36]
Petty et al., 2013	0.10 [0.02, 0.18]
Chan, 2018	0.10 [0.02, 0.18]
Serrano et al., 2014	0.10 [−0.07, 0.27]
Fitzpatrick et al., 2007	0.08 [0.02, 0.13]
Pearson, 2017	0.07 [0.00, 0.14]
Stephens et al., 2011	0.07 [−0.01, 0.15]
Goldman et al., 2012	0.05 [−0.07, 0.17]
Hauser et al., 2014	0.02 [−0.04, 0.09]
Santiago−Torres et al., 2014	0.02 [−0.18, 0.21]
Larson et al., 2013	0.01 [−0.03, 0.04]
van Zutphen et al., 2006	0.00 [−0.06, 0.06]
Weighted mean effect size for mealtime component	**0.09 [0.05, 0.13]**
Parental modeling (N = 10,760)	
Harris & Ramsey, 2015	0.19 [0.05, 0.32]
Skafida, 2013	0.18 [0.14, 0.22]
Frankel et al., 2018	0.17 [0.07, 0.26]
Goldman et al., 2012	0.16 [0.06, 0.26]
Sweetman et al., 2011	0.14 [0.04, 0.23]
Draxten et al., 2014	0.14 [−0.02, 0.29]
Vereecken et al., 2004	0.13 [0.05, 0.20]
Stephens et al., 2011	0.11 [0.05, 0.18]
Murashima et al., 2011	0.11 [0.04, 0.18]
Berge et al., 2014; Larson et al., 2015	0.04 [0.02, 0.07]
Melbye et al., 2013	0.00 [−0.08, 0.08]
Weighted mean effect size for mealtime component	**0.12 [0.08, 0.15]**
Food quality (N = 9,998)	
Trofholz et al., 2017	0.29 [0.11, 0.44]
Ayala et al., 2007	0.28 [0.16, 0.38]
Fulkerson et al., 2011	0.21 [0.14, 0.27]
Appelhans et al., 2014	0.14 [0.01, 0.26]
Chan & Sobal, 2011	0.14 [−0.03, 0.30]
Ferran−Alexander, 2012	0.13 [−0.15, 0.39]
Ayala et al., 2008	0.12 [0.06, 0.17]
Arcan et al., 2007	0.10 [−0.04, 0.24]
Masse et al., 2012	0.10 [0.04, 0.16]
MacFarlane et al., 2009	0.09 [−0.02, 0.19]
Larson et al., 2013	0.03 [−0.01, 0.06]
Babajafari et al., 2011	0.03 [0.00, 0.05]
Weighted mean effect size for mealtime component	**0.12 [0.07, 0.17]**
Atmosphere (N = 7,655)	
Berge et al., 2014	0.34 [0.13, 0.53]
Berge et al., 2013	0.26 [−0.16, 0.60]
Fiese et al., 2012	0.22 [0.04, 0.38]
Skafida, 2013	0.18 [0.14, 0.22]
Jacobs & Fiese, 2007	0.17 [−0.11, 0.43]
Stephens et al., 2011	0.11 [0.03, 0.19]
de Wit, 2015	0.11 [0.08, 0.13]
Bergmeier et al., 2016	0.06 [−0.16, 0.27]
Tremblay et al., 2010	0.00 [−0.03, 0.04]
Weighted mean effect size for mealtime component	**0.13 [0.06, 0.19]**
Involvement (N = 14,268)	
Leech et al., 2014	0.17 [0.04, 0.29]
Berge et al., 2017	0.12 [0.09, 0.16]
Chu et al., 2013	0.12 [0.09, 0.15]
de Jong et al., 2015	0.10 [0.07, 0.14]
Spurrier et al., 2008	0.08 [−0.04, 0.19]
Melbye et al., 2013	0.02 [−0.06, 0.10]
Larson et al., 2006	0.01 [−0.02, 0.03]
Weighted mean effect size for mealtime component	**0.08 [0.04, 0.13]**
Duration (N = 2,666)	
Jacobs & Fiese, 2007	0.34 [0.08, 0.56]
Berkowitz et al., 2010	0.29 [0.04, 0.51]
Berge et al., 2014	0.26 [0.04, 0.46]
Fiese et al., 2012	0.19 [0.02, 0.35]
Skafida, 2013	0.11 [0.07, 0.15]
Weighted mean effect size for mealtime component	**0.20 [0.09, 0.29]**

−0.3 −0.2 −0.1 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7

Less nutritionally healthy | More nutritionally healthy

Figure 15. Meta-analysis synthesizing studies on social, environmental, and behavioral attributes of family meals and identifying components of family meals that are related to better nutritional health in children. The forest plot shows the distribution of effect sizes for each mealtime component (point estimates of *r* value as squares plus 95% confidence intervals as error bars; see also values) and weighted mean effect size for mealtime component across studies (diamonds; width equals 95% confidence interval of the weighted mean effect size; adapted from Dallacker et al., 2019).

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Scientific Practices and Methodological Issues

This final section of our report highlights some scientific practices the Center has adopted and also actively contributes to. Subsequently, we turn to three illustrative studies that demonstrate how the analysis of the rules of experimentation, replication, and methodological diversity can be very helpful tools in the ongoing debate on how to create replicable and robust results in the behavioral sciences.

Scientific Practices at the Center

The Center has established an internal, mandatory *study registration system,* which is a central place for storing study materials, data, analyses, and other materials for all kinds of study types (behavioral, online survey, simulation, EEG, fMRI, etc.). It allows past, current, and future researchers at the Center to get a bird's-eye view of the studies currently underway and those conducted in the past. Furthermore, the system supports the budget and Institutional Review Board (IRB) approval process. The system promotes a culture of reproducibility of studies and analyses and facilitates the sharing of study materials, data, analyses, and other components—either proactively (e.g., on the Open Science Framework [OSF], www.osf.io) or on demand. The system uses the git versioning system and can automatically deploy experiment code to the Center's laboratories and automatically track any data that are collected. Using a versioning system ensures that, even long after a study has been conducted, it is still traceable which code version of the study was deployed; the Center is currently testing the use of *docker images* to additionally handle any library dependencies a code might have.

When perusing the Center's publications of the last few years, it becomes evident that our researchers are increasingly making their materials, data, and code publicly available (e.g., on www.osf.io) and increasingly preregistering their analyses (e.g., on www.aspredicted.org). Furthermore, to increase the dissemination of results, where appropriate, our researchers more and more post preprints of their work online (e.g., on PsyArXiv; see the category "Working Papers" on the Center's online publication list for examples) and more and more publish open access. Members of the Center have contributed in various ways to improving scientific practices at the Center

and beyond, including supporting the reuse of scientific data through facilitating the documentation of data (Arslan, 2019), the standardization of EEG data (Pernet et al., 2019), running complex, longitudinal studies online (Arslan et al., 2020), running interactive studies online (https://lioness-lab.org), and establishing an infrastructure for collaboration in primate cognition research (Many Primates et al., 2019; including Lou Haux from our Center).

To engage with the broader scientific community, the Center has published a book on its recent research that consistently includes interactive elements (see Box 1 in the Introductory Overview). Furthermore, the Center's Mehdi Moussaïd recently published a French popular science book on the wisdom and madness of crowds (Moussaïd, 2019), which attracted wide attention in the French-speaking world; he also established the accompanying, highly successful YouTube channel "Fouloscopie," which—at the time of writing—has 158,000 subscribers.

The Measurement of Dishonesty and Risk: Three Case Studies on Why Measurement and Replication Matter for Advancing Science

How Experimenters' Use of Deception Interferes With Studying Participants' Degree of Dishonesty

From cheating on tax returns to major corruption scandals—there is no denying that people often lie to their advantage. To empirically examine the individual and environmental factors underlying dishonesty, many studies have simulated this fundamental conflict in simple experiments such as the coin-flip task. Here, participants toss a coin out of view of the experimenter. They then report the outcome to the experimenter—for example, by computer. If they toss a head, they win a

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small amount of money; if they toss a tail, they get nothing. When this experiment is repeated with a large number of participants, the ratio of heads to tails should be 50–50. But almost all studies find that participants report more heads than tails. In other words, at least some participants lie in order to "earn" more money. Over the last decade, researchers have conducted numerous studies using this or a similar setup to investigate the various factors that lead to dishonesty. To comprehensively study the underlying factors, we (Gerlach et al., 2019) conducted a meta-analysis synthesizing the results of 565 studies on dishonesty with a total of 44,050 participants. In this brief report, we focus on a—perhaps surprising—question, namely: Does the honesty of the researchers impact the observed cheating? That is, does one find similar rates of cheating irrespective of whether the experimental laboratory running the study routinely deceives their participants or has implemented a no-deception policy (such as the Center's own laboratory)? We found a difference in the level of dishonesty, although not in the direction one might expect: Controlling for other relevant factors in a meta-regression, deception laboratories actually report, on average, lower cheating than no-deception laboratories (e.g., 7 percentage points fewer liars in coin-flipping tasks). This is important because one key defense for the use of deception in experiments is that it increases experimental control, especially when the behavior of interest is a highly undesirable one (see Hertwig & Ortmann, 2008). However, the fact that the use of deception alters the level of dishonesty, relative to several other experimental and deception-free paradigms, suggests that it raises participants' suspicions, prompts second-guessing of experimenters' true intentions, and ultimately distorts behavior and endangers the control it is meant to achieve.

Can We Replicate a Landmark Study? Heterogeneity in Banker Culture and Its Influence on Dishonesty
In 2014, a landmark study was published in *Nature,* suggesting that banker culture undermines honesty (Cohn et al., 2014). Other professions did not exhibit this effect, suggesting that banking culture is particularly problematic. Given the importance and scale of the banking industry, as evidenced in the global financial crisis of 2007–2008, this finding garnered enormous media attention, even though among behavioral scientists the study generated criticisms.

Motivated by the reproducibility crisis in the social sciences, we (Rahwan et al., 2019) sought to find out if the original finding could be replicated. Bankers are a largely inaccessible population—a factor that excluded them from a recent large high-profile replication effort. Still, we ran the same incentivized coin-flipping task to measure honesty in two different banking populations and three different nonbanking populations across three continents. In our two banker studies ($n = 148$ and $n = 620$), we observed some, though not reliably elevated, dishonesty among bankers primed to think about their work. This contrasts with the original study's finding ($n = 128$), for which we found evidence of underpowering. However, consistent with the original study, we did find that having nonbanking professionals ($n = 67$, $n = 205$, $n = 242$) think about their job did not have a reliable effect on their honesty. Together, these findings reveal that inducing professional identity—a proxy for culture—results in varying effects on honesty across professions and jurisdictions, both in direction and range. For the banking culture specifically, these results suggest that there is variance in the effects on honesty and that such culture may not be as categorically "corrosive" as the original study suggested. For policy-makers, our findings suggest that caution should be exercised in generalizing the original study's findings to their national jurisdiction.

How the Standard Economic Measurement of Risk Preference is Flawed
Although it is uncontroversial to claim that people markedly differ in their willingness to take risks, several questions have long remained unanswered in the literature on human risk preferences (Mata et al., 2018): Is there a general factor of risk preference, akin to the general factor of intelligence? Or are

risk preferences highly domain specific? Is risk preference a stable psychological trait? These conceptual issues remain unclear because few attempts have been made to integrate multiple risk-taking measures, particularly measures from different and largely unrelated measurement traditions (self-reported propensity measures assessing stated preferences, incentivized behavioral measures eliciting revealed preferences, and frequency measures assessing actual risky activities). Adopting a comprehensive psychometric approach (1,507 healthy adults completing 39 risk-taking measures, with a subsample of 109 participants completing a retest session after 6 months), we (Frey et al., 2017) provided a substantive empirical foundation to address these issues. In short, although a general factor of risk preference emerged from stated preferences and generalized to specific, actual real-world risky activities (e.g., smoking), we

found only weak correlations between self-reported propensity and behavioral measures. Importantly, we found substantial inconsistencies between the risk preferences implied by the six different behavioral elicitation methods we included. To explore this further, we (Pedroni et al., 2017) compared each individual's implied risk preferences across these six different behavioral elicitation methods—both in terms of the overt choices and by using computational modeling—and found no consistency in observable choices or in latent constructs (e.g., probability weighting) across the elicitation methods. This result strongly suggests that economists' and psychologists' common practice of measuring risk preferences with one simple behavioral elicitation method (e.g., lotteries) is highly problematic as it creates the fiction of a unique risk preference.

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Suprematist Kazimir Malevich's late-period work of art does not seem to give much space to "emotional states of mind." It was precisely this lack of expression that made us choose his *Three Female Figures* as the icon for the newly established Center for the History of Emotions in 2008. The blank faces and hollow shapes symbolize one of our main assumptions: emotions are not a given, but are shaped through learning processes and social interaction.

K. Malevich (ca. 1930). Three Female Figures.
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Introductory Overview

History is generally about continuities and discontinuities. The Center's history over the last 3 years has seen both. There were continuities in our overall goals, major assumptions, and guiding research questions, and there were discontinuities in our team composition, research areas, and focus groups.

To start with continuities: The Center is still committed to basic research on the history of emotions in modern and modernizing societies around the world. It conceives of emotions as individual experiences that are socially shared and communicated. At the same time, experiencing emotions is a learning process that is deeply embedded in social practices and interactions, from early childhood to old age. Culture is thought to play a highly significant role in framing emotions and investing them with meaning. Institutional settings are infused with scripts that prefer some emotions over others, allow certain emotional practices and suppress others, and have a say on how intense those practices can be.

Although culture and institutions tend to be relatively viscous, they do change over time. Sometimes, change is incremental; at other times, it is sudden and revolutionary. Emotions are affected by change and they themselves effect change. Social protests that can bring down governments or shift policies are usually triggered by strong emotions such as indignation, anger, resentment, and fear. Emotions mobilize people to act and thus help to transform whole societies. On the other hand, they are themselves affected by societal and institutional transformations. When, to give just one example, religion loses its grip on modern societies, this also influences the fate of emotions like humility, pity and compassion, fear or joy.

Through its various research areas and diverse projects, the Center analyzes the role and impact of emotions in modern history. It investigates how emotions have been changed by history and how emotions have changed history. It looks at certain moments, but also focuses on the *longue durée.* Furthermore, it observes emotional practices in different national and institutional settings and compares transnational exchanges, transfers, and collisions. While the Center's initial focus was on Europe and South Asia, its geographical scope expanded to include Africa, East Asia, as well as South and North America.

This global focus allows the Center to make three distinctive contributions to the history and theory of emotions. First, our studies show that the ways in which emotional rules, expressions, and languages impact how emotions are felt vary not only through time, but also through space. Second, looking at specific emotions in different cultural contexts allows us to compare them to show similarities and differences. It also enables us to trace how emotions are shaped by and shape global encounters in today's globalized world. Third, theoretical and methodological reflections in the history of emotions have until now mostly originated in Europe and the United States, thus using particularistic data in order to establish a universal theory. The global perspective of the Center opens us up to the provincializing of Europe and to new forms of theorizing from the Global South.

Key References

Rozenblatt, D., Cummins, C., Vasilyev, P., & Vidor, G. M. (2017). Focus: Criminal law and emotions [Special section]. *Rechtsgeschichte—Legal History, 25,* 242–295.

Vidor, G. M., & Kounine, L. (Eds.). (2017). Law and emotions [Special section]. *Journal of Social History, 51* (2), 219–312. https://academic.oup.com/jsh/issue/51/2

Research Areas

When the Center was founded, it organized research projects in three areas: *Education and Cultivation of Emotions; Emotions and the Body;* and *Emotions and Power.* In 2014 and 2016, we added two focus groups, one on law and another on religion. These annexes revamped the original structure. With the first cohort of researchers leaving the Institute and new researchers coming in, we decided to reorient our work to account for the widening array of "sites" where emotions move people, help them make sense of the world, and give meaning to their relationships and actions. We now host five research areas on major sites of emotion work: *Intimate Relations; Citizenship and Nation-Building; Economy and Labor; Religion and Spirituality;* and *Sciences, Medicine, and Therapeutic Cultures.* The new structure accommodates the dynamics of newly emerging research questions and projects while fostering internal dialogue both within and beyond each area.

The focus group on *Law and Emotions* has been concluded. With all but one researcher having left, it produced several major publications. The original religion group has finished its collaborative work and merged into the research area *Religion and Spirituality.*
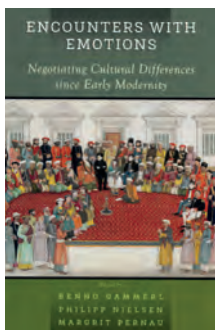
Collaborative Projects

Apart from our individual projects, our continued involvement in collaborative projects represents a unique aspect of the Center's work. Since its inception, we have been organizing projects that open up new frontiers in how academic research in the humanities is conducted. Guided by common research questions, roughly 10 project members provide one another with constant mutual feedback. The volumes that emerge from such ambitious and time-consuming engagement each create a coherent whole with chapters that refer to each other. This format enables the book to be at once thorough, concise, and intriguing.

The third collaborative project, *Encounters with Emotions,* studied transcultural face-to-face encounters in Europe, Asia, and the Pacific over a period of four centuries. Each chapter addressed questions pertinent to the historical study of emotion, from the strategies that people have used to interpret and understand each other's emotions to the ways emotions have obstructed communication. One reviewer highlighted the book's contribution to our understanding of cultural diversity and the subtle dialogue between the different narratives that it ties together. They underscored its strong theoretical framework and praised it as an important work for cultural anthropology, history, literary studies, and beyond.

Key Reference

Gammerl, B., Nielsen, P., & Pernau, M. (Eds.). (2019a). *Encounters with emotions: Negotiating cultural differences since early modernity.* Berghahn.

In 2019, several researchers embarked upon a collaborative project entitled *Feeling (Out of) Gender: Emotions, Power and Fluidity.* It builds on the insights of queer theory, which asserts that gender categories like "masculinity" and "femininity" are fluid, as is their relation to one another, and teaches us that the seeming stability of these gender categories is an effect of disciplinary power. *Feeling (Out of) Gender* extends the scope of queer theory beyond sexual encounters and orientation by exploring how emotions might sustain, underpin, disrupt, and destabilize gender binaries, norms, subjectivities, and categories. The fluidity is expressed and experienced through emotions themselves, through gendered actors' movements between spaces, and through conflicts within gendered spaces like the classroom, the workplace, the home, or the street. By encompassing a range of places including Zambia, Turkey, Russia, and India, the project transcends the boundaries of area studies.

A second initiative explores the institutional embeddedness of political emotions. The Center's research has always been concerned with the entangled relations between institutional structures and individual minds and bodies, acknowledging that they inform and permeate each other, though do not neatly map onto one another. Yet, much recent scholarship concentrates on the emotions of individuals. The project *Feeling Political* counterbalances this trend by inquiring into what it calls "institutional templating," exploring how institutions shape feelings in politics writ large. Its ultimate aim is to find a middle ground between the analysis of institutions' role in shaping emotions and individuals' unique experience of them.

This project is partly motivated by current, highly emotionalized developments in the public sphere. Its contemporary relevance prompted us to reach out to the public and organize a series of discussions on democracy and how it is affected by emotional politics.

Visibility and Outreach

Emotions are driving politics—or is it the other way around? It is a truism that today's political sphere is consumed by polarizing emotions. Emotionally restrained and composed leadership, a cherished ideal of postwar democratic politics, appears to be on the decline. Yet, the premise of the ideal itself—namely, that emotions are dangerous—is constantly reaffirmed. But why not embrace ardent dispute and fierce confrontation as part of a healthy democracy? Can there even be politics without passion?

With these questions in mind, the Center established a new format to reach beyond an academic audience. Researchers Philipp Nielsen and Kerstin Maria Pahl organized the *Dialogue on Democracy,* a series of six panels that invited influential public figures and specialists from the Center to debate the role emotions (should) play in democratic institutions and civil society. The panels each dealt with a pair of emotionalized oppositions: Participation and Protest; Law and Sense of Justice; Conflict and Compromise; Speaking and Staying Silent; Empathy and Tolerance; Cooperation and Confrontation. Participants included Daniel Günther, minister president of Schleswig-Holstein, and Robert Habeck, chairman of the Green Party. Between May and November, the dialogues attracted a growing number of guests who participated in lively debates and demonstrated that research on the issue of emotions can contribute to political debate.

Another way of making our research known to the wider public and intervening in current debates was the exhibition curated by Ute Frevert and her daughter Bettina (who works in historical-political education). Commissioned by two major public foundations, the exhibition covered the *Power of Emotions* in German history between 1919 and 2019. On 20 panels with up to 8 images each and a short text, the mother-daughter team presented a selection of 20 emotions that arguably made history and were shaped by it during the long 20th century. The exhibition travelled to almost 3,000 locations around the world, to town halls, city libraries, schools, universities, adult education centres, and Goethe-Instituts. The curators introduced the exhibition and gave talks in multiple places, such as the National University of Seoul, Hebrew University Jerusalem, Cornell College USA, the German school in Rome, and the Goethe-Institut Bucharest.

The exhibition also inspired Ute Frevert to metamorphose its structure into a monograph on *Powerful Emotions* that will be published in September 2020. Negotiations with an English press are currently underway. This follows the publication of her book *The Politics of Humiliation* in March 2020 (as an OUP trade book). Released in German in 2017, the volume analyzes how shaming and humiliation have, since the late 18th century, played out in various areas of public life: in the legal sphere (through shame sanctions like the pillory, branding, and public flogging); in education and socialization (from families and schools to university fraternities and sororities, the military, and the media); and in international relations (where special attention was paid to the body language of humiliation such as bowing, kneeling, and prostration). The book enjoyed widespread media coverage in German-speaking countries. The English version was thoroughly revised to accommodate an English-speaking audience.

Figure 1. Powerful Emotions in Korea.

Source. Marla Stukenberg/ Goethe-Institut Korea

Key Reference

Frevert, U. (2020e). *The politics of humiliation: A modern history* (A. Bresnahan, Trans.). Oxford University Press.

Emotions in History—The Successful Book Series With OUP

The series, jointly edited by Ute Frevert and Thomas Dixon (Queen Mary Centre for the History of Emotions, London), has grown remarkably over the course of its 6 years, reflecting the enormous interest in the history of emotions around the world. Seven more volumes have been published within the report period, two of which originated at the Center. Three more releases are scheduled for 2020. Ranging from the Middle Ages to modernity, the series reaches across regional and national boundaries and explores emotions through the histories of science, medicine, and psychology, as well as literature, art, religion, politics, and economics.

Joseph Ben Prestel's book *Emotional Cities: Debates on Urban Change in Berlin and Cairo, 1860–1910,* originally composed at the Center as a dissertation under the supervision of Ute Frevert, was named co-winner of the Urban History Association's Best Book in Non-North American History Award, 2017–18. It was praised as a highly innovative, parallel study of urban change that skillfully combines the methodologies of global history, urban history, and the history of emotions to enrich all three fields.


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Other attempts to elevate the Center's public visibility include the new Twitter account as well as the internet portal *History of Emotions—Insights into Research.* Since the portal was launched in 2013, it has posted more than 30 contributions, both in English and in German. Based on a single source, such as a text, photograph, postcard, or film, they elucidate the methods and questions that guide research in the history of emotions. The texts are also available on social media and have received attention both from peers and a broader audience. They have also been successfully used in academic and school teaching.

Another exemplary translation of our research into educational praxis is Juliane Brauer's 2020 book *Geschichte hören: Lied und Musik im Geschichtsunterricht* (Listening to History: Songs and Music in History Classes), which was published in a series on the methods of history teaching. Addressing a broad readership, the book encourages teachers to make songs part of history lessons on the grounds that they reveal much about the past, and particularly about people's fears, concerns, desires, and dreams. Since students are familiar with music from their everyday life, they will be receptive to an approach that brings songs into history classes and offers easy-to-use methods for analyzing them as a historical source of emotions.

Key Reference

Brauer, J. (in press-b). *Geschichte hören: Lieder und Musik im Geschichts- unterricht.* Wochen- schau-Verlag.
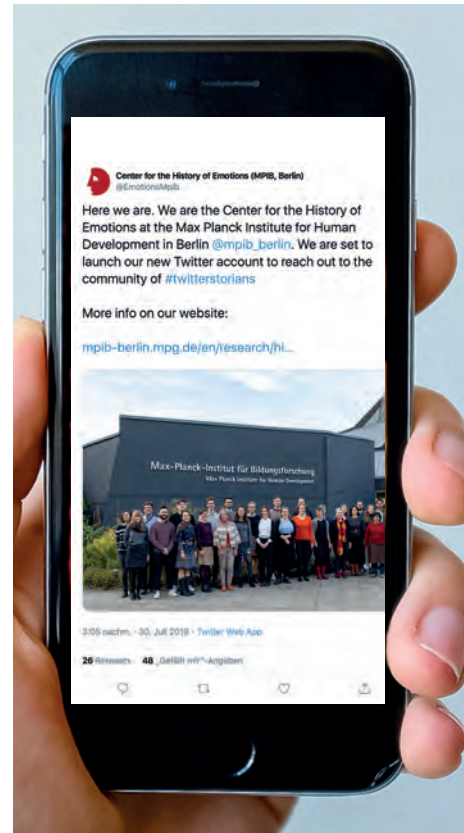
In 2019, the Center finally joined the #Twitterstorians conversation. The hashtag helps historians solicit professional advice, share resources, search job opportunities, and find new contacts. Posted by Francesco Buscemi, our tweets have proven effective in reaching out to colleagues, spreading awareness of our research, and engaging society in our work.

Domestic and International Cooperations

The strong emphasis on outreach and translation should not, however, blur the fact that most of our time is spent on doing research and sharing it with colleagues around the world. We also regularly host our colleagues to discuss their own research with us. Within the reporting period, 60 colloquia took place with 62 colleagues from 11 countries in 4 continents. Apart from nurturing already established cooperations, we started a new collaboration with the Center of Excellence in the History of Experiences (HEX). Funded by the Academy of Finland, this Center is based at the University of Tampere's Faculty of Social Sciences. It focuses on how religion, the nation, and the welfare state have been experienced in modern history. In April 2019, director Pertti Haapala and team leaders Raisa Toivo, Ville Kivimäki, and Pirjo Markkola came to Berlin and presented the group's overarching concept and first findings. Members of HEX worked with us as visiting researchers, and our Center sent researchers to participate in conferences in Tampere. In August 2018, Ute Frevert was awarded an honorary doctorate by the University of Tampere and gave a lecture as part of the conferral ceremony. Conferences have proven an excellent way to build on and expand existing cooperations and start new ones. Some explicitly remain within the Federal Republic, while others draw on international expertise and comparison. Among the former was a conference on *Heimat and Homesickness* convened by Juliane Brauer in June 2019 with Lale Yildirim (Freie Universität Berlin). As millions of people around the world have been forced to flee their homes in search of new ones, the concept of Heimat—a term hardly translatable into other languages—and the question as to who has the right to call what place home have become hotly debated. At the conference, historians analyzed the emotions that can be identified in these debates and how they influence people's conceptions of Heimat. They also investigated the strategies that some groups or discourses employ to (re)appropriate different homes and refuse to recognize others' claim to home. They drew attention to how right-wing conservatives and populists instrumentalize emotional connections to Heimat for their own agendas. Narratives about place of origin and a common future seem to be particularly conducive for framing—or even explicitly steering—the public negotiation of feelings about what and where home is and who belongs.

In contrast, the conference *Between Social Discipline and Pleasure: The Politics and Practices of Play and Games in State Socialism* was meant to intensify international cooperation and transnational theory-building. Organized by Juliane Brauer in December 2019 with Maren Röger (Universität Augsburg) and Sabine Stach (GHI Warsaw), it brought together scholars from Russia, the United States, Poland, the Czech Republic, and Germany to discuss how board games, computer games, physical games, gambling games, toys for kindergartners, and space exploration games for youth groups serve as sources for a history of everyday life in communist societies. Participants demonstrated how games as a medium and practice of socialization and entertainment induce comparative studies on how "domination as social practice" functioned before 1989/1991. This was a fine example of how analyses of pleasure and fun offer a way to bridge the history of emotions with recent research on communism.

Interdisciplinarity

The Center is no stranger to cross-disciplinary research, as we proved by organizing, in December 2018, a Max Planck Symposium on *Consciousness: Nature/Culture.* Planned by MPI directors Wolfgang Prinz (Psychology, Leipzig), Wolf Singer (Neurophysiology, Frankfurt), and Ute Frevert, together with Angela Friederici (Cognitive Science, Leipzig) and Antje Meyer (Psycholinguistics, Nijmegen), the symposium was meant to bring together consciousness research in the natural and social sciences as well as in the humanities, thus kicking off collaboration across disciplinary lines. Nineteen speakers, among them Laura Kounine, Jan Plamper, and Tamara Turner from the Center for the History of Emotions, were invited to illustrate the ways in which issues of consciousness are addressed in their respective fields.

Two more interdisciplinary initiatives were started in 2019. The Cross-Disciplinary Research Initiative (CDRI) by Tamara Turner (HoE) and Simone Kühn (LMG EnvNeuro) emerged out of the Institute-wide research colloquia. It was created to foster conversation across our groups by developing a better understanding of our various research methodologies and epistemologies. Given that our Institute houses psychologists, historians, AI researchers, neuroscientists, anthropologists, sociologists, and data scientists, our research questions, methodologies, assumptions, and ideas about what constitutes "evidence" are naturally highly diverse. With this in mind, CDRI provides a platform for discussing current and past research projects with members from other centers, inviting comments, questions, and insights from "outsider" perspectives. In the process, CDRI strives to cultivate common grounds for potential collaborative projects and publications on cross-disciplinary questions such as notions of memory across disciplines and how to capture "inner experience."

Second, a new Institute-wide discussion group formed around the themes of morality and emotion as they relate to causation and decision-making. It was instigated by historian Michael Amico, art historian and literary scholar Kerstin Maria Pahl (both HoE), and psychologist Indrajeet Patil (CHM), and comprises about 20 researchers and PhD students from all research centers at the Institute. The group's aim is to find overlaps in the research happening across the various disciplines and research methodologies that make up the Institute. While the members of this group are not racing to design projects together, they are listening and speaking in ways that are subtly shifting how they conceive their own research and make their arguments. This group is driven by the recognition that the respective research projects open onto sizable social and political questions about emotions and morality, and that scholars need to better communicate those questions and their provisional answers not only across disciplines but to a broader public.

Why think outside the box like this? The statistician George Box once said, "All models are wrong but some are useful." In that spirit, because every academic discipline has very particular access to (but not a complete picture of) its subject(s) of analysis, there is much to learn from cross-disciplinary engagement.

By and large, the methods and language used in scientific discourse have gotten in the way of collaborative thinking. This is a problem that academia faces as a whole. Here at the Institute, we are in a position to tackle it.

Internal Reading and Discussion Groups (Selection)
Forum—In 2019, a new meeting space was created by Michael Amico and Karsten Lichau for casual discussion of questions, problems, and ideas relating to work as historians of emotions. The conversations have been free-flowing and covered distinct topics, including the current state of the history of emotions, history more broadly, science, disciplinarity, literature/narrativity, and contemporary events and politics.
Subjectivity and Structure in Historical Practice—In 2019, a small group of researchers and PhD students met every month to discuss the topic of "subjectivity" in the writing of the history of emotions. The group focused on the relation between the individual and larger social structures, experimenting with primary source examples to contemplate scale, perspective, and structure and where they originate on the historical scene, including within the individual.
Sound and Feeling—While the strong affective impact of sound and music has long been taken as a given, it has recently come under critique, and with it the longstanding tradition that associates vision with reason and sound with "irrational" emotions. Yet, numerous sources account for the historical power of the close intertwinement of sound, music, and emotions. This group, initiated by Karsten Lichau in early 2018, seeks to historicize this relationship.
Emotions and Economy—Since 2016, researchers and PhD students from the IMPRS Moral Economies have been discussing new empirical and theoretical studies on economy and emotions, with a sharp eye toward the transnational dimension of the topic. This initiative was revived with new questions and colleagues in 2018 to discuss current research literature on morality, economy, and emotions.

Research Area 1: Intimate Relationships

People become intimate with one another through emotions such as love, hate, pride, and jealousy. While their intimacy is shaped by expectations about how they should feel as a parent, friend, woman, migrant laborer, comrade, or another social role, the projects in this research area show how the emotions of intimate relationships always refine social identities, reinforce the work of institutions, and reconstruct the public sphere. Together, the projects offer a global perspective: How did the exclusivity of same-sex love between soldiers in the American Civil War strengthen the ideal of friendship? How did immigrants transform their expression of love to withstand migration from Italy to Canada? How did women gain economic power and rework tropes of social respectability through their relationships with "sugar daddies" in 20th-century colonial Africa? Research on adoption and child-rearing practices in modern Germany and a study of romance among industrial laborers in contemporary Delhi further reveal how an emotionally intimate public has long structured modern globalized societies.

These projects take a close look at rituals, habits, and spatial arrangements of affection and kinship in order to better understand where the power of social norms and values accrues and how they are adapted to intimate relationships. Their analyses reveal the extent to which social policies, legislation, norms, and ideals are a response to emotional ambivalence. One key conclusion is that the ability of intimate relationships to bring people together and form communities is inseparable from their destabilizing and destructive potential.

The Forgotten Union of the Two Henrys:
A History of the "Peculiar and Rarest Intimacy" of the American Civil War

Henry Clay Trumbull and Henry Ward Camp, members of a northern regiment in the Civil War, described themselves as being "united in well-nigh perfect oneness." What were the broader social and political implications of their "seldom-equaled attachment"?

Others have, over time, reduced the intimate relationships between men to mere sensation, depicting them as manipulative, backstabbing, or sodomitical. That was not the case here. This project shows that the two Henrys' relationship was a model for what it meant to be a law-abiding, Christian citizen in a democratic republic because of, and not despite, the peculiarity of their intimacy. Their "well-nigh perfect oneness" was an example of both the potential and limit of the commons, which explains why emotions of enthusiasm and confusion both surrounded and permeated their relationship.

That it gained prominence during the Civil War is crucial for demonstrating how intimate relations were central to the understanding and enacting of the shifting power dynamics of the American political experiment. Its principles included separation of power, free speech to critique "friends," and a sense of community based on social ideals. These principles were impossible to fully realize. The ongoing question of what any one person owes to or wants from another generates emotion that gives historical force to the ideals of "union," "friendship," and other markers of group identity. This project takes a closer look at this process by showing how the broader place and power of social ideals must be understood in relation to sites where the limits and power of social intimacy become "one." It was this combination that gave the two Henrys' rare relationship public visibility and value during a time of war and national reckoning. Their relationship stuck out and stood for what could not be fully said or what was only imagined to be possible. This is how ideals of union and friendship reconcile a diversity of everyday realities across class, race, and time and realign them into dreamscapes of peace or calls for war. In fact, if the two Henrys' intimacy risked misunderstanding, it was that very risk within its "sense" that produced the power and ideal of friendship that made their intimacy representative of an idealized community norm.

Researcher

Michael Amico

A gift from Camp to Trumbull, inscribed. This project draws on material from close to 2,000 pages of unpublished letters, hundreds of places, and a smattering of objects, photographs, and pictures.

© Michael Amico

Researcher

Sonia Cancian

Key Reference

Cancian, S. (in press-b). *With your words in my hands: The letters of Antonietta and Loris, 1948–1949.* McGill-Queen's University Press.

With Your Words in My Hands: The Letters of Antonietta and Loris Palma, 1948–1949

Love and migration have always weighed upon lovers, and stories about their separation continue to fascinate us. How did separation and writing shape lovers' understandings of themselves and their affective ties? In what ways did migration drive the emotions of lovers, and how did love drive their migration? This critical edition represents an extraordinary two-sided collection of migrant love letters by Antonietta Petris and Loris Palma, a young, literate couple writing in Montreal and Venice between 1948 and 1949. Their letters not only feature the reflection, resilience, and reification that defined their love at a distance. They also underscore the emergence of the transnational strategies—material, emotional, and ephemeral—that both letter writers employed to reassure each other of their intimate connection. Through the ink on the page, the agency of each of the writers emerges; they assert with determination the successful outcome of their migration.

Researcher

Rukmini Barua

Key Reference

Barua, R. (in press). Matters of the heart: Romance, courtship and conjugality in contemporary Delhi. *International Labor and Working-Class History.*

Love and Labor in the City: Romantic Love and Delhi's Workers, From the 1950s to the Present

South Asian cultures often posit a distinction between "love marriages" (self-chosen unions) and "arranged marriages" (those in accordance with social custom). These ideologically powerful oppositions frame much of the discourse around romance, intimacy, and conjugality though, in practice, they are porous and fluid. The thorny relationship between personal choice and the social norms governing marriage in India thus complicates the common assumption that cultures around the globe have shifted toward "pure relationships" based on equality, romantic love, and individual desires. The study's ethnographic interviews in an industrial locality in contemporary Delhi evidence such complexity. Many interlocutors highlighted the proliferation of romantic relationships, "love marriages," and the emotional bond between the couple while simultaneously referring to heavy social and normative regulation.

Through its focus on the urban working poor in postcolonial Delhi, this project draws attention to the emotional and affective dimensions of working lives and investigates the place of social hierarchies in the constitution and transformation of emotions. It analyzes the connections between romance and intimacy and the parallel shifts in labor regimes, migration patterns, and the practices of urban settlement and displacement. This project examines, on one level, discourses of romance that emerged out of institutions like the state, family, and community groups, as well as those produced through popular cinema, poetry, and literature. On another, it analyzes lived experiences and the everyday practices involved in the imagining, expression, and performance of romantic love. It demonstrates that historically contingent, classed and gendered ideas of social respectability critically shape the discourses and the practices of romance and suggests that the vocabularies and communication of love are spatialized and patterned by the quotidian rhythms of work and life.

Researcher

Stephanie Lämmert

Urban Intimacies in Eastern and Central Africa in the 20th Century

The project investigates the history of romance and intimacies in eastern and central Africa in the 20th century by engaging with broader narratives about female respectability, such as stories of nation-building, social and economic change, and negotiations of "modernity." The language of modernity functioned as an important means for women and others to assert their own interests. The project inquires into how women shaped and played with romance throughout the 20th century and, at the same time, how they were confined by public moral assessments of their behavior. While the colonial, missionary, and male gazes dominated the way women were seen, judged, and represented in the press, a nascent, more "modern" perspective felt pride in women's economic autonomy and understood sexual and/or romantic unions as a matter of women's choice.

The project elucidates how extramarital affairs and marriage choice produced very different

emotions in different social spaces, which were at once entangled and separate. While in public institutions such as the church or the school and in private ones such as the family, women were shamed for transgressing conservative ideals of female respectability, they were also admired or envied for the same actions in other (or even the same) social spaces.

The project's rich array of sources consists of missionary, government, and mining company publications and archives, newspaper collections, interview material, court records, and novels and murals. The material stems from Zambia, Tanzania, and the Democratic Republic of Congo between the 1920s and 1990s, with a particular focus on the Central African Copperbelt and urban Tanzania.

The project analyzes love stories and common urban tropes like the "sugar daddy" in order to develop a fresh take on urbanity and intimacy in African history. Feelings associated with urban romance and female respectability,

Figure 2. "Kuwa na msimamo" (follow your principles). A "sugar daddy" tries to lure a schoolgirl into a romantic relationship. Mural in Dar es Salaam, Tanzania, 2014.

© Stephanie Lämmert

whether those of incensed or benevolent observers or those of the women involved, were unstable. Emotions associated with female respectability were fluid, as women navigated different social and material worlds and acted differently according to the demands or liberties of each of these particular spaces.

Adopting a Child in Germany:
The Contested Politics of Belonging and Care in a Globalizing World (1945–2000)

Adoption is a complex topic that involves politics, economics, religion, law, culture, ethics, and social concerns. National and transnational histories of adoption can offer insights into how societies have changed their views on childhood and family life, the welfare state, solidarity, altruism, and humanitarianism. The relationship between institutions regulating and organizing adoption and the individuals doing the adopting has long been shaped by questions of identity. Differing conceptions of the "child's best interest" also bear considerable weight in the decision to allow a child to be adopted.

What significance does historical research on adoption have for our understanding of socialization, the public's interest in private matters, and children's well-being? How have institutions, the media, and individuals grasped the relation between social and genetic identity throughout the history of adoption, and how have they sought to account for different familial constellations?

The scattered research that has been conducted on the history of adoption in Germany tells us that it has become progressively

institutionalized. Moreover, by highlighting the difference between biological and social parenthood, adoption has helped expand the limits of the "normal" family. An open question is whether adoption has countered the overvaluation of "natural" origins in reproductive medicine and elsewhere. In the history of transnational adoption, racist and ethnic stereotypes have exerted considerable influence. Adoption also concerns issues of poverty. Ultimately, adoption history allows us to understand how love in parent–child relationships was practiced throughout the 20th century and how scientific knowledge about love's psychology was produced and circulated both within German society and transnationally between Germany and the children's countries of origin like Vietnam.

In 2019, a workshop was convened at the Center together with Benedikt Stuchtey (Philipps-Universität Marburg) to discuss methodological and theoretical approaches to the social and cultural history of adoption. A selection of papers is in preparation and Stuchtey and Hitzer will lead a section on the topic at the Munich Historians' Conference in 2021.

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Research Area 2: Citizenship and Nation–Building

Emotions are not only personal to individuals and constitutive of face-to-face relations; they are also at the center of political processes. Emotions create feeling communities that reach far beyond direct interpersonal relationships. They are at the basis of political parties and social movements, of regions and nations, but also of supranational communities. These communities are imagined, but they are also held together by emotions, whether they are actually practiced or merely asserted. Communities frame emotion rules in a variety of ways and enforce them directly through their institutional power, but also through speeches, newspapers and journals; through rituals and genre conventions in art, literature and music; and through the creation of material environments geared toward provoking particular emotional reactions.

Projects on France, Italy, Germany, Britain, India, and Japan show that emotions are one of the core mechanisms of inclusion and exclusion. While the attribution of certain emotions leads to integration into the national community and the recognition of civic rights linked to citizenship, the darker side of emotions can also make it plausible to citizens why certain people should be marginalized and deprived of their rights.

Researcher

Francesco Buscemi

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Spectacular Speeches:
Emotions, Rhetorical Practices, and the New Canon of Public Speaking in France and Italy (1750–1848)

Between the 18th century and the second half of the 19th century—an era of democratization, participation, and nationalization—new rhetorical practices came to define what political eloquence meant. The project begins by detailing the birth of a new canon of emotionalized rhetoric in France and its origins in homiletics and theatre. It then analyzes how these techniques were adapted and modified across the Italian peninsula, where they played an important role in disseminating and consolidating the new politics of the nationalization of the masses. In particular, it investigates why and how eliciting emotions became the most important element in modern political rhetoric.

How did new political elites train themselves to perform spectacular speeches in order to engage the emotions of their audiences? How did their audiences react? How was their listeners' reception of this rhetorical style conditioned by their experiences in theatres and churches? How did political institutions try to regulate the circulation of public speeches? These rhetorical practices also shed light on the impact of emotions in the lawmaking process. The rising importance of participatory politics required political actors to find new techniques to capture people's attention. New political institutions founded after the French Revolution, such as representative assemblies, clubs, political associations, and parties, were animated by the lively speeches of their members. As the French and Italian revolutionaries soon realized, the most effective lawmakers were often those able to summon up the emotions of the assemblies.

Taking into consideration the performance of these speeches and the role of the audience as a real agent, this project studies the cultural framework of these emotions along with the social practices and media that transmitted them.

Figure 3. Mirabeau arrive aux Champs Élysées (Mirabeau arrives in Elisium), by J.-M. Moreau, engr. L.-J. Masquelier, Paris, after 1791.

Source. CC0 Paris Musées / Musée Carnavalet.

Emotions and Temporalities

Completed Project: Emotions and Modernity in Colonial India. From Balance to Fervor, Delhi, Oxford University Press, 2019

Historically, modernity has been linked to increasing discipline, implying an always tighter and interiorized control over the emotions. This has been followed up for factories (Marx); the bureaucracy (Weber); early modern courtly society (Elias); as well as for prisons, hospitals, and mental asylums (Foucault). What these accounts leave unexplained is the emotionalization that was happening at the same time in other social fields: friendship and family, but also politics and the public sphere, religious fervor, and most notably nationalism. It is here that the book intervened, looking at North India between the Revolt of 1857 and the First World War. It drew on a rich and hitherto unexplored archive of Urdu sources, ranging from advice literature, journals, and newspapers, to children's literature and nostalgic descriptions of courtly culture. The book argues that, in this era, emotional ideals shifted from balance to the desire and celebration of fervor and excess. Passions were now linked to the possibility of a revival of the community and the nation—only peoples who felt strongly would come out victorious in the battle for survival and would reach the pinnacle of powerful nations. Emotions, however, do not constitute discipline's other so much as its other face—processes of disciplining were inseparable from intense emotions, not only of resistance, but also of the desire and the struggle to become the disciplined subject of the future.

Current Project: Feeling for the Future—South Asia 1912–1970

This new project takes off where the last project ended and investigates how emotions linked to the future in North India and Pakistan between 1912 and 1970. While books analyzing the relation between the past, history writing, and the present are legion, studies on the future are still rare, and even rarer are those with a focus on South Asia. Reinhart Koselleck argued that after the French Revolution, the space of experience and the horizon of expectation started to draw apart. History no longer served as *magistra vitae,* and experience could not provide lessons for the future. This, however, might be true for the countries who imagined themselves as the vanguard of progress—for all the others, the future was seen not so much as open but as already having arrived elsewhere, leaving them with the task of catching up. Imaginations of the future changed dramatically in the time under investigation. From 1900, visions of a struggle for survival, peaking in the mobilizations of the 1930s, competed with strands of millenarism in the national movement, which saw the aim not so much in a better future than in the end of time, in the advent or return of an eternal and unchanging republic of villages no longer subject to historical change. After 1947, both models lost traction and were replaced by a vision of the future dominated by the categories of development and planning.

The project first aims at tracing the emotions linked to different imaginations of the future—all of them can be brought under the umbrella category of hope and anxiety, but the hope in the struggle for survival felt radically different from the hope cultivated by the experts in the planning commissions of the 1950s and 1960s. It secondly investigates how emotions are not only a product of concepts and interpretations of the future, but how they also contribute to linking these concepts to the experiences of actors and hence render them plausible.

The archive for this project consists of journals and newspapers and other widely publicized texts. It also integrates sources beyond language: architecture, photography, and cinema.

Two collaborations are central for this project: the ERC project on *India's Politics in Its Vernaculars,* led by Anastasia Piliavsky (King's College, London), which will help develop the section on concepts of the future; and the project led by Dana Sajdi (Boston College) on *Global Cities Represented,* which will help to build up the chapter on architecture.

Researcher

Margrit Pernau
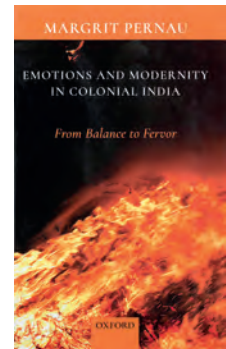
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Karsten Lichau

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A Political and Cultural History of the Minute's Silence

This project explores the yet unwritten history of the minute's silence. Established in the aftermath of the First World War, this ceremony became an important element in numerous nations' commemoration of war dead during the 1920s; later, it also spread into other parts of modern memory culture. Centering on the introduction of the minute's silence into Britain's, France's, and Weimar Germany's remembrance cultures, the project explores how (silent) sounds and emotions enact different politics of commemoration.

In the first years after its "birth," the minute's silence was mostly performed as an official, publicly staged event, where all citizens of the nation were supposed to simultanuously mourn the dead soldiers. Often, the moment of silence was framed by a rich acoustical program that included church bells, maroons or bugler calls, Christian hymns, national anthems, and military marches. But newspaper articles, personal letters, and diaries also report that it was laden with manifold, often largely diverging feelings: grief and mourning, reverence, repentance, but also indifference or even anger and hatred. Chal-lenging research on the commemoration of the First World War that has mostly dealt with textual, architectural, and visual objects, this project examines how citizens' engagement in ephemeral and often fragile sensory, emotional, and kinesthetic practices played a crucial role in national memory politics.

This political and cultural history of the minute's silence reads it as a complex of "emotional practices" comprised of the perception and production of (silent) sounds; other sensory, affective, and cognitive processes; and the bodily movements they involve. These practices had significance as articulations and negotiations of political and cultural issues. Thus, sources repeatedly dwell on participants' unease with the display of mourning gestures in secular, public places, which they would rather have reserved for the private or religious sphere.

Sounding out the ephemeral, emotional, and acoustic dimensions of commemoration practices, this project questions the widely held assumption that cultural forms of remembering the First World War conformed to established traditions of memorial culture.

Researcher

Hannah Malone

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The Politics of Grief: Fascist Italy's Military Cemeteries of the First World War

Mussolini's Fascist regime sought to exploit emotions by taking control of the commemoration of fallen soldiers of the First World War. The loss of over half a million Italians in the war unleashed a powerful mixture of grief, sorrow, pride, and anger among the population. Due to this emotional resonance, remembrance of the fallen was an ideal site for the exercise of power and the promotion of nationalism. Once in charge, the Fascists used the memory of the dead to redefine the national community and to serve a political agenda. Originally, Italian soldiers who died fighting in the war had been buried in small cemeteries or mass graves close to the battlefields. However, in the late 1920s, Mussolini had the bodies of over 300,000 soldiers reinterred in new cemeteries for reasons of propaganda. Accommodating up to 100,000 dead, the cemeteries were built along the former frontlines in northeastern Italy and present-day Slovenia. Their architecture took various forms, including that of a medieval fortress, a giant staircase, and a tower of Babel.

This research combines emotional, political, and architectural history in order to uncover the political motivations behind the creation of the cemeteries. Drawing on both visual and textual sources, it explores a range of documents held in previously inaccessible military archives as well as propaganda that includes

Figure 4. Ossuary of Monte Grappa, built 1932–1935, Italy.

© Hannah Malone

videos, pamphlets, newspaper articles, and postcards. As the sources suggest, the Fascists aimed to channel the emotions elicited by the dead in support of the regime. As sites of rituals and rallies, the cemeteries were meant to foster feelings of pride, triumph, self-sacrifice, and even joy, while restricting sadness, regret, and resentment toward what some saw as pointless bloodshed. Propaganda declared that "one should not cry for the dead," but personal responses show how individuals could resist the regime. Thus, the Fascist cemeteries present an ideal case study for analyzing the interplay between national politics and individual emotions, a timely issue given the emotionality of politics today.

Performing Patriotism: War Songs and Emotional Communities in Contemporary Japan

As Japan looks forward to the Tokyo 2020 Olympics—despite the delay—music has once more become a site of public debate over the politics of national pride and the limits of artistic expression. However, this very contemporary concern has ignited a much older anxiety tied to the history of musical composition by and for the Japanese military during the Second World War. These so-called war songs, or *gunka,* supported a brand of nationalism that exploited nostalgia for an ancient, unspoiled land and encouraged admiration for its military might on a global scale.

The legacy of Japan's war atrocities makes it problematic for people to employ *gunka* to express their "pride" or "love" for the nation. Personal recollections are mostly denied a public space in Japan's musical landscape today, reflecting a continued discomfort with the ghosts of wartime past. Yet, these tunes have managed to find new life in the private sphere. But who continues to sing these songs and why? What kinds of communities are formed in engagement with this music? And how do these war songs mediate feelings of the past, present, and future?

This project explores these questions by conducting fieldwork with musical subcultures, which, united in their shared emotional motivations, expectations, and interests, have formed online communities dedicated to the preservation of *gunka.* Just as these tunes were composed to kindle nostalgia for an imagined ancient past, so too is their revival steeped in a "vicarious nostalgia" for Japan's former military glory, which is being given new life through the voices of men and women born decades after the end of the Second World War. The research reveals that for these communities, war songs function as a conduit for social renovationism, an ideology that seeks to restore a sense of lost "cultural authenticity" by developing new conceptions of the future. For these communities, the singing, sharing, and posting of *gunka* online is embraced as a patriotic practice that promotes an idealized image of the nation's past and counters anxiety about the fallen present. This shared frame of reference, or "interpretative community," shapes how people construct meanings and conceptions of the self and the collective. The research demonstrates that these songs inhabit a contested space between the remembering and forgetting of Japan's military past and imperial imprint in the Asia-Pacific region, which evokes questions about what it truly means to sound and feel Japanese in the 21st century.

Researcher

Makoto Harris Takao

Figure 5. Japanese Military Song Postcard "hinomaru koshinkyoku" (Rising Sun March, c. late 1930s).

© Makoto Harris Takao

Research Area 3: Economy and Labor

The research area pursues three aims. First, it analyzes how emotions have shaped economic and social relations. Second, it investigates the intentions and expectations with which emotions have been used for economic practices and theories. And third, it examines historical changes in economic and industrial relations from the 17th century to the present with a special focus on the transformation of the emotional mindsets and behaviors of workers, entrepreneurs, and consumers.

The center has a longstanding interest in the history of capitalism. The crises and economic cycles of capitalism, its expansion to formerly noncapitalist regions, and the structural changes that it constantly imposes on industrial and business relations set the framework for the group's empirical case studies on Germany, France, Britain, the United States, the Soviet Union, and Turkey. By critically questioning the functions and uses of emotions in a globalized world, the studies look at perceptions and practices of class, gender, hierarchy, health, success, solidarity, inequality, community, efficiency, and—last but not least—the meaningfulness of work. Just as labor relations have changed dramatically over the past 200 years, so have the emotions that give meaning to work. The same applies to emotions that are mobilized to address social issues, criticize capitalism, and demand changes in economic policy. Sometimes, opponents of capitalism have attributed the economically successful with a lack of feelings toward the workers and employees who are the backbone of economic progress, while those lower classes attempted to compensate for their physical and psychological exploitation by seeking out numbness. The area's projects explore how these emotions and their absence have been employed and expressed in business, politics, and art and culture, and how they have influenced social relationships and the dynamics of capitalism and market societies more generally.

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Capitalism—A Longstanding Interest of the Center

The "economic sphere" is not a purely rational space, nor is the "homo oeconomicus" guided exclusively by reasons of expediency. Economic changes are prompted and influenced by shifts in emotional cultures and, conversely, economic activity impacts emotional practices. Thus, from the Center's early days, its investigations into the tight relationship between emotional and economic practices have been developing crucial findings on how capitalist economies emerge, stabilize, develop, and reproduce themselves. The Center's first conference on *Emotions and Capitalism* dates back to 2012. Sabine Donauer's award-winning 2013 dissertation *Emotions at Work—Working on Emotions: On the Production of Economic Selves in Twentieth-Century Germany* was lauded both within and beyond academia.

Anne Schmidt's project *Advertising Emotions* focuses on one of the main arenas where capitalist discourses and practices meet: the advertising department. By tracing the effects of newly emerging knowledge within the entangled networks of advertising culture, it asks how capitalist subjects were brought forth in and through this culture. The manuscript is completed and currently in the phase of final revision before submission for publication.

In 2019, Ute Frevert's book on *Capitalism, Markets and Morals* was widely covered and discussed in German-speaking media. Recent calls for a "moral economy" provided the impetus for the inquiry into the historical relationship between capitalism and morality. While the majority of economists agree that capitalism is the most effective and innovative economic system, 60% of Germans today consider it a system in which the rich get richer and the poor get poorer. Are claims to and endeavors for morality within the economic sphere just attempts to cover over grievances and systemic defects? The book shows that capitalism has been morally contested and criticized since its very beginning, both in theory and, above all, in practice. This led to the organization of self-help associations, housing and consumer

The Importance of Feeling Nothing: A History of British Insensibilities, c. 1780 to 1870

Few things make the meaning and importance of feelings so apparent as their absence. This is the first study of the history of insensibility, of its function and its purposes. Numbness, stupor, indifference, callousness—what has feeling nothing historically meant in political, economic, and social contexts? And what do we learn about history by exploring the lack of emotions?

A British reader opening a newspaper in the pivotal years around 1840 would encounter a wide array of insensibilities, especially when it came to articles about the lowest echelons of society: socially engaged writers, journalists, and philanthropists decried the unfeeling abandonment of the poor, the homeless, and the orphans as not befitting a civilized nation; the Chartists, the first British working-class movement, underlined their wish for political participation (one man, one vote) with passionate rhetoric and considered the political and entrepreneurial establishment deaf and insensible to their needs and desires. "It is," Friedrich Engels would write in 1845, "utterly indifferent to the English bourgeois whether his working-men starve or not, if only he makes money."

Critiques of the industrial, rationalized, capitalist, and technological—in brief: the modern—age denounced insensibility in order to effect change. Was that simply rhetoric or did unfeelingness indeed become a powerful political and social weapon? And more generally: How to reconcile the search for pain-free surgery and the introduction of anesthesia, a long-desired form of insensibility, with the notion that numbing the senses would promote detachment? Drawing on contemporaneous social theory, political rhetoric, literature, and medical texts, this project argues that insensibility concerned political, social, and economic power because whoever invoked it thought it a fruitful way to voice their grievances. The different groups among the lower classes—factory workers, tradespeople, domestic servants, merchants, flower girls, scavengers, and others—served as actual symbols of heartless progress. But they also inspired artistic production, be it in Charles Dickens's novels or in the social realist paintings of the Victorian age, providing heart-wrenching and awareness-raising, but also picturesque and palatable images of poverty. Insensibility had a political agenda and the intertwining of politics, social reform movements, and cultural imagination made insensibility a politically potent emotion.

Figure 6. Downtime during hard times. How did images of unfeelingness become sentimental, but effective tear-jerkers? (Frances Montague Holl, Faces in the Fire, 1867.)

© Ashmolean Museum, University of Oxford (WA1991.184)

Researcher

Agnes Arndt

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The Capital of Capitalism: Emotions and Entrepreneurship in Germany and Beyond

Why is capitalism, despite all conflicts and criticism, still the most successful, most dominant economic system? What creates its success, and what sustains its resilience? How does capitalism recover and renew itself from its cyclical crises? And what role do the emotions of its most important agents—investors and entrepreneurs—play?

The core thesis of the project is that capitalism would not exist without the symbolic capital that results from the economic exploitation of emotions. Concentrating on different emotional communities of entrepreneurs in the German-speaking area between the 1840s to the present, the project investigates how, why, and by whom these emotions have been formed and informed. It analyzes which sort of economic, political, and cultural systems foster particular emotions and which hinder them. And it asks whether entrepreneurs and the greed often associated with them is specific to capitalism.

While the notion that the greed of bankers, investors, and entrepreneurs caused the 2008/2009 financial crisis featured prominently in public debates of the time, the project's initial findings demonstrate that capitalism—despite its instability and fallibility—has expanded with such tenacity and developed even under noncapitalist conditions precisely because it draws on mental and emotional resources that differ from mere personal greed.

The project compares the historical development of entrepreneurship in Germany with entrepreneurial behavior in other parts of Western and Eastern Europe by drawing on source material comprising autobiographical and biographical texts, personal objects, letters, journals, and social networks. This comparative research aims to further our understanding both of pleas for stronger regulatory mechanisms as well as of the reasons why capitalism has a seemingly inherent tendency toward crises while, at the same time, always remaining capable of weathering them.

Capitalist Cold: Debating and Depicting Callousness in Europe and America, 1840s to the Present (Conference, 6–7 December 2018)

A specific form of social coldness has long been attributed to capitalism. Allegedly insensitive to the needs of those who helped it succeed, the capitalist system is said to undermine and endanger its own existence through the exploitation of human and ecological resources. Criticism of this kind not only pervades contemporary debates, but has always been part of the artistic, journalistic, and academic discussion of capitalism. The philanthropy of capitalists who wish to improve the conditions of men and women while still trying to reap financial benefits has been partly recognized as an attempt to limit and contain the negative consequences of capitalism. Nonetheless, capitalism and its proponents have never been able to shake the charge that the economic system is defined by a lack of feeling. But what do unfeelingness and related concepts such as callousness, insensitivity, cold-heartedness, and uncaringness actually mean in these contexts? Are people lacking or are they suppressing emotions? Is it a real feature, an expectation, or a typological structure by which an entire group of capitalist investors, bankers, industrialists, managers, and entrepreneurs is characterized? Is it believed to be inherent or acquired and, importantly, can it be altered or unlearned?

The conference *Capitalist Cold* explored the intersection between unfeelingness—alternately understood as acquired callousness or genuine indifference—as an inherent human characteristic and an external attribution in

Europe and North America from the 1840s to the present. Papers from historians and neighboring disciplines, such as cultural studies, art history, music history, and literary studies, drew on historical sources and literary and visual culture in order to provide insights into different adaptations, variations, and representations of unfeelingness. Concentrating on the projections, practices, places, and products of unfeelingness, conference participants inquired into the social settings in which unfeelingness occurred, the individuals or social groups who were said to be particularly unfeeling, the stages and cycles that debates and representations about unfeelingness underwent, and the extent to which these debates correlated with times of economic or social crisis. The results of the conference will be published by the conference organizers, Agnes Arndt and Kerstin Maria Pahl.

Inequality and the Passions in Early Modern Europe

Researcher

Stephen Cummins

The connections between social stratification, economic inequality, and emotions in early modern Europe were intricate and complex. Such inequality and social divisions were seen as not only essential to functioning communities but, for most, also as divinely ordained. Yet, this acceptance and its social enforcement belies the envy, scorn, and resentment engendered by the changing dynamics of inequality. The traditional nobility clashed with new entrants to the upper classes, who ascended through trade and finance. Such social divisions and debated hierarchies were both produced and shaped by passionate acts. The project focuses on these entanglements in early modern Italy with comparative work on early modern England.

The early modern European social fabric was woven through bonds of dependence and patronage. Such ties were accompanied by emotional ideologies stressing fidelity and love toward those of a higher station and mercy and indulgence toward those of a lower station. One of the major characteristics of early modern European social structures, especially in Italy, was the existence and continued role of the nobility. Nobles organized much economic production and were the major consumers of luxury goods. They also believed themselves to be endowed with different abilities and skills due to their virtuous blood. This could be instantiated through self-conscious refinement or a proclivity to martial ferocity. Nobles engaged in a range of emotional confrontations through which status was disputed, such as the duel, verbal insults, and civil litigation.

Alongside the high nobility, this project also addresses the emotions of the urban poor. The growing masses of the poor in early modern Europe were increasingly characterized as "plebeian," an undifferentiated mass with animalistic passions that often led them to violence and cruelties. This project explores how such prejudicial attitudes were foundational for thought regarding the emotions. It also examines how plebeian displays of emotion can be read without such polemic baggage, seeing them instead as demands for justice or changes in economic policy, especially taxation.

The Neapolitan revolution of 1647–1648 was especially significant in this respect. Sparked by increased taxes on foodstuffs, the revolt was led by the plebeian "masses" in its early days. Analysis reveals the rebellion as a site of emotional and physical interaction. It highlights how emotions about social orders and material relations were realized in urban space, which led to renegotiations of hierarchies, such as the ransacking of government offices or the improvised crowd justice meted out to hated aristocrats and tax collectors.

This project has a twofold purpose: First, it demonstrates that hierarchy was deeply involved in the formation of early modern concepts of emotions. Second, it shows how social formations, such as nobility, subjecthood, and lordship, were structured through emotional as well as material and symbolic means.

Researcher

Alexandra Oberländer

"Work as Prime Necessity"?
An Emotional and Cultural History of Work in the Late Soviet Union (1960–1980)

One of the most defining but overlooked aspects of nostalgia about the Soviet Union is nostalgia for the workplace. Former Soviet citizens fondly remember the camaraderie in the workshop, the regular gatherings for celebrations in the office, or the general sense of belonging provided by the Soviet workplace. They claim to have found a purpose in their work that disappeared with the end of the Soviet Union. This emotional bond felt toward one's workplace and colleagues, its preconditions, and its manifestations are at the core of this project. How Soviet citizens experienced their work and what they considered work to both be and mean are its leading questions. This project aims to rethink the history of the Soviet Union between 1960 and 1980 through the lens of work. Soviet policies sought to transform work into the "prime necessity" of wo/men. The focus on labor as a transformative force for the new Soviet wo/man was revived under Khrushchev, who imagined communism as something that would begin within the next generation. Usually, the narrative of Soviet history is told as a story of utter failure. The allegedly nonexistent Soviet work ethic is a constitutive element in this narrative, succinctly summarized in the joke: "They pretend to pay us and we pretend to work." But in terms of implementing work as a prime necessity, the Soviet Union succeeded, even if not necessarily as Soviet ideology had imagined.

This project will analyze notions of work in the late Soviet Union by asking what was considered as work in the first place. Which activities were perceived as work and which as leisure activities? How did emotions shape and constitute the boundaries between work and leisure? Since monetary wages were just one means for survival and many necessary services, such as housing, healthcare, and childcare, could not be bought for money but were provided by one's employer, the workplace became the linchpin for the organization of everyday life in the Soviet Union. This created a genuine emotional attachment of working people to their workplaces, who often described their factories, enterprises, or offices as *"rodnoi"* (native/homelike/domestic). The Soviet workplace was conceived of as an extended version of home and a miniature version of the Soviet Union, a notion often framed as "patriotism" toward the factory or institution.

The project draws on a wide array of archival material, newspapers, Soviet popular culture, films, diaries, memoirs, letters, and interviews to assess the emotional and cultural history of work in the late Soviet Union.

Figure 7. Khoziaiki stroiki (The mistress of the construction site).

© A. Galagoza, Sovetskoe foto 7 (1970), p. 27

Researcher

Esra Sarıoğlu

The New Woman and Moral Politics: A Herstory of Women's Feelings and Agency in Turkey

How do capitalism, emotions, and gender interact? The project aims to answer this question by tracing the historical trajectory of feminine modesty in Turkey through the lens of emotions, including shame, embarrassment, and shyness. By recasting feminine modesty as a set of emotional and embodied obligations that women have shouldered in Turkish society, the project examines how the dynamics of capitalism and emotions throughout the 20th century shaped working-class women's changing experiences on the

labor market and at the workplace. The project brings fresh perspectives from feminist phenomenology, symbolic interactionism, and Bourdieuian sociology to emotions and embodiment and contributes to discussions on the constitution of emotions and their relation to the historical structures of the capitalist labor market and gender.

The project studies the history of Muslim women in Anatolia who did not work outside the home until the First World War, although non-Muslim women in the Ottoman Empire had been working in factories since the late 19th century. Muslim women's eligibility to work depended on their so-called moral status. Sometimes, they were asked by employers to provide a certificate of chastity. In the first decade of the 21st century, however, women's value in the labor market seems to be no longer determined by their chastity. Women workers employed at hotels, restaurants, shopping malls, movie theaters, fast-food chains, cosmetic stores, and supermarkets are now hired on the basis of their sociability and extraversion.

Expanded employment opportunities, which are also reflected in women's feelings and embodied modes of being, are closely connected with the dynamics of capitalist globalization. The restructuring of the global economy has ushered in a significant shift in employment opportunities away from manufacturing and toward services, away from muscle power and toward cultural capital, away from the male and toward the female, radically altering the skills required of women workers. Gender reforms in the early 2000s improving gender equality in Turkey also allowed women to cultivate new embodied and emotional capacities.

The fieldwork consists of the researcher's own participant observation as well as of interviews with saleswomen in Istanbul. While the interviews provide information on the emotional and embodied skills saleswomen are expected to have, the participant observation stage—a stint of cashier work at a large supermarket in Istanbul—offers insights into the cultural politics of emotions on the sales floor in Turkey during the era of globalization.

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The End of Solidarity? Deindustrialization in Germany and France (1960–2000)

Deindustrialization in the Global North since the 1960s and 1970s has usually been perceived as a period in which the loss of factory jobs caused solidarity among the working classes to slowly erode. Recent studies stress the atomization of the working class and the repercussions that the loss of work has had for industrial cities and regions, which has put the social cohesion of emotional communities constructed around work at risk.

While these studies focus on the downfall of these regions, this research project explores how politicians, employers, and workers alike searched for new solidarities and ties that could bind the people of the deindustrialized regions together after the infrastructure built around communal work in the coal mines and steel plants began to vanish. This is all the more important because manufacturing regions have been destinations of immigration since the industrialization of the 19th century, and conflicts around national belonging have shaped the process of deindustrialization. However, rather than describing the nostalgia

for the past and the mourning of what was lost, the current project shines a light on the emotions that replaced solidarity and the ways in which it continued to exist.

Lens in the coal basin of northern France and Gelsenkirchen in the German Ruhr Valley are both emblematic of the decline of heavy industry and have been forced to grapple with high unemployment and poverty. Using sources from municipal administrations, NGOs, and companies, this project relies on oral history interviews with former coal and steel workers and their families, local mayors, politicians, and social workers in the two cities.

Solidarity during times of deindustrialization did not simply disappear. Rather, its locus shifted. One key example from the case studies Gelsenkirchen and Lens is the omnipresence of the cities' soccer clubs, Schalke 04 and Racing Club de Lens. The teams have taken over the workplace's emotions of belonging and translated the practices of solidarity learned in the industrial sector into the realm of leisure. Players on the pitch have

Researcher

Julia Wambach

come to represent the coal miners' hard work, and the clubs' success in times when deindustrialization hit hard has helped to recreate an emotional community when traditional modes of solidarity at the workplace seemed to have failed.
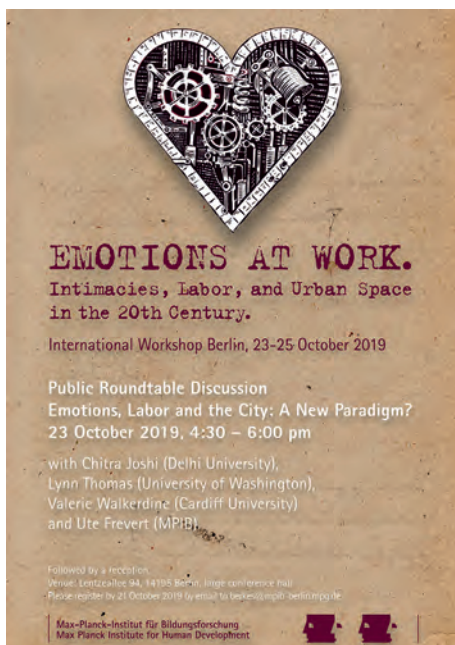
Emotions at Work: Intimacies, Labor, and Urban Space in the 20th Century (Conference, 23–25 October 2019)

The conference took its bearings from Georg Simmel's claim that there is a mental state specific to modern urban life. However, it went beyond Simmel's concentration on the 19th century by foregrounding the emotional experiences of working classes and the everyday life of city sojourners during the 20th century. Through the exploration of emotional practices, embodiment, and discursive representations of feelings, it offered new perspectives on changing labor practices and politics, processes of migration, the transformation of urban life, shifts in gender dynamics, and the city as a site of the production and circulation of emotions.

Conceptualized as a dialogue between the history of emotions, urban history, and labor history, the workshop brought together researchers working on cities in Africa, Europe, Turkey, and South Asia. The first panel explored how intimate encounters in the urban landscape generate new possibilities and perils and how urban institutions regulate the ways intimacy can be expressed. The second panel uncovered a rich array of emotions produced and managed at industrial workplaces. By zooming in on the workspace as a formative place for emotional communities, a place of community building, inclusion, and exclusion, the panel examined emotion-specific dynamics of capitalist industrialization and labor forces. The panel also addressed the repercussions of the loss of work on workers' identities and selves. The third and final panel explored the affective implications of urban hierarchies on working classes. Focusing on upward and downward mobility and the ongoing influences of more conventional forms of power on the structures of capitalism, this panel discussed the ways in which working classes emotionally navigated these complex structures of social mobility generated by the market, the education system, and legal institutions.

The workshop also featured an innovative format to advance academic discourse. Panelists for the roundtable discussion entitled "Emotions, Labor, and the City: A New Paradigm?" were asked to submit a short paper based on questions prepared by the workshop organizers. Response papers were then precirculated among roundtable panelists to facilitate discussion. Based on these and other papers, the organizers—Rukmini Barua, Stephanie Lämmert, Esra Sarıoğlu, and Julia Wambach—intend to publish a special journal issue.

EMOTIONS AT WORK.
Intimacies, Labor, and Urban Space in the 20th Century.
International Workshop Berlin, 23–25 October 2019

Public Roundtable Discussion
Emotions, Labor and the City: A New Paradigm?
23 October 2019, 4:30 – 6:00 pm

with Chitra Joshi (Delhi University),
Lynn Thomas (University of Washington),
Valerie Walkerdine (Cardiff University)
and Ute Frevert (MPIB).

Followed by a reception.
Venue: Lentzeallee 94, 14195 Berlin, large conference hall
Please register by 21 October 2019 by email to bedere@mpib-berlin.mpg.de

Max-Planck-Institut für Bildungsforschung
Max Planck Institute for Human Development

Research Area 4: Religion and Spirituality

Religion reveals much about the historical contours of emotions. Humans have often felt profoundly about the collective effervescence of worship, the personal rigors of belief, and the contested stakes of community belonging. Emotions in religion present a potent example of the challenges of the individual/social divide because religious life is a site both of shared feeling as well as the exemplary subjective feelings of personal religious experience. On the other hand, emotional cultures cannot be understood without extensive accounting for the place and practice of religion and spirituality. The emotions attributed to gods and other supernatural figures as well as ideas about the ways in which these same figures act through and upon human emotions play vital roles in human action and understanding.

The projects gathered under this theme interrogate the connection between zealotry and religious belief, engaging critically with the assumption that intense emotions are inherent to religiosity. A comparative investigation of historical debates over the relative merits of passion and moderation in religious practice in Christianity, Judaism, and Islam reveals important evidence about how emotions have changed in history.

A focus on the history of what "religious feelings" have meant necessitates two principal approaches. First is the consideration of "religious feelings" as a description of emotions that historical actors believed to be special to religion in a certain way, either uniquely religious in quality or given special valence or intensity by religion. The second, related approach addresses how "religious feelings" have been used as a scholarly concept together with its limitations and potentials, especially concerning its connection to Western understandings of the religious. The group has found that it is important to engage dialectically with both the plainer "emotions in religion" and the special claims of a "religious feelings" approach.

Islamic Sermons and Public Piety in Bangladesh

Since the 19th century, sermon gatherings have been at the center of public piety and public expression in Bangladesh. The project followed this significant practice up to the present. Sermon gatherings *(waz mahfils)* are increasingly popular and mostly attended by the laboring classes. These important public events have often been overlooked by researchers due to the perception that they are nothing more than Islamist propaganda. However, they have a significant role in public life and are an important genre for affective communication, which, in turn, makes them important for the study of emotions.

A corpus of dozens of sermons was constructed through extensive fieldwork and interviews. The analysis reveals how popular sermonizing shapes what can be said, imagined, and felt in different fields of social life—the religious, political, and poetic. The gatherings are driven by participatory practices that involve dramatic techniques of narration, vocal craft, and emotional communication styles, ranging from laughter evoked by political satire to emotional immersion and upheaval.

The project urges scholars to pay attention to Islamic speech's musical and performative poetics and to expand their notions of civic participation and public discourse. This will allow a reconsideration of the place of religious aesthetics, emotions, and the senses in Islam.

For his work, Max Stille was awarded the Walter-Witzenmann-Prize by the Heidelberg Academy of Sciences and Humanities in May 2020.

Figure 8. Preacher and audience create joint emotional response.

© Max Stille

Researcher

Max Stille

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Researchers

Şeyma Afacan
Yaara Benger Alaluf
Stephen Cummins
Margrit Pernau
Max Stille
Makoto Harris Takao
Carlos Zúñiga Nieto

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Religious Feelings and "Preaching Passions"

The focus group *Religious Feeling—Feeling Religious,* established in 2016, built on its initial phase to pursue individual projects, regular meetings, and collaborative work. The group explored a broad range of times and spaces, taking many perspectives on the nexus between religiosity and emotion. The group's spanning of centuries, countries, and religious traditions presented its most fruitful intellectual challenges and opportunities, demanding rigorous consideration of issues of comparison and interchange between normally distinct historiographies.

This collection of projects included Şeyma Afacan's exploration of the role of religious feeling in the late Ottoman Empire. Also in the Islamic world, Max Stille explored emotional transitions in North India from 1840 to 1920. Christianity in different times and places was surveyed through several projects. Stephen Cummins' investigation of penitential practices in early modern Italy dealt with reconciliation and contrition. Makoto Harris Takao's project on religious weeping as an emotional practice in Japanese Christianity (1540–1640), with special reference to Japanese masculinity, took another angle on early modernity. The Pacific and Caribbean worlds were studied by Carlos Zúñiga Nieto, who focused on emotional bonds in the lives of Catholic missionary nuns in the 19th century. For Judaism, Yaara Benger examined the uses and significances of joy in the Hasidic branch of Breslov and its meaning for devotional practice.

Together, the group found that treating the practice of preaching and sermons as sources could be one meeting point between these varied independent projects and provide an important focus for comparison. Preaching and sermons were a relatively "cross-cultural" category, in which similar (or revealingly diverse) forms of instructive religious speech can be seen in different times and spaces, often with a marked attention toward emotion. This stands counter to contemporary perpetuations of the idea that sermons are either unemotional or intensely—even dangerously—emotionally stimulating or manipulative. The stereotypical contrast between the "hate preacher" and the dull sermonizer indicates

the complex and instructive history of emotions in preaching.

The group undertook a collaborative project on sermons and the history of emotions. Some of the output of this collaboration will be featured in a forthcoming special issue of the *Journal of Religious History.* The projects took a reception-oriented approach to highlight how people have employed sermons to manage their emotions. This was a conscious effort to move away from an unsatisfactory didactic model that holds that preachers simply control their audiences.

The volume opens with a methodological and theoretical exploration of the issues of preaching and religious feelings. This article by Stephen Cummins and Max Stille confronted the tensions between the "religious feelings" approach, which ascribes a separate status to a range of specially religious emotions, and an "emotions in religion" approach that claims that emotions in the religious field do not represent their own subtype. It also modeled a reception history approach to the history of emotions, demonstrating the particular ways in which this could be theorized through analyzing communication processes. A further set of empirical articles explored the themes of the methodological piece in depth. Margrit Pernau and Max Stille chose the example of Ashraf Ali Thanawi's prolific sermonizing in 19th-century India, centering on his sermons about the love of the Prophet Muhammed. Their exploration concluded that dutiful obedience and passionate intensity were not contradictory in 19th-century Sufism. Makoto Harris Takao studied neo-Confucian sermons in 18th-century Japan. With a focus on the popular instructor Hosoi Heish¯u, Takao reconstructed the emotional expectations of audiences and argued that a Eurocentric history of emotions has numerous inadequacies. Stephen Cummins investigated the "internal" missions of the Jesuit order in early modern Italy, which preached peace and orchestrated moments of dramatic reconciliation as part of their sermonizing. These highly emotional events featured hatred turned to love, with grieving people embracing the murderers of their kin.

Religion as Emotion Knowledge: Religious Knowledge Systems and Emotions from the 18th to the 21st Century (Conference, 20–21 June 2019)

Building on the vast range of work on religions and emotions in recent years (both on their interrelation and in isolation from one another), the conference experimented with the concept of *religion as emotion knowledge.* It set out to explore how religion as a body of knowledge shapes emotions not just within religion itself, but also in other knowledge systems in modern societies.

A common thread in many papers was the view that religious emotion knowledges are materialized in the body. Contributors highlighted various mechanisms in the transmission of emotion knowledge and carefully reconstructed their social contexts. The conference cultivated dialogue on the historical mutability of religions and emotions and their relation to one another.

Contributions to the conference sought to complicate binaries inherited from the Western Enlightenment, such as religious/secular, emotion/reason, and irrationality/rationality. Tracing emotions both inside and outside of the religious generated a nuanced picture of their presence and form since the Enlightenment. The conference underlined the fluidity, plurality, and historicity of knowledge, in terms of both its content and what counted as knowledge. The interrogation enabled attendees to ask broader theoretical questions about modernity, such as what the concept of *religion as emotion knowledge* adds to the decolonization of religion and how it challenges the idea of linear progress.
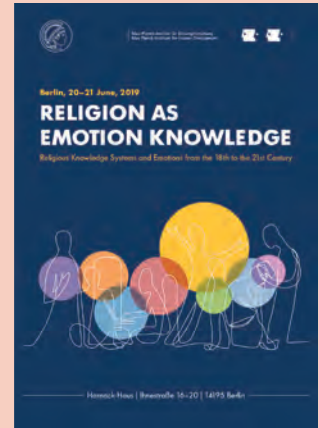
Within the Pale of Pleasure: Polish Jews and the Pursuit of Happiness (1918–1939)

Researcher

Emma Zohar

Many Polish Jews described their life in interwar Poland as happy and content. Others described the desire to achieve a good or meaningful life in both spiritual and secular terms. However, since its early days, the image of Polish Jewry has zoomed in on poverty, suffering, and sorrow, as many Polish Jews suffered anti-Semitic attacks, distress, and even hunger. Three central forces have shaped the image of Polish Jewry: emigration, Zionism, and the Holocaust. This project focuses on the "practices of pleasure" in the everyday and spiritual life of Jews in interwar Poland.

The first part examines leisure culture in the commercialized age, which gradually gained greater presence in the Polish public sphere. Theatres, cinemas, and libraries were established in many cities and became affordable, while cafes and restaurants grew in accessibility and popularity as did tourism and traveling. These processes integrated not only the wealthy, but also working-class people, citizens of rural areas, youngsters, and women. Even ultra-Orthodox Jews started to adopt some modern habits and the Agudat-Israel central committee had to deal with the ultra-Orthodox women's growing interest in fashion and personal care. This section on commercialized pleasure analyzes how Jewish individuals spent their free time, to what extent their ethnic and religious identities influenced the way they chose to spend their time, and the ways in which leisure activities confronted them with spiritual dilemmas.

The second part explores intimate pleasure and new perspectives on love and relationships in the diverse Jewish community. As part of the decreasing power of religion and the secularization process that began among the Jewish population in Poland toward the end of the 19th century, marriage lost its role as the pinnacle of Jewish traditional life. The borders between boys and girls opened at school as well as in the secular youth movements, sex was more openly discussed, and intimate relationships between the sexes were common even before marriage. Love, an emotion that was loaded with religious meaning, came to be associated with sexual satisfaction, passion, and even hedonism. The project aims to disclose whether there were specific features that defined how Jews in Poland formed their romantic—and even sexual—relationships under the auspices of religious meaning.

Research Area 5: Science, Medicine and Therapeutic Cultures

Research in this area focuses on science, medicine, and therapeutic cultures in a global perspective, looking at Europe, the USA, and North Africa from the 19th century to the present. Together, the projects investigate the role these disciplinary fields have played for the understanding of emotions in modern society. Institutionalized sciences like physiology, psychology, and medicine, as well as less/noninstitutionalized therapeutic cultures like Islamic rituals and self-help groups have, over history, sought to define what human emotions are and how they differ from affect, how they function, and how they should be dealt with. They have defined which emotions are pathological or detrimental to the body and which facilitate the well-being and happiness of the individual and society alike.

At the same time, emotions have found their way into scientific and science-related practices as objects of psychological and other therapeutic techniques. They have also functioned as means of treatment used by physicians or healers to cure sickness or to enhance sick people's quality of life and ability to cope. Thus, they have been seen as important motivators of behavioral change and as fundamental for drawing the line between the morally good and bad, the normal and the pathological.

Science, medicine, and therapeutic cultures have thus produced emotion knowledge that more generally influences or prestructures cultures of emotion in multiple areas and social institutions. Such knowledge concerns emotion norms and moral assessments as well as specific ways of dealing with and expressing emotions.

Researcher

Anja Laukötter

The Classroom As a Laboratory of Global Modernity, 1850–1980

This newly starting project studies the development of the classroom from the second half of the 19th century up through the latter half of the 20th century. While the focus lies on West and East Germany, this entangled history also engages with events in Scandinavia, France, Great Britain, and the United States. Moreover, the project connects these "Western models" with a case study on a former German colony, Tanzania. The analysis' diverse geographic scope aims to link global and local perspectives and spaces. It draws on approaches from the history of emotions, social history, cultural history, history of the everyday, media history, history of the body, and the history of science.

A variety of case studies support the argument that the classroom was a laboratory of modernity where ideas about a globalized world found concrete expression. In this laboratory, children became pupils and parents aimed to become child-rearing experts. It was an interactive space where experiments were carried out on the relations between children, their parents, and teachers. Advice manuals, pedagogical and psychological literature, and other media helped them behave properly and manage their emotions. Moreover, the project elucidates how the classroom, its transforming spatial layout, and various media structured the content and methods of learning and teaching and how they shaped student's bodies. It explains how the measurement of educational accomplishments often reproduced assumptions about class and origin. Thus, the classroom as a space of experience and future expectations were closely intertwined. The project also details how scientific research—from psychology to the empirical study of human development—contributed to a "scientificization of the schoolyard" by quantifying the body, mind, and emotions in concepts like intelligence, talent, performance, and, later on, emotional intelligence and emotional competence. In turn, these forms of conceptualization were hypostasized into life goals in themselves—a shift that can still be felt today. They have even been defined as a "site of war" (Didier Eribon). Despite all attempts to define how the classroom should look once and for all, it has always been characterized by a degree of uncertainty, which makes it not only a specific social and epistemic space, but, perhaps most significantly, an emotional space.

Internal Expertise: Investigating Emotions, Insanity, and Political Crime in the Modern Court in Europe in the 19th and 20th Century

This project built on insights from the former Research Area *Law and Emotions,* which examined both the way that emotions are addressed by legal codes as well as the emotional practices of various protagonists in the courtroom. It sought to understand how emotions interact with systems of knowledge and social practices in the scientific-legal setting and to explore how scholars might better grasp historical emotional epistemologies. The presentation of evidence in the court of law often appeals to our notion that "the facts speak for themselves." But when trying to discern a criminal motive, they hardly ever do. While the court of law has consulted expertise beyond juridical purview since the medieval period, many medical examiners of the modern era turned from the corpse to the criminal, not only investigating the cause of death, but the cause of the deed. Practitioners of the 19th-century human sciences introduced new techniques for investigating criminal motives, and the modern courtroom became a site of increasingly vociferous debates about the drives, intentions, and feelings of the defendant. As a result, the fate of defendants was often determined by the emotional facts medicalized by expert witnesses.

Some of the cases in which criminal intent became most scrutinized and publicized—often leading to changes to the penal code—were political crimes, and specifically the assassination of government officials or regicide. The emotions animating political crime, however, were discussed differently than those behind domestic or civil cases and increasingly became evidence for criminal insanity.

Researcher

Daphne Rozenblatt

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Feeling the Way Through With Sound: Social Warmth, Critical Feeling, and Affective Trance in North African Popular Islamic Rituals

Drawing from nearly 3 years of cumulative ethnographic fieldwork in North Africa from the Mediterranean to the Sahara Desert, the research project is the first to thoroughly document the history, musical repertoire, and current practice of Algerian *dīwān,* a nocturnal trance ritual of the Bilaliyya Sufi Order. Situated primarily within the disciplines of psychological anthropology and music studies, this project investigates the fundamental role of feeling in North African Sufi and popular Islamic rituals, particularly as they pertain to states of "consciousness," social and transpersonal pain and suffering, and memory. "Feeling," in this cultural context, enfolds what we parse out in English as "affects," "emotions," "sensoria," and "atmosphere." In these ritual worlds, feeling functions systematically as an entire orientation to and organization of the world. Because the way things feel is what makes any given moment intelligible, feeling ways of knowing and acquiring knowledge—sensibility and "sense ability"—are therefore meticulously cultivated and prioritized. For example, in *dīwān,* cultivation of feeling begins with the collective affective laboring of ritual atmosphere *(ḥāl)* in order to precipitate various categories of trance. Because the majority of this "warming" is done through musical labor, the project pays particular attention to the functions of music in ritual as the primary setter-in-motion of this vibrant, vibrating atmosphere of "social warmth." With *dīwān* music cultivating this critical warmth, adepts suffering from mental-emotional pain are ignited into varying states of trance which are locally ordered through taxonomies of feeling intensities: that is, ordered by their *affective* qualities. Rather than "altered *states* of consciousness"—an idea that typically implies something of "the mind" in Western philosophic traditions—here, trance is an affective-bodily *process* that fluctuates, sometimes over hours. As the music precipitates and intensifies bodily sensoria and emotions, adepts then feel their pain *through* the sound and *with* the sound, physically *moving* and thus fully engaging with and inhabiting their suffering. By detailing the dynamics of these phenomena, this research underscores that approaches to suffering and how one is meant to relate to it are culturally variable and intimately linked to notions of what constitutes the "self" and the "mind."

Researcher

Tamara Turner

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Hitzer, B. (2020a). *Krebs fühlen: Eine Emotionsgeschichte des 20. Jahrhunderts.* Klett-Cotta.

Minerva Research Focus
Emotions and Illness: Histories of an Intricate Relation

The Minerva research focus *Emotions and Illness: Histories of an Intricate Relation* started in 2014 by focusing on a specific illness with particular relevance to the 20th-century history of emotions: cancer. It studied the extent to which the confrontation with cancer actually shaped emotional practices like fear, hope, and disgust, and attitudes toward a person's own body, psyche, human existence, suffering, and death.

While a number of articles in renowned journals such as *Osiris* were published during the run of the project, the sum of the results were presented in Bettina Hitzer's habilitation, which was submitted to the Freie Universität Berlin in 2017. An abridged and revised German edition was published in January 2020; an English edition is in preparation. In March 2020, *Krebs fühlen* was awarded the Leipzig Book Fair Prize for Best Nonfiction Book.

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Key Reference

Geisthövel, A., & **Hitzer, B.** (Eds.). (2019a). *Auf der Suche nach einer anderen Medizin: Psychosomatik im 20. Jahrhundert.* Suhrkamp.

Starting in 2017, a second project within the Minerva Research Focus investigated the history of psychosomatic medicine in the 20th century. The ideas of psychosomatic medicine have become widely disseminated and accepted, gaining prominence at a time when catchphrases like "emotional intelligence" and "emotional competence" show that even the popular neurosciences are beginning to question the old dualism of mind and emotion.

Even though psychosomatic medicine struck a powerful chord in the 20th century and has developed a wealth of diagnostic and therapeutic methods practiced in a multitude of clinics and specialized hospital departments, a comprehensive history of the field remained to be written. In 2019, *Auf der Suche nach einer anderen Medizin* became the first publication to delimit the history of this very heterogeneous discipline in 20th-century Germany, its attempts to escape medicine's weighty political baggage, and its responses to social upheavals.

Composed of 33 texts by historians of medicine and science, the book offers a broad, yet nuanced survey of the diversity of psychosomatics. Its format is neither an edited volume nor a compendium-style reference work. Instead, editors Bettina Hitzer and Alexa Geisthövel (Charité Universitätsmedizin Berlin) carefully designed it as a collaborative

monograph organized chronologically with introductory articles on each period. Combining diachronic and synchronic perspectives, the texts illuminate important pioneers and protagonists, diagnostic and therapeutic methods, and paradigmatic illnesses, portraying psychosomatics as a form of medicine that saw itself as the more humane alternative to modern high-tech—and therefore supposedly soulless—medicine. In addition to the editors' work, the coherence of the volume was reinforced in an author's workshop held at the Institute in 2017.

The book was published in the prestigious series *suhrkamp taschenbuch wissenschaft (stw),* which for nearly 50 years has been printing both classic theoretical texts and innovative intellectual interventions from a broad range of academic fields.

The research on these two projects led to new questions of particular social relevance, which opened up further historical perspectives on the Minerva Research Focus's topic.

These include, firstly, the question of whether and how historians should work with or criticize models of the body developed in the life sciences, and especially epigenetics. While history examines change and questions how experiences and memories influence contemporary societies, epigenetics researches how environmental influences are reflected in gene functions. To explore the opportunities

and challenges brought about by epigenetics, the conference *Epigenetics: Innovations of Memory,* organized in collaboration with Dagmar Ellerbrock (TU Dresden), was held from 13–15 June 2018 at the Institute.

Experts from different disciplines engaged in dialogue about the questions:

(1) whether, and if so, which, epigenetic terms and concepts are compatible for historical research,

(2) what kind of interdisciplinary cooperation might result from this,

(3) if and how this might influence and change the relationship between life sciences and cultural studies, in particular by broadening the scope of historical research through models borrowed from the life sciences.

The keynotes were held by Jay M. Winter (Yale University) and Dorothee Wierling (Forschungsstelle für Zeitgeschichte, Hamburg). Among the speakers were human geneticist Bernhard Horsthemke (Universitätsklinikum Essen), historian of science and biologist Ute Deichmann (Ben-Gurion University of the Negev), sociologist Maurizio Meloni (Deakin University, Melbourne), psychologist Vanessa Lux (Ruhr Universität Bochum), and Ohad Parnes from the MPI for the History of Science.

Another line of inquiry arose while researching the question of how therapeutic practices and "objects" influenced the emotional experience of having cancer. This inspired a collaborative undertaking with Anne Schmidt (MPI for Human Development) and a number of German and Dutch colleagues, most notably historian of technology Martina Heßler (Technische Universität Darmstadt). A common workshop in 2018 aimed to hash out various interdisciplinary approaches to conceptualizing the *Multifaceted Relationship between Fear and Technology.*

Fear can be a reaction to the proliferation and effects of certain technologies. But feelings of fear can also be inextricably bound up with the use of technology and can even be desired and sought out. These facts raise a number of questions that have until now received little attention: What role does knowledge about fear, its physiology, and its functioning play in the development of certain technologies? How does marketing research evaluate and measure the need for fear and the fear of fear? What role does the exchange of knowledge between various industries and fields of research play, and what effects do these exchanges have? How do marketing and the media use and produce fear when trying to pave the way for the implementation of certain forms of technology? Does the fear of technology adhere to a similar logic in the fields of commercial production, private consumption, and politics, or does it take on different patterns in different fields?

The workshop addressed such questions from historical, philosophical, sociological, and anthropological perspectives, thus contributing to our understanding of a little researched, complex relation. Some of the workshop papers were published in a special issue.

To wrap up the Minerva Research Focus, the conference *Feeling DIS/EASE: New Perspectives on Modern History* was held at the Institute in January 2020. This conference was not so much meant to take stock of what has been achieved, but to discuss how historiography on the relation between emotions, illness, and health could be opened up to different topics and techniques. To this end, 27 historians from the United States, Canada, France, Denmark, the United Kingdom, Finland, Switzerland, and Germany (including the keynote speaker Joanna Bourke, Birkbeck College London) were invited to reflect on new paths toward expanding the methodological approaches scholars might take when studying *Feeling DIS/EASE.* Spanning the history of the senses, material history, spatial history, the study of human–machine interactions, narrative theory, and security and prevention studies, the conference presented a broad range of ideas about what constitutes the modern history of emotions. The papers and discussions showed how much the history of emotions can benefit from a stronger integration of these other methodological and theoretical approaches.

A publication of the conference papers in collaboration with Rob Boddice (University of Tampere/McGill University) is planned and negotiations with major publishing houses are currently underway.
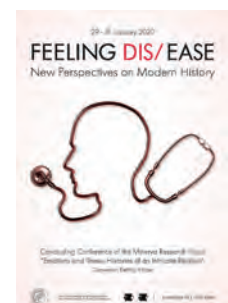
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International Workshop at the Max Planck Institute for Human Development
10–12 October 2018

Key Reference

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FEELING DIS/EASE
New Perspectives on Modern History

Concluded Research Areas—Concluded Projects (Selection)

Researchers

Juliane Brauer
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The first decade of the Center was defined by a generation of researchers and their long-term projects. Originally divided into three research areas *(Education and Cultivation of Emotions, Emotions and the Body, Emotions and Power),* the Center was expanded in 2014 with a focus group on *Law and Emotions.* We boast a considerable number of concluded studies in the form of submitted and published habilitation and doctoral dissertations, monographs, coauthored and edited volumes, and a vast array of articles in peer-reviewed journals.

The research area **Education and Cultivation of Emotions** was extremely productive and gave birth to some remarkable monographs.

Future as Program: Youth, Music, and the Cultivation of Feelings in a Divided Germany

Key Reference

Brauer, J. (in press-c). *Zeitgefühle: Wie die DDR ihre Zukunft besang. Eine Emotionsgeschichte.* transcript.

During the first two postwar decades, hundreds of songs were composed in East Germany that thematized future dreams, hopes, and desires about the new socialist state. More than simply expressing new emotions and styles of thinking, the singing of these songs trained, habituated, and actualized these new feelings and ideas. Analyzing how and why which songs were sung when and where reveals how collective singing was used as a strategy to cultivate specific emotions. The book works at the intersection of the history of emotions, historical future studies, and historical anthropology in order to probe how emotional practices in the GDR aimed to communicate and negotiate emotions of time. Emotions of time—a concept developed in the book—serve as a heuristic to define how the GDR was a particularly radical modern-time regime. The book thus makes an original contribution to the history of modern, 20th-century Germany. In doing so, it writes a history of how the East German state sought to implement a vision of the future and of dissent against this hegemonic vision.

Juliane Brauer's habilitation process at the Technische Universität Dresden started in January 2018 and was successfully concluded in 2019. The book will be published in October 2020 with financial support from the Federal Foundation for the Study of Communist Dictatorship in East Germany.

Feeling Differently: Homosexuality and Emotional Life Between Rural and Urban Settings in West Germany (1960–1990)

Key Reference

Gammerl, B. (in press). *anders fühlen: Homosexualitäten und Gefühlsleben zwischen Stadt und Land in der Bundesrepublik (1960-1990).* Hanser.

Logo of the project "anders fühlen"— "feeling differently."

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How did the transition from criminalization to emancipation to normalization shape the emotional styles of gays and lesbians? The study argues that the common narrative of a shift from shame to pride fails to do justice to the complexity of this history. This analysis of oral history interviews, as well as gay and lesbian publications, shows that courage and self-confidence developed alongside timidity and fears of failing, thus offering fresh perspectives on liberalization through the history of emotions.


In June 2018, Benno Gammerl successfully defended his habilitation manuscript at the Freie Universität Berlin. A monograph based on this manuscript will be published in 2021.

Key Reference

Jensen, U. (2019b). *Wie die Couch nach Kalkutta kam: Eine Globalgeschichte der frühen Psychoanalyse.* Suhrkamp.

Uffa Jensen, today professor at the Technische Universität Berlin, published his habilitation in 2019. The book discusses the significance of emotions in psychoanalytic practice, detailing the crucial role emotions played in the transmission of psychoanalytic knowledge around the world. Reviewers in leading German newspapers praised it as a "magnificent" book that combines "narrative talent and a strong sense for intellectual surprises."

Emotions and Knowledge in Health Education Films and the Shaping of the Modern Subject in the 20th Century

Anja Laukötter was awarded the 2019 Otto Hintze Prize for Young Researchers by the Michael and Claudia Borgolte Foundation for her habilitation, which was submitted to the Humboldt Universität zu Berlin in 2018. The jury selected the work because of its exemplary rigor, methodological nuance, and astounding findings in a complex field fraught with snares. Beside several other findings, they particularly praised how the book demonstrated that the 20th century witnessed the "development from a knowledge society to an emotions society." Since the First World War, filmmakers had been trying to mobilize audiences' knowledge and emotions to compel them to change their behaviors, and their strategies underwent a marked shift in the 1950s. By the end of the 1980s, scientifically founded information in educational films tapered off, making way for communication that fused knowledge with emotions. The analysis of a large corpus of health education films (from East and West Germany, the United States, and France) revealed that, while the early 1990s still assumed that society was founded in knowledge, the move toward a society based on emotions had gained footing. Filmmakers were no longer interested in transmitting knowledge about how diseases spread and ran their course. Rather, they came to grasp the right emotions and emotional management as the most important aspects of self-conduct and the realization of the (sexual) self.
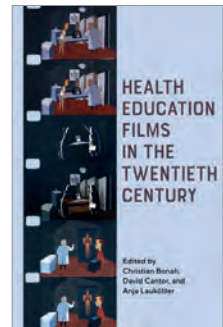
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Bonah, C., Cantor, D., & **Laukötter, A.** (Eds.). (2018). *Health education films in the twentieth century.* University of Rochester Press.

Laukötter, A. (in press-a). *Körperpolitik im Kino des 20. Jahrhunderts: Eine Emotionsgeschichte.* Wallstein.

In addition to publications collaboratively composed by the focus group on **Law and Emotions**, it also gave rise to individual monographs like Laura Kounine's *Imagining the Witch: Emotions, Gender, and Selfhood in Early Modern Germany,* which was published by OUP in 2018.

Feeling the Law? Debates on Rechtsgefühl and the Relation Between Emotion and Judgment in German Jurisprudence, 1870–1933

Are judges permitted to consult their emotions when judging? Is it even possible to make a purely logical judgment devoid of all emotion? How did jurists perceive the role of emotions in their work, and how were they expected to manage their emotions? Sandra Schnädelbach's dissertation, supervised by Ute Frevert, explored the heated controversies on the feeling for justice, or *Rechtsgefühl,* in German society. Schnädelbach argued that the "right" use of emotions was central to juristic thought and practice around 1900 and that the concept of the *Rechtsgefühl* served to legitimize the status of the jurist, the judge, and the law itself. New sciences like experimental psychology, new media, new ideas about gender, and new forms of social polarization all influenced discussions about jurists' feelings and impacted jurisprudential praxis itself. In a period when the bourgeois elite and the institutions of law and justice were in crisis, the concept of the feeling for justice was utilized by divergent political groups. The book traces the shifts in knowledge about emotions, the rules about how to express emotions, and the emotional practices that shaped how judges and jurists in the German Empire and Weimar Republic approached their own feelings.

Defended at the FU Berlin in November 2017, the book was published in spring 2020.

Researcher

Sandra Schnädelbach

Key Reference

Schnädelbach, S. (2020). *Entscheidende Gefühle: Rechtsgefühl und juristische Emotionalität vom Kaiserreich bis in die Weimarer Republik.* Wallstein.

The Center took part in the Max Planck Society research initiative *The Challenges of Migration, Integration and Exclusion* (WiMi), a 3-year multidisciplinary collaboration of six Max Planck Institutes (2017–2020). Two projects highlighted with case studies the emotional dimension of migration and resettlement as well as the impact that emotions of exclusion can have on nation and community-building. A workshop on *Inclusion and Exclusion of Immigrants with Similar Cultural Background* (2017), co-organized with partners from the MPI for Demographic Research, discussed processes of integration in different national contexts.

Researchers

Deepra Dandekar
Soňa Mikulová

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Dandekar, D. (2019b). Zeba Rizvi's memory-emotions of partition: Silence and secularism-pyar. *Contemporary South Asia, 27*(3), 392–406. https://doi.org/10.1080/09584935.2019.1647143

Mikulová, S. (2018). German expellees in West Germany after 1945 and their integration into church communities. In A. Bouju & A. Edel (Eds.), *Similar but different: Inclusion and exclusion of immigrant communities sharing similar cultural backgrounds with their host societies* (pp. 35–40). Max Planck Society for the Advancement of Sciences.

(a) Migration and Emotions: Refugees to India After 1947

This research explored entanglements between the memories and emotions of the India-Pakistan Partition in 1947 through the archived oral narratives of erstwhile refugees. The project analyzed memories of perilous cross-border fleeing and the ensuing difficulties of resettlement and exclusion, which influenced the lives of 10 million displaced persons. It described how these memories were nevertheless recounted by erstwhile refugees with pride, an emotion that highlights the successful rebuilding of their individual and family status after migration. Proudly sharing their stories in the public domain, in turn, made them community leaders. Organized under the WiMi rubric of "representation of exclusion," this research engaged with how memories of exclusion are transformed into emotions that transcend exclusion. Its ultimate aim was to emphasize refugee success and pride in the public history domain.

(b) Integration of German Expellees in Germany after 1945

In the initial postwar years, approximately 12 million ethnic Germans from Central and Eastern Europe arrived in Germany. Although legally equal and part of the same nation, these newcomers were both welcomed with acts of solidarity and compassion and confronted with indifference, contempt, and hostility. Drawing on the WiMi concept of exclusion and the history of emotions, the project explored the emotional dimension of integration, which transcends legal and socio-economic issues. Focusing on Catholic Church communities, the research analyzed emotional expressions and practices that were expected, encouraged, tolerated, or deplored by old and new members alike. The research findings demonstrate how the efforts of some local clergymen and believers obstructed the inclusion of new members by resisting changes to the emotional community that existed before the arrival of expellees.

In March 2019, Deepra Dandekar, Soňa Mikulová, and Sonia Cancian organized a conference on *Representations of Migration and Emotions of Exclusion.* More than 120 applications from across the globe evidenced high interest in exploring the role of emotions within processes of migration and integration. The papers will be published in an edited volume.

Researcher

Sonia Cancian

Key Reference

Cancian, S. (in press-a). Love at the threshold of war and migration: A war orphan's story. In M. J. Borges, S. Cancian, & L. Reeder (Eds.), *Emotional landscapes: Love, gender, and migration.* University of Illinois Press.

Skins of Memory: The War in Italy and Postwar Migration to Canada, 1946–1971

How did war memories influence the migration of Italians after the Second World War? What emotions emerge in the reconstruction of these memories? What are the meanings of these memories for migrants' identity, belonging, and emotional and familial lives over time and space? This project analyzed the emotional memories of war among Italian transnational families in Canada and Italy in order to explore how emotions and memories connected to war violence and loss are linked to people's ability to move several decades after their migration. The comparison of life histories of families in Canada and Italy reveals the role of migration in the preservation of emotions and war memories in two distinct sociopolitical and geographical contexts. Memories are identified through the recounting of personal and family stories, emotions, ideologies, and events in interviews, letters, and diaries. The outcome will include a monograph and two articles.

The Healthy Self As Body Capital: Individuals, Market-Based Societies, Body Politics, and Visual Media in 20th-Century Europe

In autumn 2016, the international research group "The Healthy Self as Body Capital: Individuals, Market-Based Societies, Body Politics and Visual Media in 20th-Century Europe" started its work. The project is funded by the European Research Council (under the European Union's Horizon 2020 research and innovation programme—Advanced Grant agreement no. 694817). The research group is directed by Christian Bonah (University of Strasbourg) and Anja Laukötter and is comprised of senior and junior researchers. The research team is based at the University of Strasbourg and at the MPI for Human Development.

The group's historiographical research, carried out with a cultural-studies bent, focuses on visual media (ranging from documentary and amateur film, television and the internet), the body, and their relation to a variety of health issues. The group seeks to connect this visual history of the body with economic history. We conceive these visual media not merely as a mirror or expression of the things they depict, but as media and art endowed with their own distinct, interactive, performative power. To underline this approach, we have chosen to work with the concept of "body capital." As a form of capital, the body has been treated as a means of production, a source of value to be protected, (emotionally) managed, and harvested, a source of value constantly at risk, and a value that promises future returns. The term body capital stems from the economic concept of capital and its use in sociological criticism. On the one hand, the concept confronts the reality of the prevalent use of "human capital," defined as embedding resources in people. On the other hand, it draws on Pierre Bourdieu's notions of cultural or social capital, which he developed to explain social inequalities and domination as effects of economic capitalization. We argue that body capital provides a framework for studying the interdependencies between bodies and their emotions, screens, and markets.

This framework opens up a new perspective on questions about the commodification of bodies and the marketization of health; about the links between health, emotions, and aesthetic appearance; and, most importantly, the increasing imperative to measure and make measurable bodies and capital.

The project focuses on the entangled histories of Germany, France, and Great Britain in four fields of investigation:
– food/nutrition;
– movement/exercise/sports;
– sexuality/reproduction/infants; and
– dependency/addiction/overconsumption.

Alongside several publications, this international research group has organized several conferences and workshops—some in close cooperation with the Wellcome Trust, the Science Museum London, and the London School of Hygiene and Tropical Medicine. Moreover, the "body capital" team has organized spring schools to reach out to younger scholars in the field. Additionally, we have curated several public screenings on the studied material, including programs on alcoholism, nutrition and overweightness, and sport and gender.
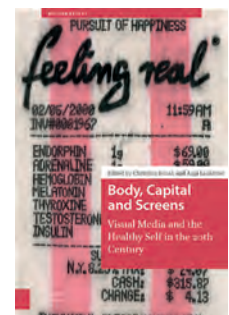
The Berlin Team consists of:

Anja Laukötter
(Co-Director)
Sandra Schnädelbach
(Postdoc Researcher)
Philipp Stiasny
(Postdoc Researcher)
Lukas Herde
(PhD candidate)

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Visual History in the Twentieth Century: Bodies, Practices and Emotions
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April 9–13, 2018
Max-Planck-Institute for Human Development

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(last update: April 2020)

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Center for Humans and Machines

Director: *Iyad Rahwan*

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Introductory Overview

The Center for Humans and Machines (CHM) conducts science to understand, anticipate, and shape major disruptions from artificial intelligence (AI), the Web, and social media to the way we think, learn, work, play, and govern.

Our goal is to understand how machines are shaping human society today and how they may continue to shape it in the future. We believe the challenges posed by the information revolution are no longer just computer science problems. In the following, we outline the theoretical tenets of our five research themes, reporting on work carried out between 2017 and 2020. As the Center was founded in July 2019, this report includes research conducted by CHM members formerly based at the Massachusetts Institute of Technology (MIT), Cambridge, USA, as well as work done during the transition. It also outlines plans for future work at the Institute.

The Center explores various projects, organized into broad themes, which are diverse in terms of their scientific methodology and research questions they explore. Each theme is scoped by an overarching research question, as shown in Figure 1.

The detailed accomplishments and plans for each theme will be outlined in detail below. First, however, it is important to outline the overall scientific approach of CHM and its relationship to existing disciplines.

Interdisciplinary Methods

The Center is decisively not a traditional computer science department nor a traditional behavioral science department. Rather, it brings together scientists from diverse disciplines in order to shed light on the phenomena of interest (see Figure 2).

In particular, CHM employs (or will employ) scientists from three major groups of disciplines. First, computer scientists and data scientists provide the essential technical capability to produce computational systems we are interested in studying (e.g., a reinforcement learning algorithm or a generative adversarial network) or to create technical measurement instruments (e.g., to collect social media posts from Twitter or to scrape online discussion forums and apply natural language processing techniques to them). However, our primary objective is not to contribute to the field of computer science directly in terms of new computational tools—although this does happen on occasion. This is evident in the fact that our primary publication venues are not computer science conferences and journals. The second pillar of CHM are the social (behavioral) and cognitive sciences, which provide experimental methods and the theoretical foundation for understanding how humans interact with machines. So we aim to hire highly quantitative psychologists, political scientists, economists, biologists, and anthropologists.

Finally, the disciplines of physics and mathematical/statistical modeling provide an additional suite of tools typically not available to a typical computer scientist. This enables us to use tools from network science, dynamical systems, differential equations, and multilevel statistical modeling/Bayesian inference.
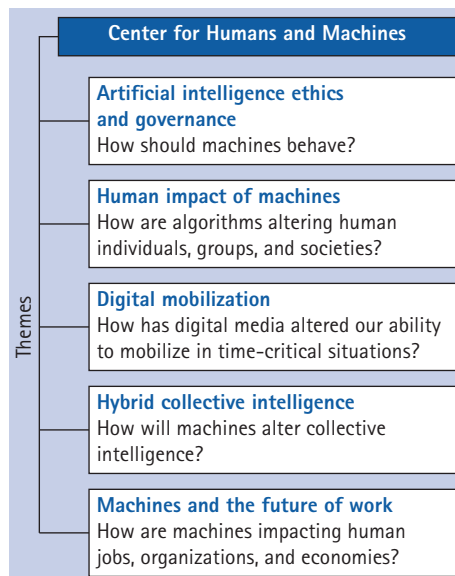

Center for Humans and Machines

Artificial intelligence ethics and governance
How should machines behave?

Human impact of machines
How are algorithms altering human individuals, groups, and societies?

Digital mobilization
How has digital media altered our ability to mobilize in time-critical situations?

Hybrid collective intelligence
How will machines alter collective intelligence?

Machines and the future of work
How are machines impacting human jobs, organizations, and economies?

Themes

Figure 1. The current research themes of the Center span topics related to both AI and social media.

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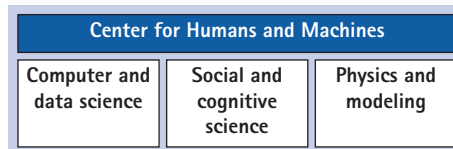| Center for Humans and Machines		
Computer and data science	Social and cognitive science	Physics and modeling

Figure 2. The research methodologies used at the Center build on diverse scientific disciplines.

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Key Reference

Rahwan, I., Cebrian, M., Obradovich, N., Bongard, J., Bonnefon, J.-F., Breazeal, C., … Wellman, M. (2019). Machine behaviour. *Nature, 568*(7753), 477–486. https://doi.org/10.1038/s41586-019-1138-y

Overarching Philosophy: Machine Behavior

The overall philosophy of CHM centers around the notion of *machine behavior,* that is, the study of behavior exhibited by intelligent machines and by hybrid human–machine collectives (see Figure 3). The contours of this emerging field were outlined in a *Nature* review article spearheaded by CHM director Iyad Rahwan, and coauthored with 23 eminent computational and behavioral scientists (Rahwan et al., 2019). CHM aims to be a world leader in the expansion of this field.

Behavioral Questions

Consider the following research questions in a variety of domains of human and social life in which algorithms play a role:

News ranking algorithms:
- Does the algorithm create a filter bubble?
- Does the algorithm disproportionately censor content with a particular political leaning?

Algorithmic justice:
- Does the algorithm discriminate against a racial group in granting parole?
- Does a predictive policing system increase the false conviction rate?

Autonomous vehicles:
- How aggressively does the car overtake other vehicles?
- How does the car distribute risk between passengers and pedestrians?

Autonomous weapons:
- Does the weapon respect necessity and proportionality in its use of force?
- Does the weapon distinguish between combatants and civilians?

Algorithmic trading:
- Do algorithms manipulate markets?
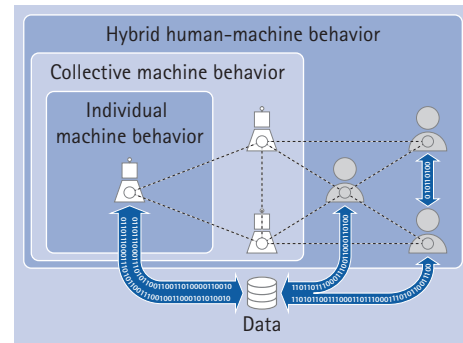- Does the behavior of the algorithm increase the systemic risk of a market crash?

Figure 3. We are interested in studying the behavior of machines, as they interact with humans at various scales.

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Algorithmic pricing:
- Do algorithms of competitors collude to fix prices?
- Does the algorithm exhibit price discrimination?

Online dating:
- Does the matching algorithm use facial features?
- Does the matching algorithm amplify or reduce homophily?

Conversational robots:
- Does the robot promote products for children?
- Does the algorithm affect collective behavior?

What is special about these questions is that they can all be studied from a purely behavioral perspective by behavioral scientists who are agnostic to the internal implementation of the algorithms. We argue that this approach is very helpful, though significantly underutilized. Indeed, most people studying these systems are the scientists and engineers who build them. And while these scientists and engineers use the scientific method to benchmark and characterize their creations, they often study a very limited set of properties.

For example, a scientist designing a novel romantic-matching algorithm may prove theoretical properties of the algorithm or benchmark it by using simulated data. Subsequent real-world testing of deployed online dating algorithms, even when not shrouded

by industrial secrecy, would still be scoped by commercial objectives. This means that many important research questions remain unexplored.

Aim and Scope of CHM

CHM aims to become a major proponent of the observational and experimental study of machine behavior as a complement to analytical algorithm design and the engineering-oriented scientific study of machines. Thus, we have begun to provide a home for researchers from a wide variety of behavioral sciences (economics, political science, psychology, etc.) to study machine behavior using their best tools.

Note that CHM's focus on machine behavior makes its agenda quite distinct from that of traditional computer science departments, whose aims are to engineer better computer systems. But this does not mean we do not do computer science. In fact, we leverage our and our collaborators' computer science knowledge in order to build advanced algorithms for our studies (e.g., we built reinforcement learning agents to play games against humans in experiments). We also use computer science knowledge to build better measurement tools (e.g., to scrape social media data or job description data and apply natural language processing techniques to them).

Furthermore, while CHM aims to inform scholarship in qualitative fields such as science, technology, and society (STS), technology law and policy, we have made an explicit decision not to pursue scholarship in those fields. This is not our comparative advantage, since we are primarily scientists. We therefore plan to hire very few, if any, people from these fields unless they were open to collaborating on scientific projects.

In summary, as depicted in Figure 4, we can identify the place of CHM, and the emerging field of Machine Behavior more broadly, at the intersection of fields that engineer intelligent systems (computer science, AI, machine learning, social media) and fields that study behavior (quantitative psychology, economics, political science, anthropology). The scientific results that CHM produces then inform think-
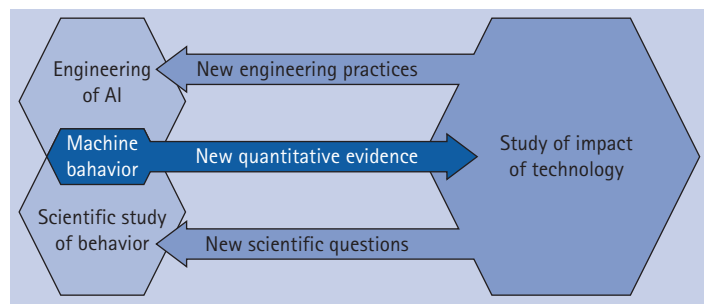

Figure 4. Machine behavior in relation to other fields.

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ing and ongoing debates in fields concerned with the qualitative study of technology and society (STS, technology law, technology policy, computer ethics, etc.). Furthermore, CHM looks to these fields for guidance on important new questions.

Kinds of Questions

Nikolaas Tinbergen, who won the 1973 Nobel Prize in Physiology or Medicine alongside Karl von Frisch and Konrad Lorenz for founding the field of ethology, identified four complementary dimensions of analysis for explaining animal behavior. These dimensions concern questions of a behavior's function, mechanism, development, and evolutionary history and provide an organizing framework for the study of animal and human behavior. For example, this conceptualization distinguishes the study of how a young animal or human develops a behavior from the evolutionary trajectory that selected for such behavior in the population. The goal of these distinctions is not division, but rather integration. While it is not wrong to say that, for example, a bird's song is explained by learning or by its specific evolutionary history, a complete understanding of the song will require both.

Despite fundamental differences between machines and animals, the behavioral study of machines can benefit from a similar classification. Machines have mechanisms which produce behavior, undergo development that integrates environmental information into behavior, produce functional consequences that cause specific machines to become more or less common in specific environments, and
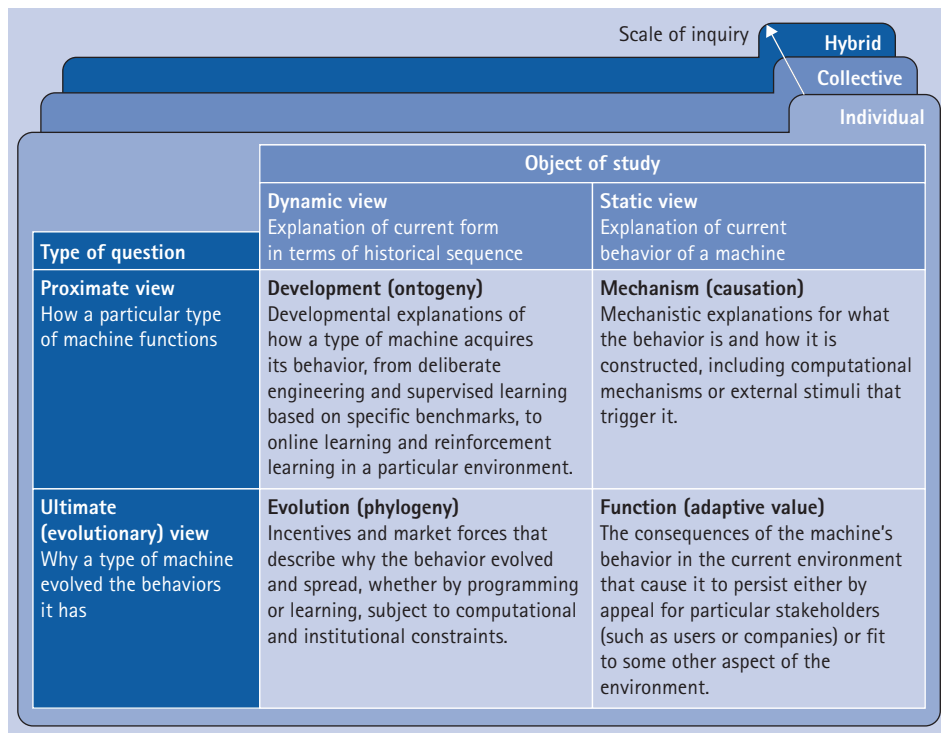
Figure 5. The foundational questions of machine behavior, inspired by Tinbergen's four questions in biology (adapted from Rahwan et al., 2019).

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embody evolutionary histories through which past environments and human decisions continue to influence machine behavior. Scholars of computer science have already achieved substantial gains in understanding the mechanisms and development of AI systems, though many questions remain. Relatively less emphasis has been placed on the function and evolution of AI systems.

The four categories Tinbergen proposed for the study of animal behavior can be adapted to the study of machine behavior, as shown in Figure 5. Tinbergen's framework proposes two types of question, *how* versus *why,* as well as two views of these questions, *dynamic* versus *static.* Each question can be examined at three scales of inquiry: individual machines, collectives of machines, and hybrid human-machine systems.

Theme: Artificial Intelligence, Ethics, and Governance

This theme explores the psychological and social mechanisms that shape people's trust in intelligent machines, how people react when this trust is breached, and how desirable machine behavior can be agreed upon and enforced.

Past Work

Much of the research in this area, which started at MIT, is concerned with the question of how an autonomous vehicle should behave and how its behavior is judged by people. Rather than taking an axiomatic approach to AI ethics, or on legal aspects of tort and regulation, our aim was to understand how laypeople expect an autonomous vehicle to behave in a critical situation, such as an unavoidable accident in which at least one person must be harmed, but a decision can be made about who that person is (pedestrian, passenger, jaywalker, etc.) (see Figure 6).

This work has been propelled by the global success of the Moral Machine experiment, which was spearheaded by director Rahwan's group at MIT in collaboration with others (Awad et al., 2018). The platform yielded a treasure trove of data, some 80 million decisions in moral dilemmas, and counting (see also Figure 7 below). This has enabled us to conduct an extensive analysis of the cross-cultural similarities and differences in how people wish autonomous vehicles to behave in moral dilemmas (Awad, Dsouza et al., 2020). We also explored how people apportion blame in (nondilemma) semiautonomous
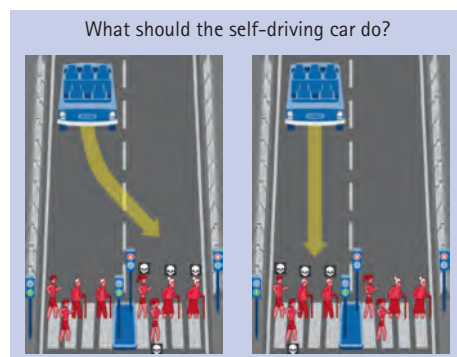
vehicle accidents and found that people seem to disproportionately blame humans in shared-control vehicles (Awad, Levine et al., 2020). We have also uncovered discrepancies between the ethics that people approve of and the ethics they are willing to support as consumers. Thus, AI-system behavior could be a conduit for well-known cooperation dilemmas (Tragedy of the Commons) (Bonnefon et al., 2016).

Ongoing Work and Future Plans

We wish to build on our earlier success by exploring more realistic scenarios that are more relevant to policy-makers. AVs are unlikely to actually face ethical dilemmas very frequently. Rather, their design is likely to embed particular tradeoffs when it comes to the safety of different road users. For example, some cars may be statistically more likely to kill pedestrians than other cars. We are exploring the distributions of fatalities that people are willing to accept, even given marked improvements over the status quo. We are also exploring safety thresholds that people want to see before they trust autonomous vehicles. We believe this question is of critical importance, since people may have unrealistic expectations from machines compared to humans, leading to irrational aversion against safer technologies. Identifying these biases, their causes, and their possible resolution could have a significant impact on the real-word adoption of autonomous vehicles and, ultimately, road safety. More broadly, over the next years, this theme will continue to use behavioral science to quantify people's expectations of a variety of intelligent machines and to diagnose situations in which they may overtrust or undertrust them. Our work will focus on behavioral phenomena and their underlying psychological explanations, paving the way for better public policy and technology design.

What should the self-driving car do?

Figure 6. Screenshot of a random Moral Machine scenario.

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Principal Investigator
Iyad Rahwan

Overarching question
How should machines behave?

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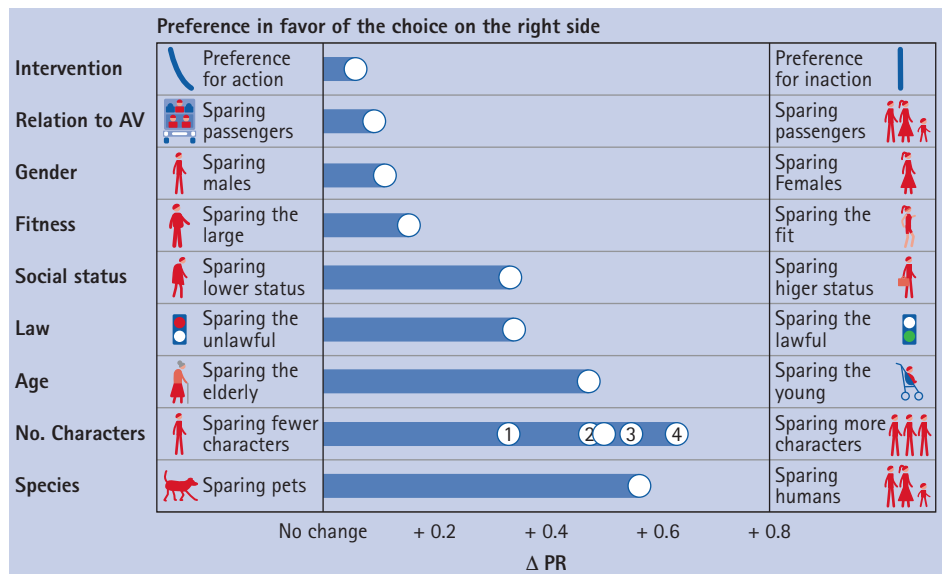
Figure 7. Average Marginal Component Effect (ACME) for each preference. In each row, ΔP is the difference between the probability of sparing characters possessing the attribute on the right and the probability of sparing characters possessing the attribute on the left, aggregated over all other attributes. For example, for the attribute age, the probability of sparing young characters is 0.49 (s.e. = 0.0008) greater than the probability of sparing older characters. The 95% confidence intervals of the means are omitted owing to their insignificant width, given the sample size (n = 35.2 million). For the number of characters (No. characters), effect sizes are shown for each number of additional characters (1 to 4; $n1$ = 1.52 million, $n2$ = 1.52 million, $n3$ = 1.52 million, $n4$ = 1.53 million); the effect size for two additional characters overlaps with the mean effect of the attribute. AV = autonomous vehicle (adapted from Awad, Dsouza et al., 2018).

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Theme: Human Impact of Machines

Machines are an integral part of our daily lives. Given that we are markedly shaped by the conditions that surround us, how might our interactions with machines be altering human individuals, groups, and societies? This research group studies the impacts—broadly conceived—that our relationship with machines may be having on the human system (illustrated by Figure 8).

The ubiquity of algorithms, coupled with their increasing complexity, tends to amplify the difficulty of estimating the effects of algorithms on human individuals and society. AI agents can shape human behaviors and societal outcomes in both intended and unintended ways. For example, some AI agents are designed to aid learning outcomes for children while others are designed to assist aging seniors. These AI systems may benefit their target groups by nudging those humans into better learning or safer mobility behaviors. However, with the power to nudge human behaviors in positive or intended ways comes the risk that human behaviors may be nudged in costly or unintended ways—children could be influenced to buy certain branded products and elders could be nudged to watch certain television programming.

The way that such algorithmic influence on individual humans scales into society-wide impacts, both positive and negative, is of critical concern. As an example, the exposure of a small number of individuals to political misinformation may have little effect on society as a whole. However, the effect of the insertion and propagation of such misinformation into social media may have more substantial societal consequences. Further, issues of algorithmic fairness or bias have been already documented in diverse contexts, including computer vision, word embeddings, advertising, policing, criminal justice, and social services.

Figure 8. How are intelligent devices impacting us?

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Additional questions regarding the impact of algorithms include: How are online dating algorithms altering the societal institution of marriage? Are there systemic effects of increasing interaction with intelligent algorithms on the stages and speed of human development? In order for society to have input into and oversight of the downstream consequences of AI, scholars of machine behavior must provide insight into how these systems work and the benefits, costs, and tradeoffs presented by the ubiquitous use of AI in society.

Past Work

The past work on the human impact of machines, like for the other research themes, has been outlined and conducted by Nick Obradovich and colleagues both at MIT and in the transition between MIT and MPI for Human Development. Our article introducing machine behavior, on which Nick Obradovich was a lead author, outlined the criticality of studying the human impacts of algorithms in the context of hybrid human-machine systems (Rahwan et al., 2019). The overall focus of this theme can be broadly segmented into two classes: (1) empirical investigations and (2) methodological advances.

The first broad segment of this theme focuses on empirical investigations of the ways that algorithms alter human behaviors and functioning. This approach uses quantitative and causal inferential methods to investigate how humanity's relationship with machines—broadly conceived—may be affecting the human system. These questions include whether or not decisions influenced by algorithms may produce disparate social impact (Serna et al., in press) as well as the potential for humans to detect misinformation generated by machines.

The second broad segment of this theme focuses on furthering the methodological

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questions and tools needed to accurately assess the human impacts of algorithms. For example, to assess whether or not a particular algorithm is likely to behave in harmful ways toward humans, one needs to outline and develop tools for studying algorithms both in the laboratory and in the wild (Epstein et al., 2018; Rahwan et al., 2019). But one must also advance the metrics and methods used for studying humans in the process, too. For example, a more thoroughly developed approach to natural language processing can aid in investigating both bot and human discussions and behaviors online (Mir et al., 2019).

Ongoing Work and Future Plans

Our work in this theme will continue to advance along both segments. A current empirical question of interest relates to accurately characterizing the degree of overuse of online social media platforms. Nick Obradovich is employing over 5 years of Twitter data he has collected to investigate the individual-level dynamics of Twitter use, disuse, and overuse. At the same time, Obradovich is working to advance the validity and accuracy of algorithmic measurements of online sentiment. Having a valid and accurate manner to measure online sentiment—and emotion—is critical in being able to map potential psychological impacts of human-machine interactions online.

There are many future topics and questions that fall under this theme, including: Do matching algorithms used for online dating alter the distributional outcomes of the dating process? Do news filtering algorithms alter the distribution of public opinion? Might small errors in algorithms or the data they employ compound to produce society-wide impacts? How do intelligent robots in our schools, hospitals, and care centers alter human development and quality of life and affect outcomes for the disabled? Other questions in this domain relate to the potential for machines to alter the social fabric in more fundamental ways. To what degree are intelligent machines influencing policing, surveillance, and warfare? And how large an effect have bots had on the outcomes of elections?

Theme: Digital Mobilization

Principal Investigator
Manuel Cebrian

With the explosion of AI and its deployment in our digitally mediated social lives, there are open questions that we must shed light on as they are critical for the social cohesion and political progress of societies all over the world who are ever more reliant on digital platforms for information spreading and political mobilization:

Overarching question
How has digital media altered our ability to mobilize in time-critical situations?

(1) Have AI-powered digital social networks improved or harmed our ability to mobilize others for a cause?
(2) Are digital social networks a force of mobilization and collaboration or instead of demobilization and conflict?
(3) What current institutions, platforms, and social structures are making the best use of Crowdsourcing and Collective Intelligence, and how can we learn from them so that society can keep up with the rapid progress of AI?

This research theme will study these questions using tools from network science and computational social science.

Past Work

In 2009, the Defense Advanced Research Projects Agency (DARPA) launched the "Network Challenge," more commonly known as the "DARPA Red Balloon Challenge." Ten red weather balloons were fixed at unknown locations in the United States. An open challenge was launched to locate all ten and the first to do so would be declared the winner, receiving a cash prize. A team led by Manuel Cebrian was able to locate them all within 12 hours using social media and a novel reward scheme that rewarded viral recruitment. This achievement was rightly seen as proof of the remarkable ability of social media, then relatively nascent, to solve real-world problems such as large scale spatial search. The challenge was also remarkable as it succeeded despite many efforts to provide false information on the location of the balloons. At the time, the false reports were filtered through a complex process involving a vast amount of human resources by the winning team (Chen et al., 2016).

The DARPA Network Challenge began a series of open challenges that explored different facets of social mobilization. The challenge conditions were able to incentivize researchers to focus on particular problems in sectors as diverse as intelligence, health, and creative problem-solving, with the lure of prestige or financial reward (see Figure 9). In the 10 years
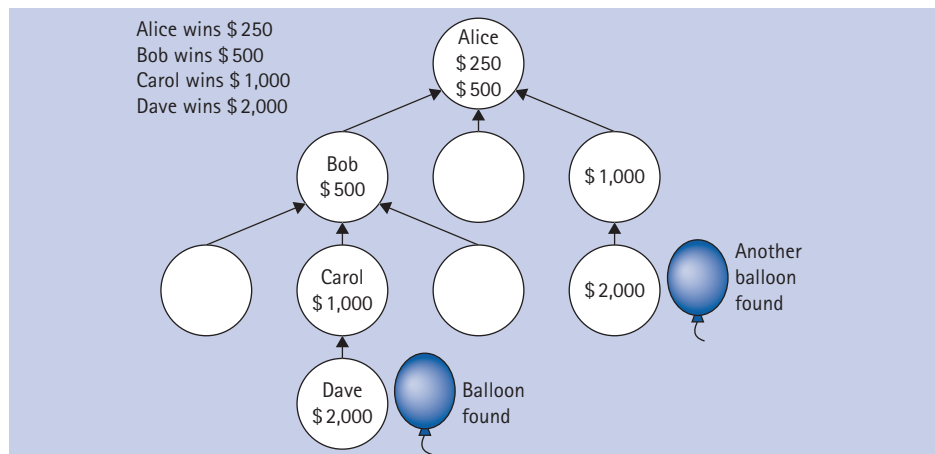
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Figure 9. Split contracts: Under this novel incentive scheme, a node u who does not possess the information can recruit a friend v through a subtree rooted at v, then v has to give half of his or her own reward back to u. Split contracts are robust—as opposed to Ponzi-scheme-like contracts—to nodes' selfishness (adapted from Tang, J., Cebrian, M., Giacobe, N., Kim, H.-W., Kim, T., & Wickert, D. (2011). Reflecting on the DARPA Red Balloon Callenge. *Communications of the ACM, 54*(4), 78–85).

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Table 1. The DARPA Network Challenge and its children

Challenge	Year	Theme	Unexpected Lesson
DARPA Red Balloon Challenge	2009	Social Search	Misinformation is inevitable
DARPA Shredder Challenge	2011	Problem-Solving	Sabotage has asymmetric power
Nexus 7 (More Eyes)	2011	Intelligence	Privacy restricts uptake
State Department Tag Challenge	2012	Social Search	Misinformation and sabotage are inevitable
CLIQR Quest Challenge	2012	Social Search	Social media needs mass media
Langley Castle Challenge	2014	Social Search	More similar (homophilous) friends mobilize faster
FiftyNifty	2017	Political Mobilization	Political polarization undermines bipartisan mobilization
Black Rock Atlas	2018	Social Search	Social media needs mass media

since, misinformation on social media has grown in prevalence and sophistication to be one of the defining social issues of our times. The misinformation observed in the Red Balloon Challenge, and unexpected adverse effects in other social mobilization challenges subsequently, turned out not to be bugs, but essential features of digital social mobilization.

Ongoing Work and Future Plans

The allure of open challenges is clear when considering how other new technologies are developed, tested, and launched. Such is the complexity and versatility of social media platforms and other internet mediated technologies, the expected behavior of instant messaging, virtual reality, or deep-fakes cannot simply be interpolated from a small subsample or a limited user-testing. While some might object to open challenges as being reckless and unsanctioned societal experimentation, we can ask what are the alternatives? Internet platform companies have resorted to closed focus groups followed by the global release of largely unregulated tools in an arms race of engagement; a process that has been described as "society as a beta test."

Reflecting on 10 years of social media challenges, we argue that emerging technologies represent sociotechnical systems of such complexity and with such far-reaching effects that suitable testing should emphasize *post-deployment* testing as much as *predeployment* testing. The challenges we study can be considered as a forum for transparent, white hat attacks on these platforms operating at the limits of their parameters.

These challenges that followed the DARPA Red Balloon Challenge brought to light some unsavoury facets of internet-mediated technologies. Aspects that have become all too familiar: sabotage, polarization, and misinformation. Yet, we are in a better place having illuminated and characterized these "edge cases," as they were considered at the time, and better placed to deal with them now that they are mainstream.

We plan to extend the type of analysis described above to significant mobilization events in the social, political, epidemiological, or creative enterprises and expand and understand the evolution of lessons learned from these events.

Just as we began to understand and characterize the power and pitfalls of social media with the Red Balloon Challenge a decade ago, we look forward to investigating a further decade of large mobilization and crowdsourcing events, as they will likely involve the use of AI as it emerges as a mainstream and general-purpose technology.

Theme: Hybrid Collective Intelligence

The success of humans is due to our outstanding ability to adapt to new environments. Individually, we quickly infer patterns from single or multiple observations. Collectively, we develop complex cultural artifacts (e.g., tools, institutions, norms, art, language, or mental models of the world) that enable cooperation at scale. Algorithms will radically change the way humans collectively sense, learn, and act in a rapidly changing environment. This theme investigates how such change might unfold.

Past Work

In 2010, the Intelligence Advanced Research Projects Activity (IARPA) launched the Aggregative Contingent Estimation (ACE) challenge with the goal "to dramatically enhance the accuracy, precision, and timeliness of forecasts for a broad range of event types, through the development of advanced techniques that elicit, weight, and combine the judgments of many intelligence analysts." Aggregating forecasts from multiple independent judges has been known to enhance forecasts and predictions via several aggregating mechanisms. The rules of optimal judgments aggregation have long been debated. To add to this complexity, algorithms have now become better at extracting meaningful patterns from data, thus possibly competing with humans in making the best predictions, but also interacting with other human and artificial players in unpredictable ways.

Diverse groups are often said to be less susceptible to decision errors resulting from herding and polarization. Thus, the fact that many modern interactions happen in a digital world, where filter bubbles and homophily bring people together, is an alarming yet poorly understood phenomenon. But online interactions are also characterized by unprecedented scale, where thousands of individuals can exchange ideas simultaneously. Evidence in collective intelligence, however, suggests that small (rather than large) groups tend to do better in complex information environments. As part of the new IARPA Hybrid Forecasting Competition (HFC), our team developed a study that adopted the well-established framework of social learning theory (from the fields of ecology and cultural evolution) to explore the causal link between diversity and performance as a function of group size. In this preregistered study, we ex-

perimentally manipulate both group diversity and group size and measure individual and group performance in realistic geopolitical judgments. We find that diversity hinders the performance of individuals in small groups, but improves it in large groups. Furthermore, aggregating opinions of modular crowds composed of small independent but homogeneous groups achieves better results than using nonmodular diverse ones. The results are explained by greater conflict of opinion in diverse groups, which negatively impacts small (but not large) groups. This work sheds light on the causal mechanisms underlying the success (or lack thereof) of diverse groups in digital environments and suggests that diversity research can benefit from adopting a wider social learning perspective.

A relatively unexplored area of investigation in collective intelligence is real-time collective control. While crowds are known to be good at searching large solution spaces in a relatively short amount of time when their incentives are aligned, it is unclear whether they can be used for control and strategic goal-oriented action. The difference with tasks like forecasting and collective search—where there is only one fixed goal (e.g., reporting accurate predictions)—is to be able to rapidly adapt to a shifting task set, changing one's strategy in response to new goals or changes in the environment. This capacity is a common higher cognitive function in biological intelligence and an active area of investigation in AI. The advent of digital technologies and the internet era have allowed large-scale cooperation among networks of peers, which can often reach decisions in a decentralized manner as a time-critical response to external contingencies like natural disasters and civic protests.

Principal Investigator
Niccolò Pescetelli

Overarching question
How will machines alter collective intelligence?

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To test the limits of collective intelligence in goal-oriented behavior and control, our team developed an online interface designed to test the limits of internet collective action and problem-solving. The BeeMe platform allows a scalable internet crowd of online users to collectively control the actions of a human surrogate acting in physical space. BeeMe demonstrates how intelligent goal-oriented decision-making can emerge from large crowds in quasi real time. We analyzed data collected from a global BeeMe live performance (see Figure 10) that involved thousands of individuals collectively solving a science-fiction Internet mystery. We study simple heuristic algorithms that can be found in users' conversation, output human actionable commands representing majority preferences, and compare their performance to the behavior of a human operator solving the same task. Results show that simple algorithms can achieve near-human performance in interpreting the democratic consensus. When they cannot, the discrepancy is often due to human bias favoring nonrepresentative views. Our results offer insights into how real-time hybrid decision systems can be designed to allow collective participation and intelligent collective action.

As an effort to engage the public in this discussion, we created *The BeeMe Experiment,* which narrates the events of our world-wide internet performance. The documentary was premiered at the Miami International Science Fiction Film Festival 2020.

Ongoing Work and Future Plans
As an effort to study the effect of collective decisions in hybrid ecologies, the Hybrid Collective Intelligence team is planning to run a series of online group experiments with hybrid agents, aiming at determining the impact of machines on collective decisions, spread of ideas and opinions, and cultural evolution. For this purpose, one PhD student and one postdoc have been hired with experience in machine learning and cultural evolution. Questions that will be answered by this line of work are: Can machines be vectors of cultural items? Can machines speed up the rate at which collectives learn to find optimal solutions? Are machines' solutions copied more often than human solutions? Can machines acquire prestige? Do machines show biases in their decisions that are similar or complementary to those of humans? What are the strengths and weaknesses of hybrid collectives?

In parallel, we are planning to submit the results from a new study, done in collaboration with Albert Kao (Santa Fe Institute, New Mexico, USA), on the power of collective incentives in complex information environments, characterized by an overlap in information sources and intercorrelation among group members. In this study, we investigate the learning mechanisms that govern individual and collective patterns of information fruition using a highly controlled experimental laboratory design.

The BeeMe Experiment
www.vimeo.com
/370031909

Figure 10. Letting a real person be controlled by the Internet. This documentary tells the story behind the BeeMe experiment.

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Theme: Machines and the Future of Work

Robotics and AI technologies are expected to fundamentally transform the nature of work, to potentially eliminate many jobs, and to create entirely new jobs. While these questions are typically studied by labor economists, this theme complements the traditional approach using methods from data science, complex systems, and network science to shed new light on these processes.

Past Work

Past work in this theme has made groundbreaking advances in the application of network science to represent and understand labor markets. In particular, Alabdulkareem et al. (2018) was the first study to provide a bottom-up representation of workers' skills that can complement traditional classifications in terms of routine versus nonroutine (see Figure 12 below). Frank et al. (2018) was the first study to investigate the interplay between automation and urbanization: two of the most important trends in society in the 21st century (see Figure 11). In this study, it was found that, although large cities tend to specialize their workforces, this specialization favors skills that cannot be automated, leaving smaller cities more vulnerable. A recent perspective piece by Frank et al. (2019)
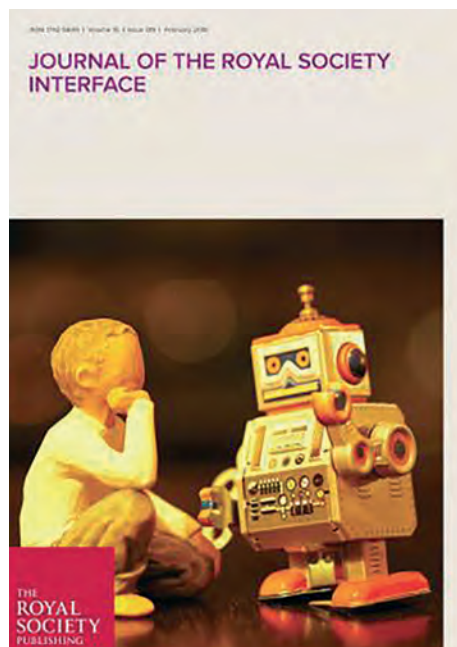

Figure 11. Cover of the issue in which (Frank et al., 2018) appeared.

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brought together 10 eminent practitioners in labor economics and complex systems to outline a path forward for the data-driven study of the impact of AI on labor markets.

Ongoing Work and Future Plans

Several lines of work are currently ongoing.

- In collaboration with colleagues at King Abdullah City of Science and Technology, Saudi Arabia, Alex Rutherford has been leading a project to digitize and analyze historical records of jobs dating back to 1939. Using large-scale text processing, we have produced a view of longitudinal structural changes in the job market over 60 years. Our interest is in changes in the degree of polarization between jobs that might have arisen due to new workplace technologies being deployed.

- Researchers from CHM and MIT have proposed an ecologically inspired model of the resilience of urban labor markets to automation. This framework is inspired by network representations of ecological collapse and was found to offer significant predictive accuracy when compared to historical data on unemployment during the 2008 financial shock. This work is currently under review.

- CHM researchers are collaborating with Guangzhou University, China, to adapt the United States' O*NET labor market classification system to the Chinese labor force using machine learning and complex systems science. This work is currently under review.

- Alex Rutherford has also conceived and designed an online game that simulates the effects of automation for individual workers in low-skilled jobs. The game is bootstrapped on empirical data on jobs, skills, wages, and education. The game incorporates a model of wage change as skills are automated. The game, *The Automated Life,* has been

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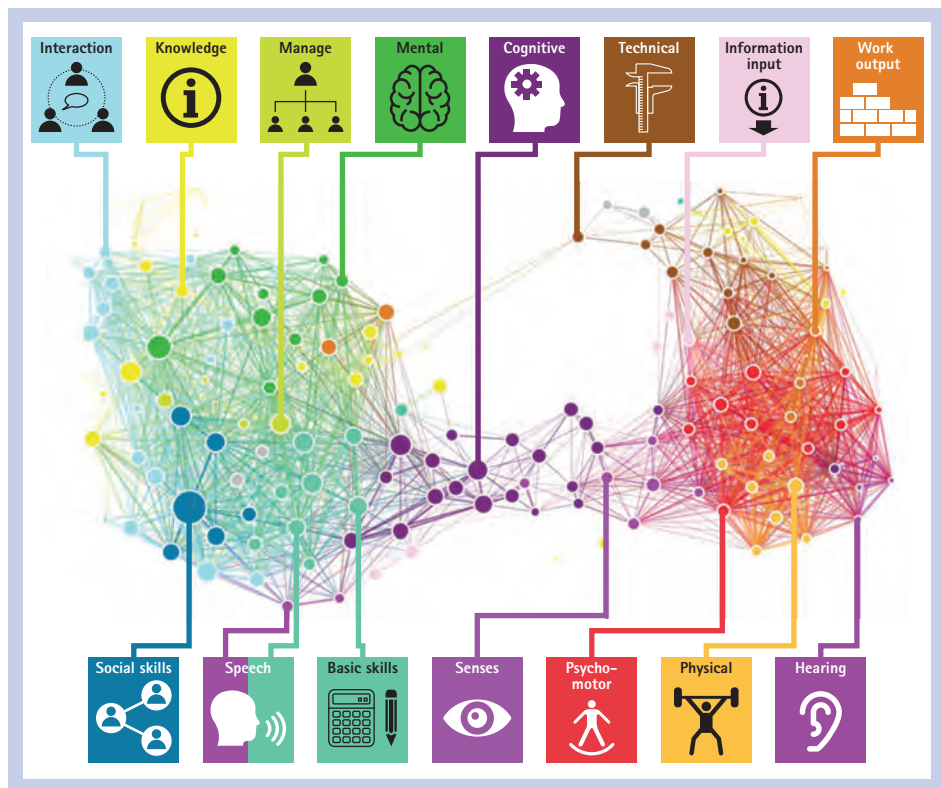
Figure 12. The skillspace, a network representation of workplace skills linked by their co-occurrence in various occupations. Nodes are skills, and skills that are found together in more jobs are linked more strongly. Colors represent O*NET skill classifications (adapted from Alabdulkareem et al., 2018).

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tested and is expected to be launched in early 2020. The game incorporates several experimental conditions to understand and contrast user behaviors and preferences.

- Presently, in collaboration with researchers at the University of Cyprus, Alex Rutherford is leading a study on the effect of automation on individual work happiness (see Figure 13). Certain jobs offer job satisfaction along several different dimensions, and the proportion of jobs offering satisfaction is forecast to change due to various reasons. This work aims to understand the effects of automation specifically on aggregate job satisfaction and, therefore, happiness.

- Several researchers from CHM, led by Alex Rutherford, have submitted a proposal to include questions in the German household survey Socio-Economic Panel (SOEP) regarding individual social resilience to life events including technological change. It is expected that this study will quantify the expected exposure of different occupations and demographics to the deleterious effects of automation. The additional questions are likely to be approved in April 2020 before a new data collection begins.
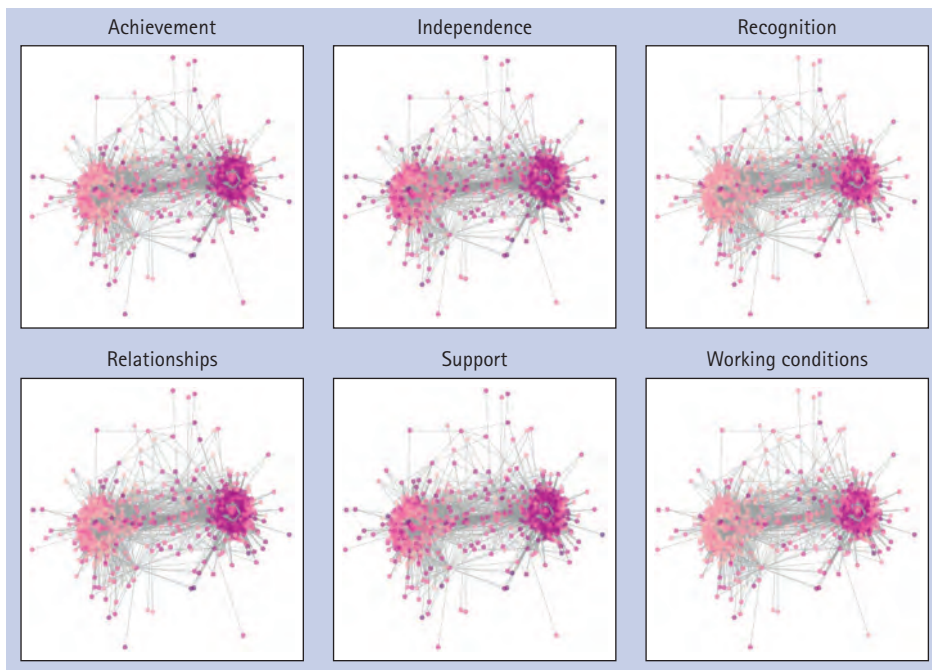
Figure 13. Projection of the six dimensions of workplace satisfaction on the job network. Nodes are jobs and links are determined by skill similarity. Nodes are colored by their work value on a scale of 1 to 7 (ongoing work).

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Center for
Lifespan Psychology

Director: *Ulman Lindenberger*

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> "But ... its eminent modifiability, and its predisposition to self-initiated action, may it develop little or much, and may it differ in amount between different individuals, is among the immutable features of humankind, which can be found wherever humans exist."
>
> *Johann Nicolaus Tetens, 1777, I, p. 766*

J. N. Tetens (1736–1807), philosopher of the Enlightenment Era

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Schmiedek, F., Lövdén, M., von Oertzen, T., & Lindenberger, U. (in press). Within-person structures of daily cognitive performance differ from between-person structures of cognitive abilities. *PeerJ*.

Introductory Overview

Founded in 1981 by Paul B. Baltes (1939–2006), the Center for Lifespan Psychology (LIP) pursues lifespan psychology as a distinct conceptual approach within developmental psychology. Since 2004, the Center has continuously extended its research program into developmental and cognitive neuroscience. The Center hosts the Max Planck UCL Centre for Computational Psychiatry and Ageing Research led by Raymond Dolan and Ulman Lindenberger, which was founded in 2014 and is located in both London and Berlin (see pp. 177 ff.). LIP also is involved in the longitudinal Cognition, Brain, and Aging (COBRA) study, which investigates the role of dopamine in cognitive aging. COBRA is conducted in Umeå, Sweden, and involves scientists from Umeå University, from the Aging Research Center at Karolinska Institutet, Stockholm, and from LIP. The Center continues to pay special attention to the age periods of late adulthood and old age, which offer unique opportunities for innovation, both in theory and practice. At the same time, it has continually strengthened its focus on the operation of maturational mechanisms during childhood, especially in relation to memory development.

Three Guiding Propositions

The Center's research agenda can be summarized by three interrelated theoretical propositions (Lindenberger et al., 2006). In line with general tenets of lifespan psychology, these propositions emphasize conceptual and methodological issues in the study of lifespan behavioral development and thereby provide a conceptual foundation for formulating research questions in specific domains of interest.

Proposition 1: Lifespan Changes in the Individual's Behavior as Interactions Among Maturation, Learning, and Senescence

The general goal of developmental psychology is to identify mechanisms that generate invariance and variability, constancy and change, in behavioral repertoires from infancy to old age. By identifying the commonalities, differences, and interrelations in the ontogeny of sensation, motor control, cognition, affect, and motivation, both within and across individuals, developmental psychologists and developmentally oriented neuroscientists attempt to arrive at more or less comprehensive theories of behavioral development. To provide explanations that qualify as psychological and devel-

opmental, the effects of agents external to the developing individual, such as educational policies (Lövdén et al., in press), parents' affect attunement, teachers' classroom behavior, or a state's retirement policies, need to be mapped onto mechanisms and organizational laws that operate and evolve within individuals. Hence, as John Nesselroade, Peter Molenaar, and others have emphasized, developing individuals are the privileged system for description, explanation, and intervention (Schmiedek et al., in press; Voelkle et al., 2018). Individuals organize their exchange with the physical and social environment through behavior (see Figure 1). On the one hand, the changing brain and the changing physical and cultural environment shape behavioral development. On the other hand, behavior alters both the brain and the environment. Hence, environment and brain act as antecedents but also as consequents of moment-to-moment variability and long-term changes in patterns of behavior. The components of this system, brain, behavior, and environment, are constantly coupled and cannot be reduced onto each other, as they jointly condition an individual's life trajectory through recursive self-regulation.

Key Reference

Lindenberger, U., Li, S.-C., & Bäckman, L. (2006). Delineating brain–behavior mappings across the lifespan: Substantive and methodological advances in developmental neuroscience. *Neuroscience & Biobehavioral Reviews, 30*(6), 713–717. https://doi.org/10.1016/j.neubiorev.2006.06.006
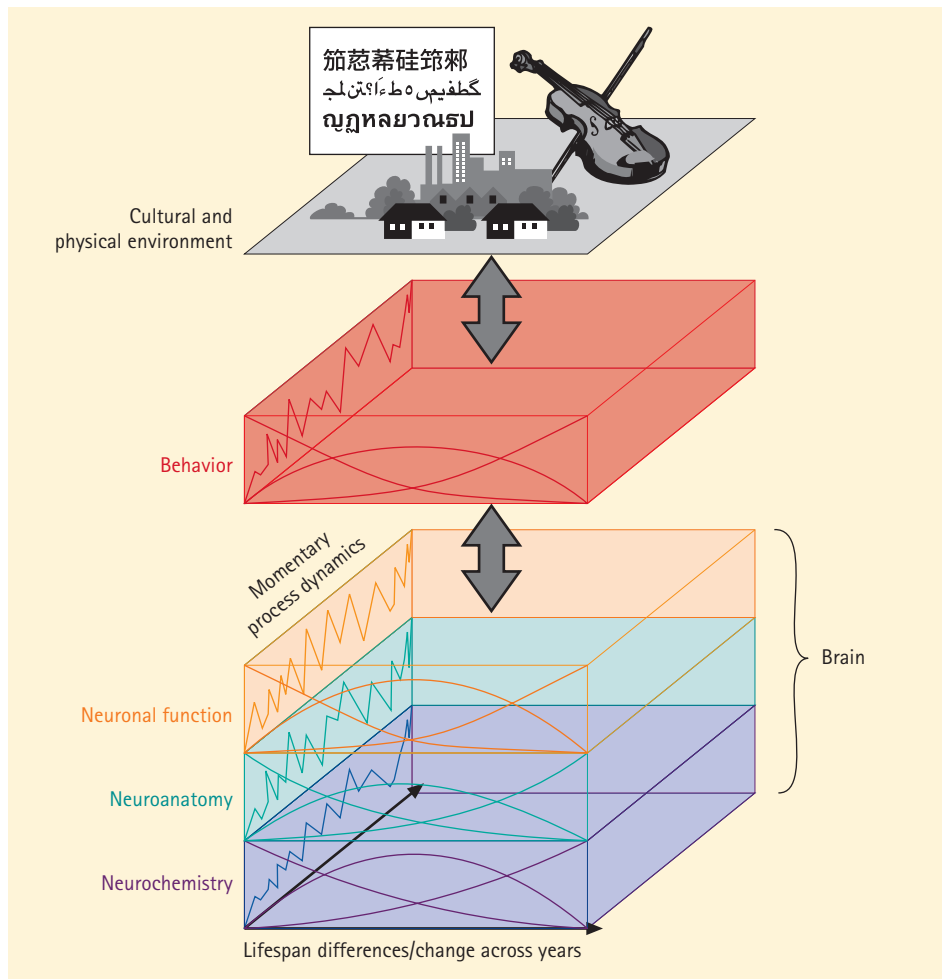
Figure 1. Environment and brain as antecedents and consequents of moment-to-moment variability and long-term changes in patterns of behavior. Lifespan changes in brain–behavior mappings are shaped by interactions among processes related to maturation, learning, and senescence. The identification of key players in the ontogeny of brain–behavior dynamics requires a coalition between formal tools for synthesis across levels of analysis and timescales as well as empirical methods to study variability and change in brain and behavior (adapted from Lindenberger et al., 2006).

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In attempts to explain the age-graded evolution of this system, *maturation* and *senescence* denote the operation of age-graded brain mechanisms and their effects on changes in behavior, which are especially pronounced early and late in life. In addition, *learning,* at any point during ontogeny, denotes changes in brain states induced by behavior–environment interactions. Maturation cannot take place without learning, and learning cannot take place without maturation. Similarly, the ways in which senescence takes its toll on the brains of aging individuals depends on their past and present learning and maturational histories. To complicate matters, processes commonly associated with maturation are not confined to early ontogeny, and processes related to senescence are not restricted to old and very old age. For instance, neurogenesis and synaptogenesis, which qualify as maturational mechanisms promoting plasticity, continue to exist in the adult and aging brain; conversely, declines in dopaminergic neuromodulation, which indicate senescence-related changes in brain chemistry, commence in early adulthood.

Thus, maturation, senescence, and learning mutually enrich and constrain each other throughout the entire lifespan and must be understood and studied as interacting forces constituting and driving the brain–behavior–environment system. Psychologists occupy a central position in this endeavor because they possess a rich and adequate repertoire of experimental and methodological tools to describe and modify the organization of behavior (Voelkle et al., 2018). In particular, direct comparisons between children and older adults help to identify commonalities and differences in the mechanisms that drive child and adult development.

Proposition 2: Lifespan Theory and Methodology Need to Integrate Evidence Across Domains of Functioning, Timescales, and Levels of Analysis

Developmental psychology is faced with three challenging integrative tasks. First, there is the need to integrate theorizing and research practice across functional domains to attain a comprehensive picture of individual development. For instance, sensorimotor and cognitive functioning are more interdependent in early childhood and old age than during middle portions of the lifespan, and developmental changes in either domain are better understood if studied in conjunction. Similar observations can be made for many other domains of functioning whose changes have
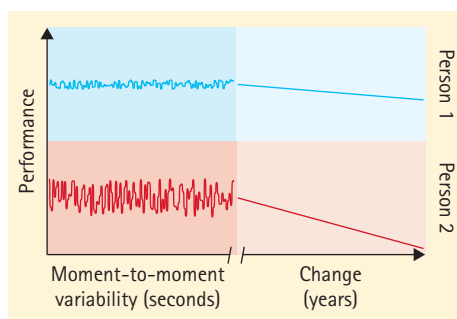

Figure 2. Example for predictions linking moment-to-moment variability to long-term change and brain changes to behavioral changes. Aging individuals with greater moment-to-moment fluctuations in behavior at a given point in time are expected to show greater subsequent longitudinal decline in mean levels of functioning than individuals who fluctuate less (adapted from Lindenberger et al., 2006).

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generally been studied in isolation, such as the ontogeny of social interaction and cognition; of emotion regulation and motivational states; or of memory, working memory, and attention.

Second, there is a need to understand the mechanisms that link short-term variations to long-term change. Short-term variations are often reversible and transient, whereas long-term changes are often cumulative, progressive, and permanent. Establishing links between short-term variations and long-term changes is of eminent heuristic value, as it helps to identify mechanisms that drive development in different directions. For instance, aging cognitive systems show a decrease in processing robustness, which may signal impending long-term changes in other characteristics of the system (see Figure 2). To articulate these different timescales, we need to gather multivariate time-series data that capture short-term variability and long-term changes in cross-domain dependencies.

Third, to arrive at mechanistic explanations of behavioral change, there is the need to integrate behavioral and neural levels of analysis. At any given point in the lifespan, one-to-one mappings between brain states and behavioral states are the exception rather than the rule, as the brain generally explores and offers more than one implementation of an adaptive behavioral outcome (Lindenberger & Lövdén, 2019). Therefore, ontogenetic changes in behavioral repertoires are accompanied by continuous changes in multiple brain–behavior mappings. Some of these remapping gradients may be relatively universal and age-graded, whereas others may be more variable, reflecting genetic differences, person-specific learning histories, the path-dependent nature of developmental dynamics, or a combination of all three. The resulting picture underscores the diversity and malleability of the organization of brain and behavior as well as the constraints on diversity and malleability brought about by (a) universal age-graded mechanisms associated with maturation and senescence, (b) general laws of neural and behavioral organization, and (c) sociocultural as well as physical regularities of the environment.

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Lindenberger, U., & **Lövdén, M.** (2019). Brain plasticity in human lifespan development: The exploration–selection–refinement model. *Annual Review of Developmental Psychology, 1,* 197–222. https://doi.org/10.1146/annurev-devpsych-121318-085229

Proposition 3: The Exploration of Age-Graded Differences in Plasticity Is a Powerful Tool for Identifying Mechanisms of Development

Both from scientific and societal perspectives, plasticity, or the alteration of developmental trajectories through experience, is a precious phenomenon (Lindenberger, 2014). Scientifically, inquiries into the plasticity of brain and behavior are rich sources of developmental information. Through the assessment of "changes in change," they offer the promise to observe the operation and proximal consequences of developmental mechanisms. For instance, studies in which research participants of different ages are instructed and trained to perform one or more cognitive tasks come with important validity benefits, such as (a) an increase in experimental control, (b) the identification of age differences near asymptotic performance levels, and (c) the assessment of transfer and maintenance effects. If neurochemical, neuroanatomical,

and neurofunctional imaging measures are assessed before, during, and after training, intervention studies also offer new insights into relations between behavioral and neural manifestations of plasticity. By partly taking control over behavior–environment interactions, mechanisms of learning can be studied in the context of maturation and senescence (Lindenberger, 2018).

From the larger perspective of societal evolution, cognitive intervention studies explore the range of possible development, or what could be possible in principle if conditions were different (see Figure 3). Hence, investigations of age changes in the plasticity of development carry the potential to explain and ameliorate the expression of human potential.

Conceptual Innovation

During the reporting period, the Center has sought to continue to contribute to conceptual innovation and integration in lifespan psychology and developmental neuroscience. In the following, we highlight three examples.
The exploration–selection–refinement model of human brain plasticity. In recent years, the project on plasticity in LIP (pp. 142 ff.), in collaboration with the laboratory led by Martin Lövdén in Sweden (see https://lovdenlab.org), has launched a new generation of experimental studies that combine behavioral skill training with repeated functional and structural imaging to directly observe the temporal progression of plasticity in humans; for a pioneering study, see Wenger, Kühn et al. (2017). To guide this work, Ulman Lindenberger and Martin Lövdén have proposed the exploration–selection–refinement model (ESR) of plastic change (Lindenberger & Lövdén, 2019). Lindenberger and Lövdén note that plasticity cannot be conceived as a process of perpetual growth, given the large number of skills humans acquire during their lifetime (see also Wenger, Brozzoli et al., 2017). Instead, the ESR model posits that local plastic change proceeds in three phases that together form a learning cycle (see Figure 4). Early in learning, available neuronal microcircuits potentially capable of implementing the computations needed to execute
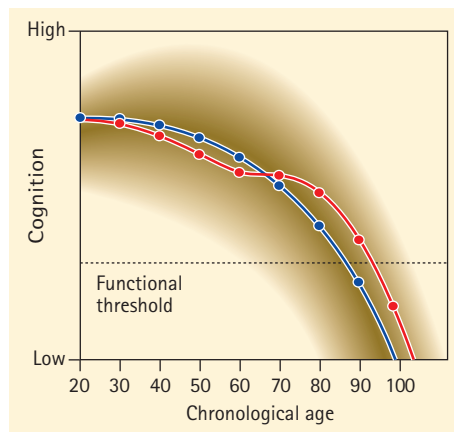

Figure 3. An individual's range of possible cognitive developmental trajectories from early to late adulthood. The blue curve shows the most likely developmental path under normal circumstances. The fading of the background color indicates that more extreme paths are less likely. The functional threshold represents a level of functioning below which goal-directed action in the individual's ecology will be severely compromised. The red curve represents the hope that changes in organism–environment interactions during adulthood move the individual onto a more positive trajectory. Beneficial changes may consist in the mitigation of risk factors, such as vascular conditions, metabolic syndrome, or chronic stress; the strengthening of enhancing factors, such as neuroplasticity; or both (adapted from Lindenberger, 2014).
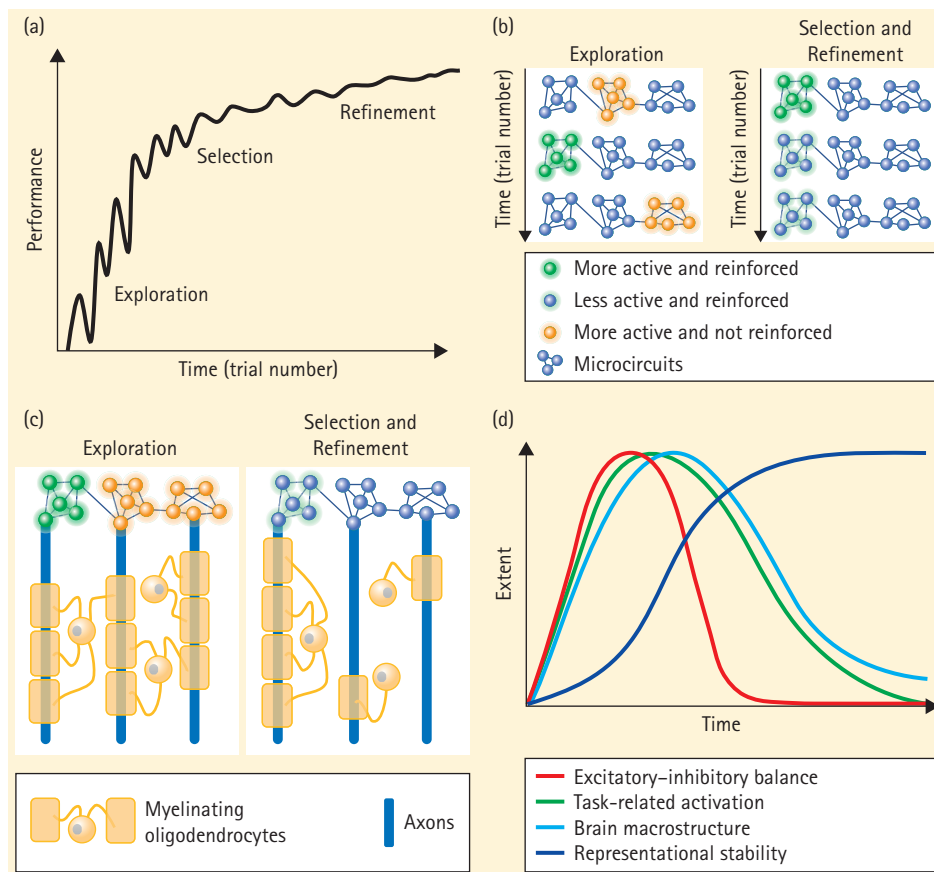
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Figure 4. The exploration, selection, and refinement (ESR) model of human brain plasticity. According to the model, local plastic change proceeds in three phases that together form a learning cycle. During the initial stages of the exploration phase, when the brain activates available microcircuits, there is substantial trial-to-trial variability in (a) behavior and in (b) patterns of neural activity. Facilitated by shifts in excitatory-inhibitory balance, this heightened level of activity induces structural change, such as the formation of new dendritic spines as well as other structural characteristics of the neuron, exemplified by myelination in panel c. Through a process of reinforcement learning that is partly mediated by the neurotransmitter dopamine, the best performing microcircuit is selected, and neural and behavioral variability starts to decrease (panels a and b). In a subsequent refinement stage, processing in the selected microcircuit stabilizes while novel structures of unselected microcircuits continue to retract (panel c). (d) At the macroscale of magnetic resonance imaging, the ESR model predicts curvilinear changes in functional activation, brain metabolites, and volume, in conjunction with a late-evolving monotonic increase in similarity of neural activation patterns (reproduced with permission from Lindenberger & Lövdén, 2019).

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a task are widely probed, and new circuits are formed, leading to an increase in gray-matter volume. During this exploration phase, there is substantial trial-to-trial variability in patterns of neural activity in these regions as well as in behavior. Exploration is deemed critical for acquiring new skills and might serve as a physiological substrate of exploration in the decision-theoretical sense, as skill acquisition generally requires the acquisition of complex rules, which only pays off in the long term. Exploration is followed by phases of experience-dependent selection and refinement of reinforced microcircuits and the gradual elimination of novel structures associated with unselected circuits, which may manifest as a decrease in gray-matter volume. The assumptions and hypotheses of the ESR will be computationally modeled and empirically tested in coming years.

Successful cognitive aging: The importance of maintenance. Together with Lars Nyberg from

Key References

Li, S.–C., **Lindenberger, U.,** & Sikström, S. (2001). Aging cognition: From neuromodulation to representation. *Trends in Cognitive Sciences, 5*(11), 479–486. https://doi.org /10.1016/S1364-6613(00)01769-1

Nyberg, L., & **Lindenberger, U.** (2020). Brain maintenance and cognition in old age. In D. Poeppel, G. Mangun, & M. Gazzaniga (Eds.), *The cognitive neurosciences* (6th ed., 81–89). MIT Press.

Tucker-Drob, E. M., **Brandmaier, A. M.,** & **Lindenberger, U.** (2019). Coupled cognitive changes in adulthood: A meta-analysis. *Psychological Bulletin, 145*(3), 273–301. https://doi.org /10.1037/bul0000179

Umeå University and others, researchers in LIP have emphasized brain maintenance as a key mechanism of successful cognitive aging. The notion of brain maintenance rests on the observation that individuals who show a relative lack of senescent brain changes also show more youth-like brain activation patterns and higher levels of cognitive performance. Brain maintenance is assumed to operate both at the general level of brain metabolism (Raz & Daugherty, 2018) and at the level of specific circuits and functions, such as the hippocampal formation, where it helps to preserve episodic memory (Nyberg & Lindenberger, 2020). Physical exercise is likely to foster brain maintenance by reducing vascular risks (Köhncke et al., 2018). Maintenance might operate in concert with other metamechanisms of successful cognitive aging, such as compensation and reserve. Attempts to discriminate among these mechanisms and compare their heuristic and explanatory value are underway (Cabeza et al., 2018).

Revisiting the dedifferentiation hypothesis of cognitive aging. About two decades ago, Shu-Chen Li and colleagues introduced a connectionist model of cognitive aging based on the observation that dopaminergic neuromodulation decreases throughout adulthood and old age (Li et al., 2001). Based on this model, it is hypothesized that declines in neuromodulation lead to dedifferentiated neural representations and processing pathways, thereby strengthening the variance that is shared across tasks. Using electroencephalography and functional magnetic resonance imaging, ongoing work by Minerva group leader Myriam Sander and colleagues within the LIME project investigates the core proposition of this line of reasoning, which states that individual neural representations become less distinct from one another with advancing adult age. A recent meta-analysis of correlated cognitive change in adulthood and old age, carried out by Elliot Tucker-Drob, Andreas Brandmaier, and Ulman Lindenberger (2019), is also relevant in this context. The authors found that an average of 60% of the between-person variation in change is shared across cognitive abilities (for details, see pp. 153 f.). In line with the dedifferentiation hypothesis, the proportion of shared variance in cognitive change increased from approximately 45% at age 35 years to approximately 70% at age 85 years.

Research Awards (Selection)
In 2017, Markus Werkle-Bergner received a Research Fellowship from the Jacobs Foundation to study the association between sleep and memory consolidation in children. In 2018, Mara Mather from the University of Southern California was awarded the Max Planck Sabbatical Award, which provides renowned scientists with dedicated grant support to foster collaboration with the hosting Max Planck Institute. This award has allowed Mara Mather and researchers of the RHYME project to deepen their collaboration on the locus coeruleus and noradrenergic neuromodulation as a prime driver of adult age differences in episodic memory (Dahl et al., 2019). In 2019, Elliot Tucker-Drob from the University of Texas at Austin received the Max-Planck-Humboldt Medal for his contributions to lifespan psychology. The medal is given to researchers with outstanding future potential who intend to collaborate with colleagues at a research institution in Germany. In the years to come, Elliot Tucker-Drob, who is an alumnus of the International Max Planck Research School on the Life Course (IMPRS LIFE) at the University of Virginia, will collaborate with Andreas Brandmaier and Ulman Lindenberger to develop multivariate methods that afford causal inferences about mechanisms that underlie individual differences in behavioral development across the lifespan.

Overview of Research Projects at the Center for Lifespan Psychology
Currently, in March/April 2020, empirical and conceptual work at the Center is structured into eight research projects (see Table 1). Compared to the 2014–2016 reporting period, the former project, *Cognitive and Neural Dynamics of Memory Across the Lifespan* (ConMem), was split into two projects, RHYME and LIME, to accommodate its growing size and within-project specialization. At the same time, the former project *Intra-Person Dynamics Across the Lifespan*

was merged with the project *Formal Methods in Lifespan Psychology,* reflecting the high degree of overlap between the two.

The activities pursued in these eight projects cover a wide array of research areas in human behavioral development. For example, the following questions have been addressed during the reporting period: (a) How can we design and implement data analysis workflows that ascertain the reproducibility of the results we report in our empirical publications (cf. pp. 295 f.)? (b) Is there a link between the precision of slow oscillation-spindle coupling during slow-wave sleep and memory consolidation in younger and older adults (Muehlroth, Sander et al., 2019)? (c) Do structural aspects of hippocampal subfields and limbic white matter predict individual differences in the learning rate among older adults (Bender et al., 2020)? (d) If the true shape of longitudinal change is exponential, but our analysis tools assume linearity, are researchers likely to notice the discrepancy in the context of standard longitudinal research designs (Ghisletta et al., 2020)? We provide our current answers to these questions and many more on the following pages.

Table 1. The Center for Lifespan Psychology at the Max Planck Institute for Human Development: Overview of Research Projects

Name of Project	Researchers, Including Postdoctoral Fellows	Predoctoral Research Fellows
Lifespan Neural Dynamics Group (LNDG; cf. pp. 195 ff.)	Douglas D. Garrett**; Niels A. Kloosterman*, Kristoffer N. T. Månsson*, Leonhard Waschke*, Iris Wiegand*	Julian Q. Kosciessa, Liliana Polyanska, Alexander Skowron
Lifespan Rhythms of Memory and Cognition (RHYME)	Markus Werkle-Bergner**; Martin J. Dahl*, Ulman Lindenberger, Chi (Zoe) Ngo*	Elisa S. Buchberger, Ann-Kathrin Jöchner, Beate E. Mühlroth
Lifespan Age Differences in Memory Representations (LIME)	Myriam C. Sander[1]**; Ulman Lindenberger	Anna Karlsson, Malte Kobelt°, Claire Pauley, Verena R. Sommer
The Berlin Aging Studies (BASE & BASE-II)	Julia A. M. Delius**, Sandra Düzel**; Andreas Brandmaier, Ylva Köhncke*, Ulman Lindenberger, Mara Mather°, Gert G. Wagner[2]	Sarah Polk
Mechanisms and Sequential Progression of Plasticity	Yana Fandakova**, Elisabeth Wenger**; Maike M. Kleemeyer*, Corinna Laube*, Ziyong Lin*, Ulman Lindenberger	Neda Khosravani, Eleftheria Papadaki
Interactive Brains, Social Minds	Viktor Müller**; Ulman Lindenberger	
Brain Imaging Methods in Lifespan Psychology	Nils C. Bodammer**; Ulman Lindenberger, Naftali Raz, Davide Santoro	
Formal Methods in Lifespan Psychology	Andreas M. Brandmaier**; Marie K. Deserno*, Charles C. Driver, Julian D. Karch*, Maike M. Kleemeyer*, Ylva Köhncke*, Ulman Lindenberger, Timo von Oertzen°	Manuel Arnold°

Note. Head of Research Planning and Research Coordination: Imke Kruse. The table refers to projects and project members as of March/April 2020; for updates, visit www.mpib-berlin.mpg.de.
**Principal investigator; *Postdoctoral fellow; °Primary affiliation with another institution.
[1] Myriam C. Sander leads a Minerva Research Group.
[2] Gert G. Wagner is Max Planck Fellow at the MPI for Human Development (see pp. 253 ff. for more information).

Research Scientists

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Martin J. Dahl
Attila Keresztes
(until 11/2018)
Beate E. Mühlroth
Chi (Zoe) Ngo
(as of 09/2019)

Elisa S. Buchberger
(as of 10/2019)
Ann-Kathrin Jöchner
(as of 01/2018)

Key References

Dahl, M. J., Ilg, L, Li, S.-C., Passow, S., & **Werkle-Bergner, M**. (2019). Diminished pre-stimulus alpha-lateralization suggests compromised self-initiated attentional control of auditory processing in old age. *NeuroImage, 197*, 414–424. https://doi.org /10.1016/j.neuroimage .2019.04.080

Dahl, M. J., Mather, M., Düzel, S., Bodammer, N. C., Lindenberger, U., Kühn, S., & **Werkle-Bergner, M.** (2019). Rostral locus coeruleus integrity is associated with better memory performance in older adults. *Nature Human Behaviour, 3,* 1203–1214. https://doi.org/10.1038 /s41562-019-0715-2

Link to LC Map
www.mpib-berlin.mpg.de /lc-map

Research Project 1: Lifespan Rhythms of Memory and Cognition (RHYME)

This project investigates lifespan changes in attention, working memory, and episodic memory at structural, functional, and behavioral levels of analysis, with an emphasis on age differences in the coordination of oscillatory brain activity. It combines experimental with longitudinal research designs and uses multimodal data from a wide range of neuroimaging methods. During the reporting period, the project's research activities were centered around four interrelated themes.

Aging Cognition, Neuromodulation, and Rhythmic Neural Activity

In their daily lives, individuals constantly experience a wide range of feelings, thoughts, and sensations. To permit goal-directed behavior and sustain cognitive development, some of these signals need to be enhanced whereas others need to be suppressed. At the neural level, this selection operation is implemented by a network of frontoparietal cortical regions, interconnected via the thalamus. Processing in this network is orchestrated through temporally synchronized activation patterns. Neuromodulators are of key importance in this process, as they regulate the efficacy of synaptic transmission. We hypothesize that senescent changes in the precision with which neuromodulators are released from brainstem nuclei might affect the functionality of selective processing, rendering selection more difficult with advancing adult age.

In a series of studies (Dissertation Martin J. Dahl) conducted in collaboration with Mara Mather from the University of Southern California, USA, we have probed the interaction between age-associated differences in the integrity and functionality of the central noradrenergic system and rhythmic neural activity in the alpha frequency range (~10 Hz). Structurally, we focused on the locus coeruleus (LC), a small brainstem nucleus that serves as the main source of norepinephrine (NE) in the brain. In the past, the LC's small size and location deep in the brain have prevented noninvasive studies of its integrity and functionality. Hence, in a first study (Dahl, Mather et al., 2019), we developed a semiautomatic method to derive individualized estimates of structural LC integrity from high-resolution neuromelanin-sensitive magnetic resonance images (MRI; see Figure 5). Applying these methods in samples of younger and older adults from the Berlin Aging Study II (see also pp. 138 ff.), we found that LC integrity correlated positively with individual differences in learning and memory across age groups and within the group of older adults. Analyses across the rostro-caudal extent of the LC revealed spatially confined and functionally relevant age differences in LC integrity. Critically, older adults who showed more youth-like intensity ratios in rostral, hippocampus (HC)-projecting LC segments also showed higher levels of memory performance. An LC probability map derived from this study is freely available to the neuroscience community to facilitate comparability of studies. Memory is tightly modulated by attention, but the contribution of adult age differences in attention to memory is not well understood. To reveal the interplay between the functionality of the NE system and rhythmic neural activity in the alpha frequency range that modulates attention, we used neuromelanin-sensitive MRI, pupillometry, and electroencephalography (EEG) to relate the structural and functional integrity of the central NE system to rhythmic neural activity in the context of a demanding auditory selective attention task. Recently, we used the same task to reveal a partial reorganization of attention-related rhythmic neural responses (Dahl, Ilg et al., 2019). We combined the auditory attention task with a fear-conditioning manipulation to manipulate NE release on a trial-by-trial level. During conditioning trials, we noted a reliable arousal response reflected in larger pupil responses and stronger desynchronization of rhythmic neural alpha activity for trials with the reinforced conditioned stimulus (CS+) compared to non-reinforced (CS–) trials. Critically, presentation of fear-conditioned stimuli during the auditory
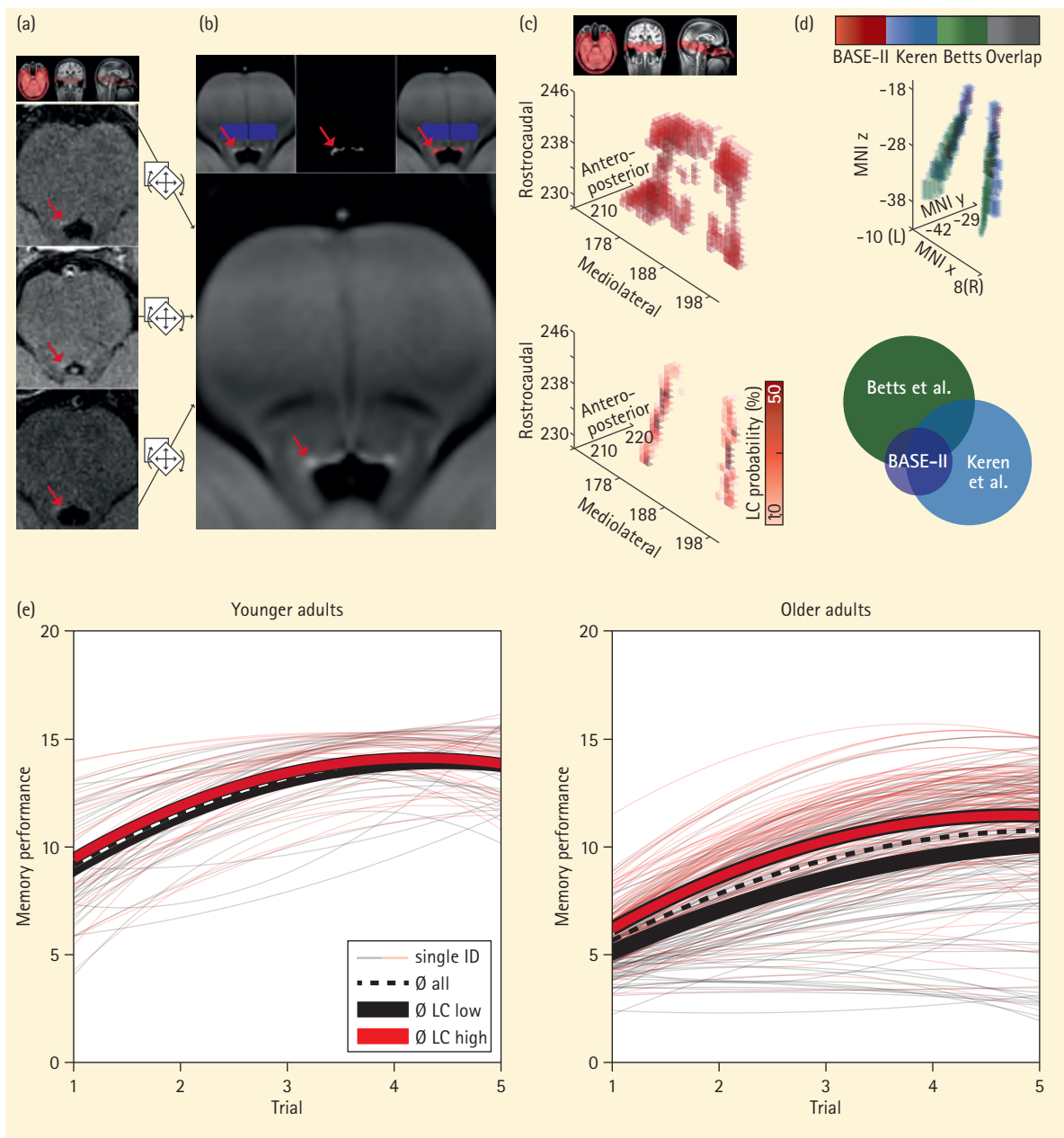
Figure 5. Schematic overview of the semiautomatic analysis procedure developed to extract individual locus coeruleus (LC) intensity values across the rostrocaudal extent. (a) Native-space neuromelanin-sensitive brainstem scans of three randomly selected participants (axial slices are shown). Hyperintensities corresponding to the LC are indicated by red arrows. (b) Neuromelanin-sensitive scans were aligned and pooled across participants to increase the signal-to-noise ratio and to facilitate LC delineation using a template-based approach. On a group level, LC location (red) was semiautomatically determined based on an intensity threshold relative to a pontine reference area (blue; see inlays). (c) Areas surviving the thresholding were grouped into a volume of interest (search space: upper plot; 3D representation) and used to restrict automatized extraction of individual peak intensities and their location. Observed peak LC locations were converted to a LC probability map (lower plot). (d) In standard space, the LC probability map was successfully validated using previously published maps. Circle radius indicates map size (i.e., number of voxels). (e) Estimated learning and memory performance trajectories for younger and older adults. To enable visualization of the association between LC integrity and memory performance, single participants (thin lines; ID) are color-coded based on LC integrity (median-split), and mean trajectories for subgroups are displayed (thick lines). Left: *n* = 33 younger adults in the low- and high-LC groups respectively; right: *n* = 114 older adults each in the low- and high-LC groups, respectively (adapted from Dahl, Mather et al., 2019).

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Key Reference

⊖**Muehlroth, B. E., Sander, M. C., Fandakova, Y., Grandy, T. H.**, Rasch, B., Shing, Y. L., & **Werkle-Bergner, M.** (2020). Memory quality modulates the effect of aging on memory consolidation during sleep: Reduced maintenance but intact gain. *NeuroImage, 209,* Article 116490. https://doi.org/10.1016/j.neuroimage.2019.116490

attention task reinstated the acquired arousal response in the absence of reinforcements. When combining the behavioral and physiological data in a structural equation model, we found that a more responsive noradrenergic system was associated with more proficient attention performance and that older adults showed a reduced responsiveness of the NE system relative to young adults (Dahl et al., 2020).

Taken together, these findings indicate that reduced structural integrity and functional responsiveness of the central noradrenergic system is associated with age differences in attention and memory. Specifically, our multimodal data suggest that age-related changes in noradrenergic neuromodulation might affect attention and memory through alterations in low-frequency rhythmic neural activity.

The Co-Development of Brain, Sleep, and Cognition

Sleep, like breathing, arguably belongs to the most basic bodily needs. Healthy sleep supports learning and memory, whereas lack of sleep hinders knowledge acquisition. After a day full of learning, sleep supports the stabilization and integration of experiences into a framework of personal memories while setting the stage for continued learning during ensuing wakefulness.

Thus far, most research into the causes of memory decline during adulthood and old age has focused on the encoding of new and the retrieval of previously acquired experiences. However, the long-term maintenance of new experiences also requires consolidation, defined as the stabilization of memory representations beyond initial encoding. According to the Active System Consolidation framework introduced by Jan Born and colleagues, sleep plays a central role in consolidation by facilitating interactions between fast-learning HC and slow-learning cortical systems.

Normal human aging entails fundamental changes in sleep and brain structure, even in the absence of pathology. To date, only few studies have attempted to unravel age differences in sleep physiology, brain structure, and memory consolidation. In part, this lack of relevant research reflects methodological problems when attempting to compare this triad across age groups.

In collaboration with Björn Rasch (University of Fribourg, Switzerland), we conducted a large age-comparative study on the influence of memory quality on encoding, consolidation, and retrieval (Dissertation Beate E. Mühlroth). The study consisted of a multisession protocol including behavioral, EEG, and MRI assessments, as well as ambulatory polysomnographic sleep monitoring. Healthy younger and older adults worked on an age-adapted associative memory task for two consecutive days. The task was developed to assess memory strength at the single-item level within each study participant. We aimed at disentangling the effects of reduced overnight forgetting from active enhancement of initially labile memory traces.

A first set of analyses targeted two main questions: first, whether age differences in sleep-dependent consolidation depend on the quality of memory representations formed during learning; and second, whether individual differences in sleep physiology and brain structure predict differences in consolidation within and across age groups (see Muehlroth, Sander et al., 2020). As expected, age differences in sleep-dependent memory stabilization were most pronounced at medium levels of encoding quality. Partial least squares (PLS) analyses identified differences in sleep physiology and brain structure that were associated with older age. However, when selecting younger and older adults based on their similarity in sleep physiology and brain structure, as reflected in the PLS scores, neither of the two in isolation was sufficient to account for age differences in consolidation (see Figure 6). We next sought to better understand what might drive the observed age differences in sleep-dependent consolidation. Active System Consolidation theory suggests that the transfer of labile HC-dependent representations into more stable cortical networks critically depends on the precise temporal coordination of cortical slow oscillations (SO) with fast-frequency thalamo-cortical spindles (Sp). Accordingly, animal research indicates that precise SO–Sp coupling is critical for consoli-
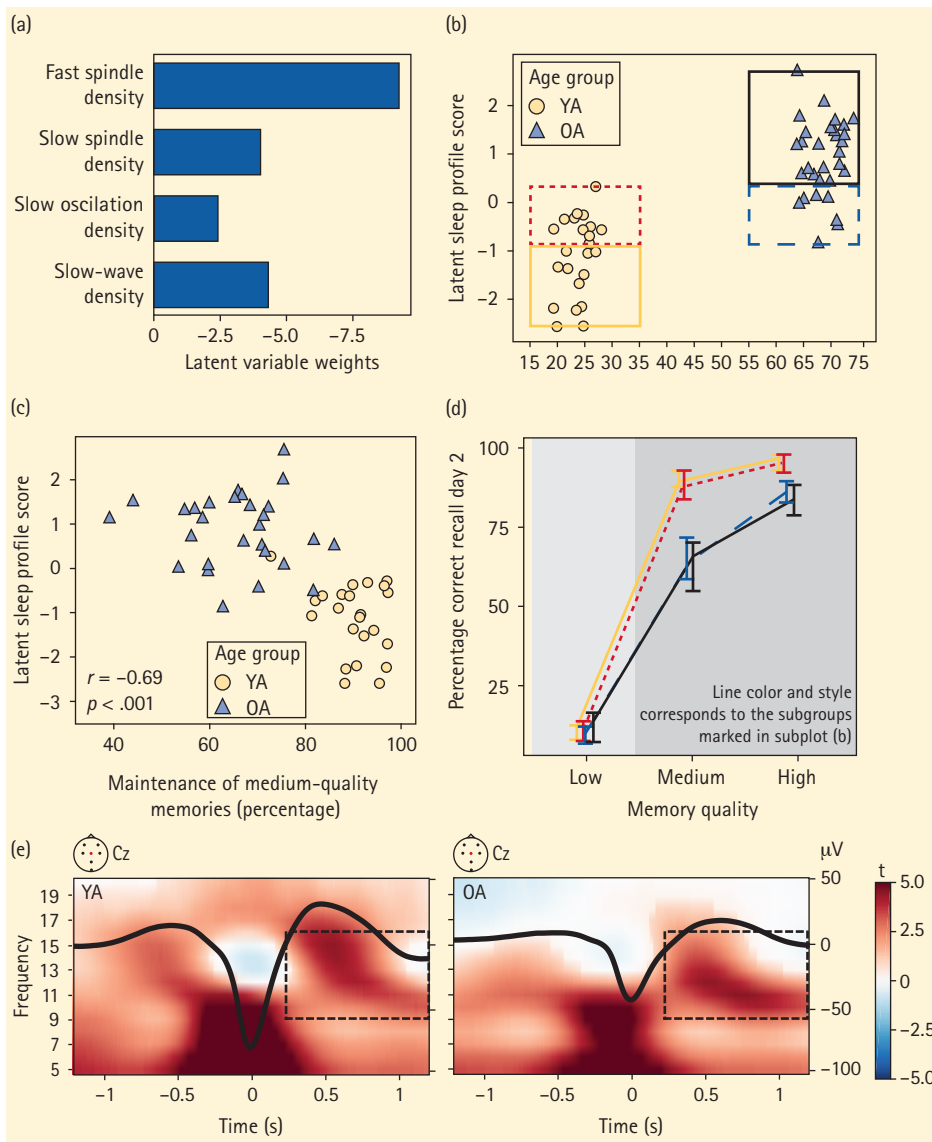
Figure 6. Sleep–memory associations in younger and older adults (adapted from Muehlroth et al., 2019, 2020). (a) Partial-least-squares solution relating physiological sleep indicators to age. The resulting latent variable captures the common variance between participants' age and sleep. Latent variable weights (in *Z*-scores) demonstrate that all physiological sleep indicators have a stable negative relation to age. (b) Each participant's expression of the latent variable is plotted against age. Overlap between the age groups is marked by dashed boxes. (c) Each participant's latent sleep-profile score is plotted as a function of memory performance. Spearman's rank-order correlation coefficients for the whole sample are displayed. Maintenance of medium-quality memories relates to the latent sleep-profile score across age groups. (d) Median behavioral performance for all subgroups is displayed, with grouping, line color, and style corresponding to (b). The first and third quartiles are depicted as error bars. Memory gain (shaded in light gray) is similar in all subgroups. Memory maintenance (shaded in darker gray) is modulated by sleep profile, but differs between younger and older adults even when they have the same sleep profile. (e) Age differences in slow-oscillation-spindle coupling (Muehlroth et al., 2019). Differences in wavelet power for slow-oscillations (SO) trials (respective down peak ± 1.2 s) compared to trials without SOs are depicted (in *t*-score units). The average frontal SO for each age group is inserted in black (the scale in μV is indicated on the right of each time–frequency graph). In both age groups, EEG power is modulated as a function of the SO phase. In younger adults (on the left), fast spindle activity (12–15 Hz) peaks during the up peak of the SO. Slow spindle power (9–12 Hz) is strongest at the up- to down-state transition. In older adults (on the right), power increases are delayed and shifted to lower frequencies as compared to younger adults.

YA: younger adults; OA: older adults.

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dation. Most studies in humans thus far have looked at the contributions of each of the two components, but not at the precision of their coupling.

We used individually adjustable detection algorithms to identify individual SO and Sp events (see Muehlroth et al., 2019). On that basis, we were able to show that less precise coupling between slow waves and spindles is indeed associated with lower overnight memory maintenance among older adults. In addition, older adults with greater structural integrity of brain regions relevant for sleep and memory were more likely to show precise coupling patterns resembling those of younger adults than older adults with lower brain integrity.

In sum, this line of research suggests that age differences in sleep-associated consolidation depend on the precise coupling among cardinal neural sleep rhythms supported by the integrity of relevant brain structures.

Research on sleep and aging has sought to develop new approaches to identify and possibly treat age-associated pathological conditions. In particular, attempts to establish sleep as a novel biomarker and treatment target for Alzheimer's disease have led to a growing interest in research on sleep and aging. This rise in interest has not been matched by a careful scrutiny of data-analytic procedures.

In a theoretical and empirical analysis (Muehlroth & Werkle–Bergner, 2020), we used electrophysiological sleep and structural brain data of healthy younger and older adults to identify, illustrate, and resolve methodological core challenges in the study of sleep and aging. We demonstrated potential biases in common analytic approaches when applied to heterogeneous populations, especially regarding markers of rhythmic neural activity during sleep. Using empirical demonstrations, we show that uncovering age-dependent alterations in the physiology of sleep requires the development and use of age-group adjusted and individualized data-analytic procedures. Ultimately, these innovations may yield valid and reliable biomarkers that discriminate

between normal and pathological age-related changes in sleep physiology.

A key challenge for the age-adapted analysis of rhythmic neural activity—like sleep oscillations—is the identification of individual rhythmic events and their separation from arrhythmic background activity. In collaboration with the Lifespan Neural Dynamics Group (see also pp. 195 ff.), we extended and improved an existing rhythm detection method (Kosciessa et al., 2020; see also p. 199 for further details).

Development of Memory Specificity and Intra–Hippocampal Maturation

At the other end of the lifespan, the project has begun to link HC maturation to memory development. Just as any other adaptive learning system, children are confronted with two conflicting goals. They need to detect regularities in the world through generalization while remembering specific events through disambiguation. Core aspects of these functions are implemented in the internal neural circuits of the HC. Animal studies suggest that HC subfields reorganize during maturation. Studying this reorganization in the human HC is technically challenging. As a result, the ontogenetic timing of HC maturation is controversial, and its contribution to generalization and specificity in cognitive development remains elusive. In a study using high-resolution in-vivo MRI data from children (6–14 years old) and younger adults (Keresztes et al., 2017), we were able to identify a multivariate profile of age-related differences in intra-HC structures and to show that HC maturity as captured by this pattern is associated with age differences in the differential encoding of unique memory representations. The uneven time course of HC subfield maturation identified in this study provides a mechanistic explanation for the observation that generalization precedes specification in memory development during childhood (for a theoretical overview, see Keresztes et al., 2018).

Research Project 2: Lifespan Age Differences in Memory Representations (LIME)

LIME investigates mechanisms of memory formation, consolidation, and retrieval, with a focus on the ways in which these mechanisms change across the lifespan (see Sander et al., 2012). The project addresses the fundamental question whether aging-induced decrements in the distinctiveness of neural representations contribute to age-related losses in memory performance during adulthood and old age. Providing answers to this question requires the coordination of concepts and methods from lifespan psychology, cognitive neuroscience, and computational neuroscience. Accordingly, the project relies on experimental research designs, advanced multimodal imaging methods, and computational modeling. The project continues and broadens the work of Myriam Sander's Minerva Group, which was established in 2016.

Research Area 1: Age Differences in Similarity and Distinctiveness of Memory Representations

Are memories represented differently in older than in younger adults? According to the dedifferentiation hypothesis, age-related cognitive decline during adulthood and old age reflects decrements in the distinctiveness of neural representations and processing pathways (Li et al., 2001). In line with this hypothesis, pioneering work by Denise Park and colleagues has shown that differences in the neural representation between items belonging to different categories, such as houses and faces, are less pronounced in older adults than in younger adults. However, most studies thus far have not yet linked differences in the distinctiveness of individual memory representations to adult age differences in cognitive performance. In the LIME project, we systematically probe whether links between neural distinctiveness and performance help to elucidate adult age differences in episodic memory.

In pursuing this research question, the project makes ample use of subsequent memory paradigms, which analyze recall success as a function of neural activity during encoding, such as variations in oscillatory power measured with electroencephalography (EEG). In particular, power increases in the theta band accompanied by power decreases in the alpha/beta bands have been shown to indicate associative binding and elaboration mechanisms in young adults. We were able to show that these oscillatory mechanisms of successful memory formation remain relevant in old age (Sander et al., 2020; see Figure 7).

In addition, multimodal analyses revealed a clear structure–function relationship between the integrity of memory-related brain regions and the strength of the oscillatory subsequent memory effect. In particular, older adults' lower structural integrity of the inferior frontal gyrus (IFG), a region known to be involved in elaboration processes, was accompanied by reduced subsequent memory effects in the alpha frequency. Taken together, these results indicate that memory representations tend to be formed with fewer details with advancing adult age (Sander et al., 2020), with downstream consequences for long-term maintenance and forgetting (see Fandakova et al., 2020).

Recent results from another study support the hypothesis that older adults form less detailed representations than younger adults. Using representational similarity analysis, we compared the similarity of spatiotemporal EEG frequency patterns during initial encoding in relation to subsequent recall performance in younger and older adults (Dissertation Verena Sommer; Sommer et al., 2019). Specifically, we addressed the question whether successful memory is reflected in relatively more distinct or relatively more similar patterns of neural activity in younger and older adults. We found that the association between memory success and pattern similarity differed between young and older adults, suggesting age differences in basic cognitive encoding processes. For older adults, better memory performance was linked to higher similarity during early stages of encoding. For younger adults, lower similarity during later periods of encoding was positively related to memory performance

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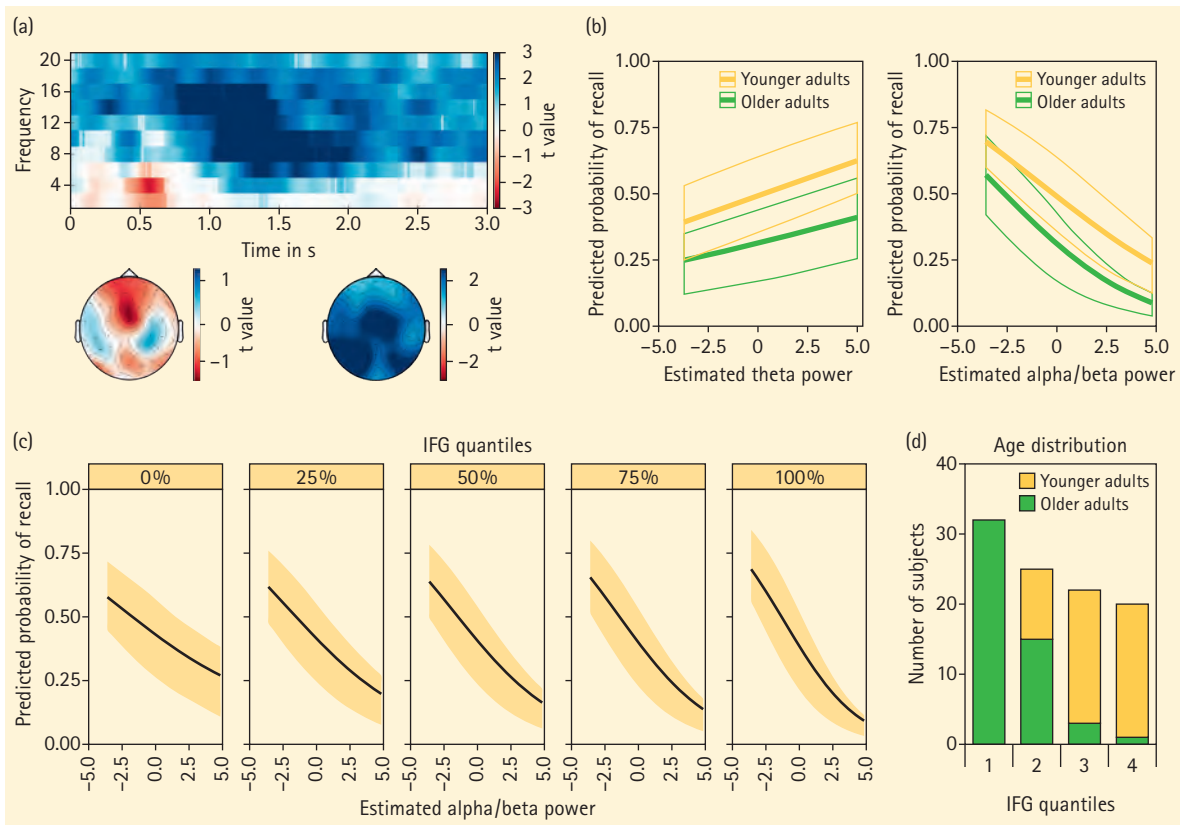
Figure 7. (a) Time-frequency plot of subsequent memory effects (thus, the difference in power of recalled vs. not-recalled word pairs) in theta and alpha/beta power, collapsed across age groups. (b) Power modulations in theta (left) and alpha/beta (right) frequencies predict single trial accuracy in both younger and older adults. (c) Alpha/beta band power is more predictive for memory recall in participants with high cortical thickness of the inferior frontal gyrus (IFG) than in those with lower cortical thickness, as shown by displaying predicted probabilities of varying alpha power for IFG quantiles. (d) Distribution of older and younger adults across different levels of structural integrity of the IFG (represented by quantiles). Most of the participants with low cortical thickness are older, indicating that reduced memory performance in older adults can be attributed to lower structural integrity of the IFG, which is related to smaller subsequent memory effects in alpha/beta power (adapted from Sander et al., 2020).

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(see Figure 8). These results suggest that older adults rely more on encoding the general gist of stimuli, reflected in increased early encoding similarity, whereas young adults tend to form and encode mental images with distinct details, reflected in increased dissimilarity during later phases of encoding.

In our ongoing studies, we take a closer look at adult age differences in representational patterns. In a recent functional magnetic resonance imaging (fMRI) paradigm, we went beyond the mass-univariate characterization of neural specificity at the category level, and instead used representational similarity analyses to relate memory performance differences between age groups to neural

pattern stability across repeated exposures, and to neural pattern similarity of different exemplars within one semantic category relative to the similarity of objects from different categories. Initial analyses suggest that the stability or self-similarity of neural representations at the item level, relative to their similarity to other items of the same category, is negatively related to adult age and positively related to memory performance.

Adaptation paradigms offer yet another approach to probe the specificity of representations. These paradigms rest on the assumption that neuronal populations reduce their responses (i.e., adapt) when stimulus features to which they are sensitive are repeated.
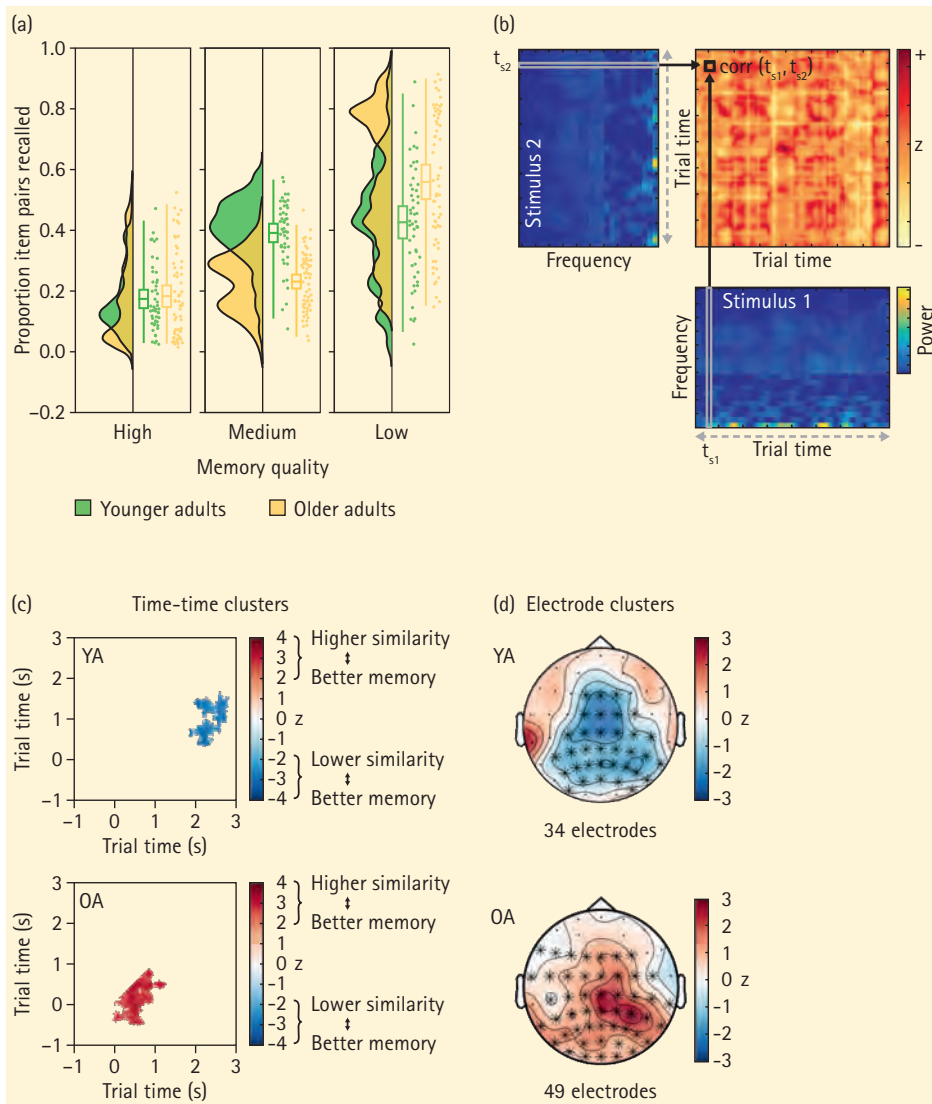
Figure 8. (a) Age differences in the quality of memory representations. In this study, participants repeatedly studied word–scene pairs followed by several rounds of cued recall. The quality of memory representations was defined by the fate of the individual pair across the course of the experiment. The figure shows the proportion items with high, medium, and low memory quality for young adults (YA) and older adults (OA). Older adults have a lower proportion of medium-quality and a higher proportion of lower-quality items than younger adults. (b) Spectral representational similarity analysis methodology. Frequency vectors from every time point of stimulus 1 are Pearson-correlated with frequency vectors from every time point of stimulus 2 (corr(t_{s1}, t_{s2})) resulting in a time-time similarity matrix representing the similarity of the frequency patterns of these two stimuli at all possible time-time combinations at one electrode. (c) Time-time clusters with the corresponding topography (d) in which the stimuli of different memory quality reliably differed from another in each age group. Whereas higher similarity in an early (positive) cluster is related to a higher recall probability in older adults, higher distinctiveness (negative cluster) is beneficial for memory performance in younger adults (adapted from Sommer et al., 2019).

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The magnitude of adaptation is thus a direct measure of representation specificity. In a lifespan EEG study, we investigated whether differences in adaptation magnitudes predict differences in memory performance between children, young adults, and older adults (Dissertation Verena Sommer). To this end, we varied the number of exposures and the degree of similarity to other stimuli of visually presented objects. Event-related potentials displayed adaptation effects in all age groups and were associated with memory specificity. Our findings demonstrate that adaptation effects reflect encoding mechanisms that facilitate the formation of stimulus-specific memory representations, again highlighting their significance as neural indicators of individual differences in episodic memory across the lifespan. The extension of this investigation to child development was accomplished in collaboration with Sarah Weigelt (formerly Ruhr-Universität Bochum, now Technische Universität Dortmund).

Research Area 2: Effects of Context on Memory Representations

Successful memory is greatly aided by the spatial and temporal settings of an event, commonly referred to as its context. This dependency of memory on context increases with advancing adult age (Lindenberger & Mayr, 2014). At the same time, and somewhat paradoxically, older adults find it particularly difficult to actively retrieve specific object–context associations. Based on these observations, our studies aim at a better understanding of age differences in the contextualization of memories and the precise conditions under which memory performance benefits from context reinstatement.

In a large multimodal study that combined EEG, functional and structural MRI, and eye tracking, we have been investigating how context shapes younger and older adults' memories for objects (Dissertation Anna Karlsson; see Figure 9a). We established a high-resolution multiband fMRI sequence that will allow us to track functional activations at the level of hippocampal subfields. So far, our behavioral results support the well-known observation of lower pair memory performance in older adults compared to younger adults, with no age group differences in object memory. For object memory performance, context reinstatement was beneficial in both age groups, and seeing an object in both a familiar and a new context impaired performance. However, pair memory was only reduced when participants saw an object in a familiar, incorrect context, but not with a new context. These results suggest different contributions of familiarity and novelty detection for object and pair memory (see Figure 9b). Our electrophysiological results suggest that power modulations during encoding, as indicated by subsequent memory effects in alpha/beta band and theta band power measured with EEG, predict single-trial accuracy for both objects and object–context pairs. Interestingly, alpha/beta desynchronization was modulated by both context condition and age group. Larger desynchronization was related to a larger beneficial effect of context for pair memory when the context was old as compared to familiar, and more so in younger than in older adults. This result suggests that younger adults' deeper elaboration during encoding is a way to establish a reliable representation of the object–context pair that comes with a higher probability of recall. We are currently following up on these findings by investigating learning-related changes in neural patterns of object-specific representations in the hippocampus as captured by fMRI.
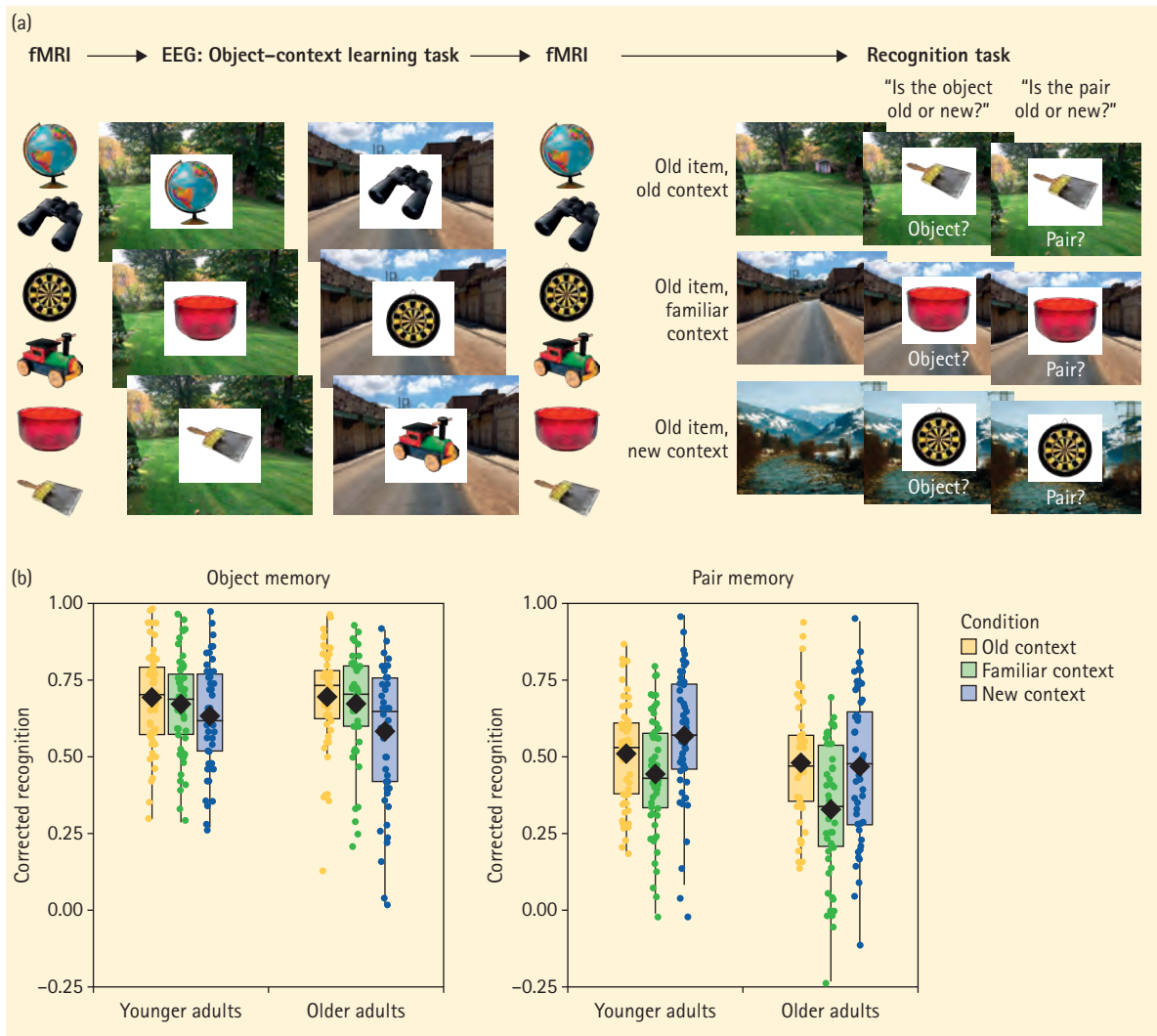
Figure 9. (a) Experimental paradigm of the multimodal study that combined EEG, functional MRI, and structural MRI to investigate the effect of context on memory (Dissertation Anna Karlsson). Participants were first familiarized with pictures of objects in the scanner to measure object-specific activation patterns. The main experiment consisted of an object–context learning paradigm during which EEG was assessed. This was followed by a postlearning fMRI measurement intended to reveal changes in memory representations. Finally, participants took a recognition memory test in which objects were presented with either the original learning context, a familiar context, or a new context. We first tested their memory for the object, followed by the question whether the object–context pair was the same as during learning. (b) First behavioral results: Corrected recognition scores (hits minus false alarms) for the different context conditions (old/familiar/new) as a function of age for object memory (left) and pair memory (right). Age groups differ when the retrieval of object–context pairs is required, but not when only objects need to be recalled. Context reinstatement (original context) benefits performance in both age groups, and seeing an object with a familiar, but incorrect context impairs performance.

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Research Project 3: The Berlin Aging Studies (BASE & BASE–II)

In the course of the 20th century, average life expectancy almost doubled. More and more individuals will experience additional years of life between the ages of 70 and 100+. What do these added years mean in terms of functional capacity and quality of life? And how do the years and months preceding death in old age differ from the years before? In concert with other longitudinal studies, the Berlin Aging Studies provide a basis for answering questions of this sort. The specific focus of the BASE project at the Center for Lifespan Psychology is on cognitive, psychosocial, and methodological aspects in the study of human aging.

For more than three decades, members of the Center have been investigating age- and death-related changes in psychological functioning in the context of the Berlin Aging Study (BASE; Baltes & Mayer, 1999; Lindenberger et al., 2010) and the Berlin Aging Study II (BASE–II; Demuth et al., 2019). Both studies are highly collaborative and multidisciplinary, involving researchers from institutions inside and outside Berlin. The two studies also take part in the Lifebrain consortium, which is funded under the European Union Horizon 2020 Framework Programme (Walhovd et al., 2018; cf. p. 139).

The Berlin Aging Study (BASE)

Longitudinal data in BASE are available for eight measurement occasions spanning more than 18 years, and mortality-related information has been updated at regular intervals. Mrs. A. was one of the 516 individuals who started participating in BASE almost 30 years ago. After having participated in all of the seven measurement occasions that followed the initial assessment, she died in December 2019 at the age of 107. As Figure 10 shows, she led an active life in her own home until a fall forced her to move into a nursing care institution about three months before her death. Additional biographical data reveal what a remarkable person she was (see Figure 11). Her life history reminds us that the data we analyze are greatly abstracted and impoverished representations of real people. As in previous years, the BASE data have continued to provide the basis for new original publications on individual differences in late-life development (e.g., Mueller et al., 2018).

Figure 10. BASE participant Mrs. A., aged 106, at her home during a visit by BASE colleagues Denis Gerstorf and Sandra Düzel in 2018.
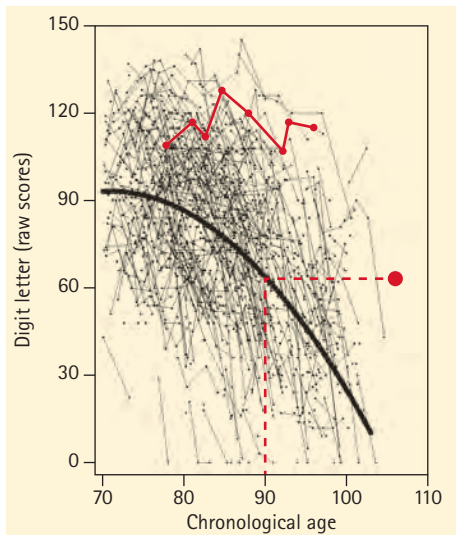
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Figure 11. BASE participants' score trajectories in the Digit Letter test, with Mrs. A.'s scores highlighted in red. At the age of 106 (larger dot), her score was still at the level of the average 90-year-old BASE participant.

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The presence of similar or identical measures in BASE and BASE-II (see below) allow for estimates of cohort differences in various aspects of normal aging, such as control beliefs (Gerstorf et al., 2019) and cardiovascular health (König et al., 2018). The results from these studies document the extent to which societal changes can influence the course of normal aging in desirable directions within relatively short periods of time.

The Berlin Aging Study II (BASE-II)

The Psychology Unit of BASE-II aims at obtaining a comprehensive picture of age-related differences and changes in brain and behavior. In search of mechanistic explanations for individual differences in normal aging, we use advanced statistical modeling techniques to investigate the impact of risk factors, such as metabolic syndrome and loneliness, and protective factors, such as physical activity.

Adults' brains differ reliably in the onset and degree of age-related volume losses. Age-related changes in cognition have been associated with differences in structural brain parameters, including cerebral white matter (WM) microstructure, hippocampal (HC) volume, as well as the integrity of neurotransmitter systems such as the locus coeruleus. By combining newly developed semiautomatic analysis procedures to assess HC subfield volumes with structural equation modeling techniques, Bender et al. (2020) found that structural characteristics of limbic WM regions and HC volume jointly contribute to verbal learning in older adults. Moreover, rates of shrinkage of brain regions and cognitive changes were exacerbated by hypertension and metabolic syndrome. Düzel, Buchmann et al. (2018) used structural equation modeling to set up a latent factor of metabolic load that was associated with indicators of physical health in both men and

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Lifebrain

BASE and BASE-II are participating in Lifebrain, a consortium of European studies funded by the EU Horizon 2020 Framework Programme. Lifebrain aims at identifying determinants of healthy lifespan development by integrating and harmonizing data and results from 11 large and predominantly longitudinal European samples from seven countries. This has yielded a database of fine-grained measures focusing on brain and cognition from more than 7,000 individual participants. A further goal of Lifebrain is to develop better statistical tools and routines for meta-analyzing longitudinal data.

Lifebrain consortium members also conducted a qualitative study to collect views and attitudes on the brain, personalized brain health, as well as interest in maintaining a healthy brain. Interviews were conducted in Spain, Norway, Germany, and the United Kingdom (Friedman et al., 2019). A global brain health survey at https://nettskjema.no was launched in 2019 to systematically explore public perceptions of personalized brain health.

www.lifebrain.uio.no

Lifebrain

Lifebrain Researchers at the MPI for Human Development

Ulman Lindenberger	Sandra Düzel
Simone Kühn	Maike M. Kleemeyer
Andreas M. Brandmaier	Ylva Köhncke

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women. In men, the metabolic load factor was also related to fluid intelligence. In a study conducted with colleagues from RHYME, structural integrity of the LC integrity was found to correlate positively with individual differences in learning and memory, both across age groups and within the group of older adults (Dahl et al., 2019; for details, see pp. 128 ff.)

In another line of work, we have examined neurobiological correlates of associations between psychosocial factors and cognitive performance. In particular, we have focused on people's future time perspective (FTP). In a special issue of *GeroPsych* (Düzel & Gerstorf, 2018a), we compiled five empirical reports from different areas of psychology to showcase the multifaceted nature of FTP, delineating its antecedents, correlates, and consequences at experiential, physiological, and behavioral levels of analysis. For instance, Düzel, Drewelies et al. (2018) reported that FTP dimensions assessing cognitive and physical future lifestyles are differentially linked with brain regions known to process future planning and represent bodily states, respectively. In a study on loneliness, we found that individuals with higher self-reported loneliness tended to have smaller gray matter volumes of brain regions that are central to cognitive processing and emotional regulation, even after statistically controlling for social network size (Düzel et al., 2019). Presumably, individuals reporting higher loneliness might be less likely to engage in active, socially and cognitively stimulating lifestyles that, in turn, might contribute to brain maintenance and the preservation of cognitive abilities (Nyberg & Lindenberger, 2020). Taken together, these results suggest that psychosocial behaviors and cognitive aging are linked through multiple neurobiological mechanisms and pathways. A mechanistic and individualized understanding of these links might facilitate the design of effective strategies for preserving cognitive health in old age.

The physical environment and neighborhood characteristics are also likely contributors to individual health and well-being. Some regional characteristics such as noise and pollution affect health directly, whereas other regional characteristics might affect health and well-being indirectly by either providing resources or limiting their use. To explore such dependencies, BASE-II has linked georeferencing data to brain characteristics at the individual level. Motivated by animal models of enriched environments, we used confirmatory factor analysis to represent the structural integrity of three brain regions at the latent level and then explored associations between brain integrity and the relative amounts of forest, urban green, water, and wasteland around the home address. A positive association between amygdala integrity and forest coverage was found, pointing to its potentially salutogenic effects (Kühn, Düzel et al., 2017). This line of work will be pursued further in collaboration with the Lise Meitner Group for Environmental Neuroscience led by Simone Kühn (see pp. 185 ff.).

Future Research Directions

In the meantime, multiple waves of data have been collected in BASE-II, turning it into a veritable longitudinal data set, with currently up to 8 years of longitudinal data. We are now setting up structural equation models that quantify level and change dependencies among cognitive abilities, the integrity of various brain regions, and their interrelations. We also continue our efforts to harmonize behavioral and MR data across the various studies and sites of the Lifebrain consortium to aid cross-country comparison and generalization. An initial result of this approach is a study reporting associations between self-reported sleep and hippocampal atrophy (Fjell et al., 2020).

Overview of the Berlin Aging Study (BASE)

The multidisciplinary Berlin Aging Study (BASE), initially directed by the late Paul B. Baltes and Karl Ulrich Mayer, was started in 1989. Ulman Lindenberger is the current BASE speaker. The study spans eight measurement occasions spaced over 18 years. Its distinguishing features include (1) a focus on the very old (70 to 100+ years); (2) a locally representative sample, stratified by age and sex; and (3) a broad-based interdisciplinarity (originally involving two research units from the Freie Universität Berlin, Internal Medicine and Psychiatry, and two from this Institute, Sociology and Psychology). In addition to discipline-specific topics, four integrative theoretical orientations guide the study: (1) differential aging, (2) continuity versus discontinuity of aging, (3) range and limits of plasticity and reserve capacity, and (4) aging as a systemic phenomenon.

The initial focus of BASE (1990–1993) was to obtain a heterogeneous sample, stratified by age and sex, of individuals from the western districts of Berlin aged 70 to 100+ years. A core sample of 516 men and women completed the Intensive Protocol comprising detailed measures from all four participating disciplines. Seven longitudinal follow-ups involving different depths of assessment were completed at approximately 2-yearly intervals. Details of the research design and assessment protocols can be found on the BASE website. The core sample formed the basis of the analyses reported in two monographs (see Baltes & Mayer, 1999; Lindenberger et al., 2010). Current work uses the longitudinal data to address issues such as variability and change, mortality prediction, self-related change, and genetic and socioeconomic predictors of cognitive change.

The Berlin Aging Study: International Research Group

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Alexandra M. Freund	University of Zurich, Switzerland
Denis Gerstorf	Humboldt-Universität zu Berlin, Germany
Paolo Ghisletta	University of Geneva, Switzerland
Christiane Hoppmann	University of British Columbia, Vancouver, Canada
Dana Kotter-Grühn	North Carolina State University, Raleigh, USA
Shu-Chen Li	Technische Universität Dresden, Germany
Ulman Lindenberger	MPI for Human Development, Berlin, Germany (Speaker)
Nilam Ram	Pennsylvania State University, University Park, USA
Jacqui Smith	University of Michigan, Ann Arbor, USA (Co-Speaker)
Ursula M. Staudinger	Columbia University, New York, USA
Elisabeth Steinhagen-Thiessen	Charité Universitätsmedizin Berlin, Germany
Gert G. Wagner	MPI for Human Development, Berlin, Germany (Max Planck Fellow)

Overview of the Berlin Aging Study II (BASE-II)

The central objective of the multidisciplinary and multi-institutional longitudinal Berlin Aging Study II (BASE-II; see Bertram et al., 2014) is to promote a better understanding of individual differences and trajectories in cognitive, psychosocial, and physical functioning by integrating multidisciplinary perspectives and data. In doing so, it conceives of aging as a systemic phenomenon and seeks to delineate sources of heterogeneity in aging trajectories. BASE-II samples molecular genetic and immunological markers and uses instruments from the German Socio-Economic Panel (SOEP) that provide georeferencing data and information about participants' socioeconomic background and living conditions. BASE-II is structured into four research units: (1) Psychology, (2) Sociology (including Economics) and Survey Methods, (3) Medicine (including Immunology), and (4) Molecular Genetics. Like its predecessor BASE, BASE-II follows a longitudinal design: At the first wave of measurements (T1), the BASE-II sample consisted of 1,600 participants aged 60 to 80 years and 600 individuals aged 20 to 35 years. Data collection of the first wave was completed in 2014. In close collaboration with Simone Kühn, eligible BASE-II participants ($n = 445$) were additionally invited for a structural magnetic resonance imaging (MRI) assessment of the brain, comprising T1-weighted imaging, resting state data, diffusion tensor imaging, and high-resolution imaging of the hippocampus. In 2015, this MR subsample was invited again for another wave of cognitive and psychosocial assessments and a second MRI session ($n = 327$). In November 2017, the older cohort of 1,600 men and women from the original BASE-II sample was re-invited in the context of the project, Sex- and Gender-Sensitive Prevention of Cardiovascular and Metabolic Disease in Older Adults in Germany (*GendAge*, funded by the Federal Ministry of Education and Research). *GendAge* includes most of the medical and biological assessments of T1, along with a third wave of cognitive and psychosocial assessments. In addition, accelerometers are used to track participants' physical activity and sleep for a week. This data collection is ongoing and will contribute to BASE-II, allowing us to further investigate individual differences in aging trajectories (for an overview, see Demuth et al., 2019).

The Berlin Aging Study II: Steering Committee

Denis Gerstorf	Humboldt-Universität zu Berlin, Germany (Speaker)
Lars Bertram	Universität zu Lübeck, Germany
Ulman Lindenberger	MPI for Human Development, Berlin, Germany
Elisabeth Steinhagen-Thiessen	Charité Universitätsmedizin Berlin, Germany
Graham Pawelec	University of Tübingen, Germany
Gert G. Wagner	MPI for Human Development, Berlin, Germany (Max Planck Fellow)

Coordination

Ludmila Müller	MPI for Human Development, Berlin (as of 08/2019)
Katrin Schaar	MPI for Human Development, Berlin (until 07/2019))

Research Scientists

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Maike M. Kleemeyer
(as of 09/2019)
Corinna Laube
(01/2019–04/2020)
Ulman Lindenberger
Ziyong Lin
(as of 11/2018)

Neda Khosravani
Eleftheria Papadaki
(as of 11/2018)

Research Project 4: Mechanisms and Sequential Progression of Plasticity

This project addresses the questions of whether and how plasticity contributes to development across the lifespan. We use training studies as a method of choice to probe antecedents, mechanisms, and consequences of plastic change across different age groups and functional domains. Special attention is given to the dynamics of plastic changes across structural, functional, and behavioral levels of analysis.

The human brain is plastic—it possesses the capacity to implement lasting structural changes in response to environmental demands that alter its functional and behavioral repertoire (Lindenberger & Lövdén, 2019; Wenger & Kühn, in press). We assume that plasticity is induced by a mismatch between environmental demands and an individual's current behavioral and neural resources. It is metabolically costly and competes with the need for stability, which facilitates the development of a well-orchestrated set of habits and skills. The resulting interplay of mechanisms promoting plasticity versus stability organizes development into mul-tiple alternating and sequentially structured periods that together support the hierarchical organization of cerebral functions and behavior (Lindenberger, 2018).

Plasticity in the Motor Domain

The acquisition of skilled motor performance provides a rich testing ground for exploring the mechanisms and progression of plasticity. In a pioneering study, we acquired up to 18 structural magnetic resonance (MR) images over a 7-week period while 15 right-handed participants practiced left-hand writing and drawing (Wenger, Kühn et al., 2017). After 4 weeks of training, we observed increases in gray matter in both the left and right primary motor cortices relative to a control group; another 3 weeks later, these differences were no longer reliable. Time-series analyses confirmed that gray matter in both primary motor cortices expanded during the first 4 weeks and then partially renormalized, in particular in the right hemisphere, in the presence of continued practice and increasing task proficiency. Based on this pattern, which is in good agreement with macroscopic and microscopic curvilinear changes observed in nonhuman primates and rodents, we have proposed that plastic changes might often follow a sequence of initial tissue expansion, selection of the most suitable circuitry, and partial or complete renormalization to baseline levels (see Figure 12; Wenger, Brozzoli et al., 2017; see also Lindenberger & Lövdén, 2019).

Motor skill acquisition involves brain regions that vary considerably in their developmental trajectories during childhood. Frontal regions, which dominate initial learning and are thought to contribute to the demand–capacity mismatch representation that triggers a plastic response, mature relatively late in childhood (Fandakova et al., 2018).
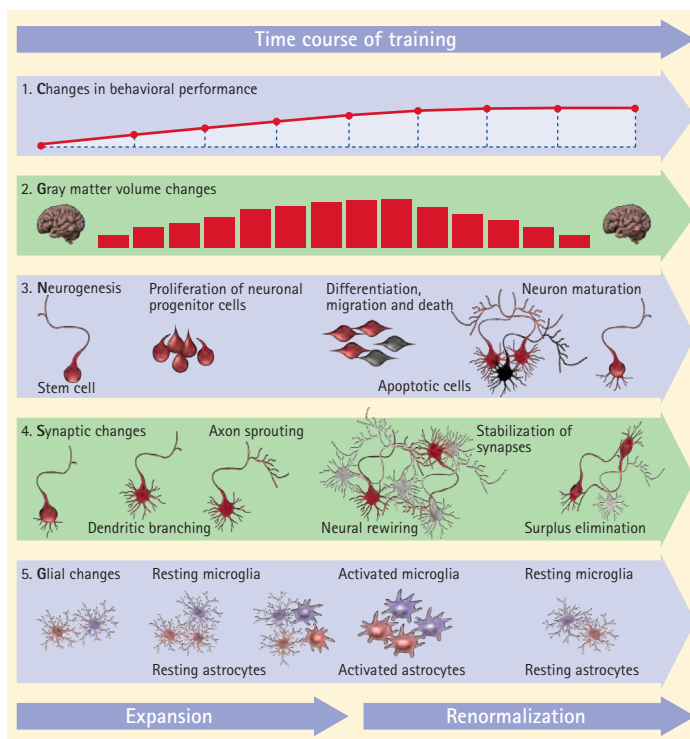

Figure 12. Schematic illustration of potential cellular changes underlying gray matter volume expansion and renormalization as detectable with magnetic resonance (MR) images (adapted from Wenger, Brozzoli et al., 2017).
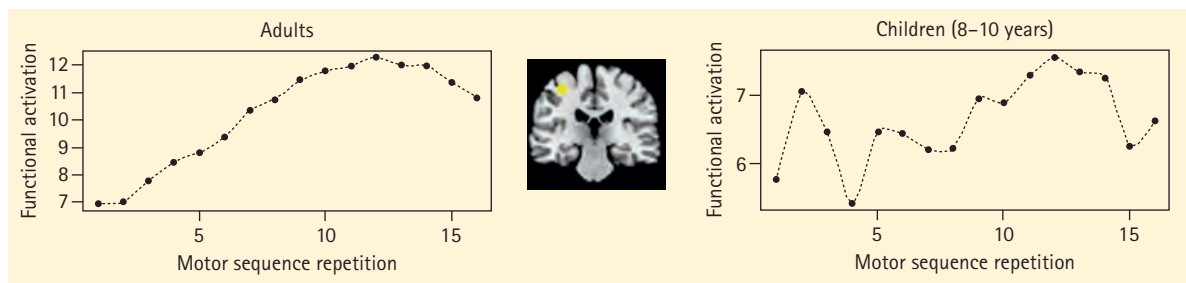
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Figure 13. The learning of a novel motor sequence is associated with greater changes in left motor cortex activity in adults than in children. While adults' motor cortex activity increased with the repeated execution of the sequence and increasing proficiency, children's motor cortex was already engaged early on during learning.

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In contrast, primary motor regions, which dominate later phases of learning, mature relatively early. To evaluate the consequences of these maturational differences, we have examined age differences in motor sequence learning between young adults and children (8–10 years). Preliminary results suggest that both children and adults show decreasing frontal activation with increasing task proficiency. However, while adults showed a corresponding selective increase in motor cortex activation over time, children activated primary motor cortex both during early and late phases of learning (see Figure 13). In the context of extended skill acquisition, these age differences in activation may suggest that structural plastic changes in primary motor areas manifest themselves/occur earlier in children than in young adults.

Plasticity in the Auditory Domain
Music expertise relies on several sensory systems and the motor system and also poses high demands on control processes. Therefore, it offers a promising model for studying how specific forms of experience interact with preexisting individual differences to mold the structure and function of the brain. In an initial investigation, we investigated plastic changes in aspiring professional musicians who were preparing intensely for a highly competitive entrance exam at a university of the arts in comparison to skilled amateur musicians. Over the course of 6 months, we observed decreases in gray matter in the aspiring professional musicians in the left planum polare, posterior insula, and left inferior

frontal orbital gyrus. The left planum polare, where the largest cluster of structural change was found, also showed increasing functional connectivity to other regions known to contribute to music expertise (see Figure 14). This increased connectivity was also reflected in analyses based on graph theory, pointing to the participation of the planum polare in a complex network. These results may provide further evidence for the expansion–renormalization pattern of brain structure in humans in the auditory domain if we assume that we captured the second portion of an expansion–renormalization cycle.

In a study that is currently underway, we aim to delineate patterns of plasticity over time in both the auditory and the visual domain and to better characterize the interplay between structural and functional plastic changes (Dissertation Eleftheria Papadaki). A group of young adults will be trained to discriminate between short melodies based on so-called microtonal intervals, which are considerably smaller than one semitone. During the 8-week training period, participants will undergo weekly structural and functional MR assessments. A second group will be trained in a visual discrimination task and will also be scanned eight times during the training period, allowing us to probe the applicability of the expansion–renormalization model in yet another sensory domain.

Boosting Plasticity in the Aging Brain
In the context of "Energizing the Hippocampus in Aging Individuals (EnergI)," a consortium funded by the Federal Ministry of

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Wenger, E., Brozzoli, C., **Lindenberger, U.,** & **Lövdén, M.** (2017). Expansion and renormalization of human brain structure during skill acquisition. *Trends in Cognitive Sciences, 21*(12), 930–939. https://doi.org/10.1016/j.tics.2017.09.008

(a)
Left planum polare | Left posterior insula | Left inferior frontal orbital gyrus

x = −48, y = −14, z = 0 | x = −38, y = −3, z = −21 | x = −32, y = 24, z = −6

(b)

Left superior temporal gyrus
right superior temporal gyrus
right superior temporal pole
left superior temporal pole
left precentral gyrus
left posterior cingulate cortex
left supplementary motor area left postcentral gyrus right postcentral gyrus
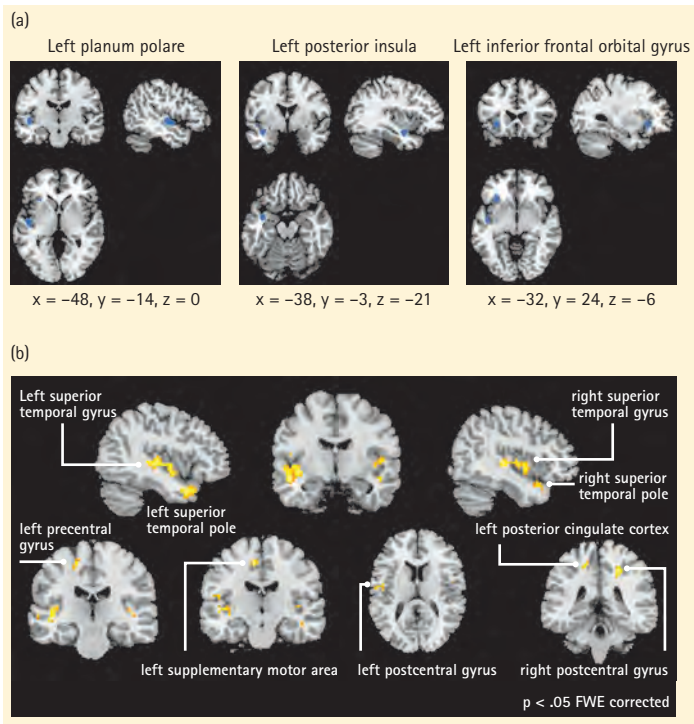
p < .05 FWE corrected

Figure 14. (a) While preparing for their entrance exam, aspiring professional musicians showed decreases in gray matter in the left planum polare, posterior insula, and left inferior frontal orbital gyrus. (b) In the aspiring professionals, but not among the amateur musicians, the biggest cluster of structural change, the left planum polare, showed increasing functional connectivity to the left and right auditory cortex, left precentral gyrus, left supplementary motor cortex, left and right postcentral gyrus, and left cingulate cortex.

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Key Reference

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Education and Research, we also conducted a large-scale training study with 160 healthy older adults. Inspired by rodent models of environmental enrichment, the central goal of this study is to test the hypothesis that plastic changes in the hippocampal formation are more easily induced when an aerobic fitness intervention is combined with a cognitive intervention. Participants were randomly assigned to one of four groups: a combined language-learning and bicycle ergometer training group; a bicycle-ergometer only group; a language-learning only group; and an active control group participating in a book club. The study was carried out in 2017 and 2018 and allowed participants to make the training programs an integral part of their daily lives using tablets with a language-learning app and bicycle ergometers deployed at their homes. The data set comprises: (a) structural MR measurements taken before training (pretest), after 3 months of training, and after 6 months of training (posttest); (b) multiple cognitive and physical fitness measures assessed before and after training; and (c) day-to-day data on training intensity, training duration, and motivational states. Data analyses are currently underway, with special attention given to the joint effects of the two interventions and the specific effects of physical exercise (Dissertation Sarah Polk, supervised by Sandra Düzel, BASE-II project).

Plasticity in Task–Switching in Childhood
Childhood is characterized by maturational changes in brain structure and function and in the organization of behavior. These developmental changes are particularly pronounced for cognitive control processes, such as the ability to flexibly shift between different task sets, and their neural manifestations (Fandakova et al., 2017). In collaboration with Silvia Bunge, University of California, Berkeley, USA, we have conducted a training study to examine individual differences in behavioral and neural manifestations of task-switching plasticity in 200 children aged 8 to 11 years (Dissertation Neda Khosravani). In a total of 27 sessions spread out over 9 weeks, children in the experimental group practiced switching among sets of different tasks. The performance of children in this group will be compared to children in the active control group, who trained the identical tasks but without the need to constantly switch among them, and children in a passive control group, who did not practice any of the tasks. To assess training progress, all children were assessed behaviorally four times during practice. In addition, about half of the participants in each group also underwent functional and structural MR measurements four times. One of the goals of this study is to extend the observation of the temporal progression of behavioral and neural manifestations of plasticity into childhood.
In collaboration with the *Brain Imaging Methods* project (see pp. 149 ff.) we also adopted a novel imaging sequence for this study to examine practice-related changes in

the myelination of cortical gray matter over time. Based on recent findings that individual differences in the fidelity with which incoming visual information is represented in the brain contributes to learning success in childhood (Fandakova et al., 2019), we aim to relate practice-related structural changes to changes in task-set representations over time. With respect to behavioral manifestations of plasticity, ongoing analyses focus on individual differences in the trajectory of practice-related change across practice sessions and how they are related to untrained measures of task-switching, processing speed, and cognitive control.

Furthermore, we also seek to understand how task-switching plasticity is modulated by gonadal hormone changes associated with puberty onset. Puberty onset typically occurs at around 8 years of age, with considerable variation in onset age across individuals. We collected saliva and hair samples to measure pubertal status via gonadal hormones and to examine whether individual differences in pubertal status are associated with behavioral and neural markers of plasticity. Here, we are particularly interested in testing the hypothesis that gonadal hormone changes associated with puberty onset influence cognitive development by altering the potential for plastic change (Laube, van den Bos, & Fandakova, 2020).

Curiosity and Surprise in Childhood

Along with surprise, curiosity, or the desire to acquire new information, may play an important role for learning and plasticity, especially during the early phases of a plastic episode when individuals are exploring the task space. We used trivia questions to examine the effects of curiosity and surprise on learning in children aged 10 to 14 years. Children of all ages showed better memory for questions that they were curious about. In contrast, higher post-answer surprise, or the discrepancy between children's initial curiosity and the interest in the actual trivia answer, benefited learning more strongly in adolescents than in children (see Figure 15). Following up on these findings, we are currently investigating how curiosity and surprise can be harnessed to facilitate learning and generalization of scientific concepts in adolescence.

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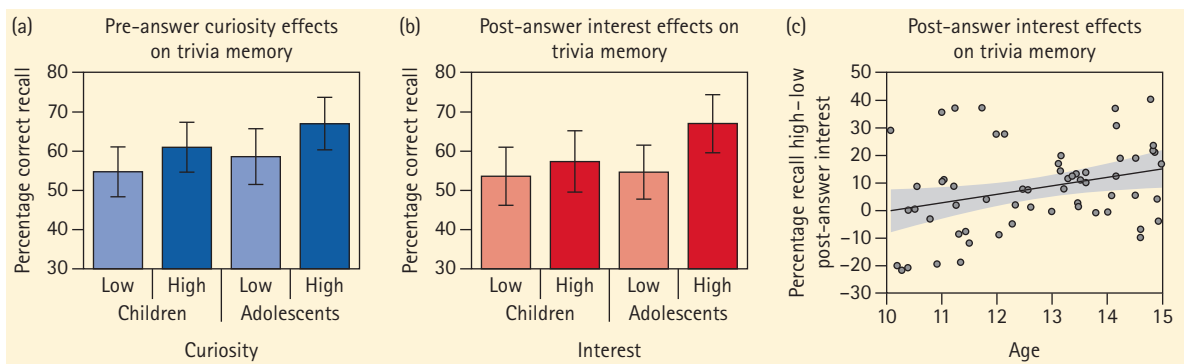
Figure 15. Children showed greater learning benefits for trivia questions that they were more curious about. In adolescents, learning was also modulated by how interesting they thought the actually presented answer was, such that they were more likely to remember the answer when initial curiosity was low but post-answer interest was high. In contrast, learning in younger children depended primarily on their initial curiosity and less so on post-answer interest.

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Research Scientists

Viktor Müller
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Caroline Szymanski
(until 07/2018)

Research Project 5: Interactive Brains, Social Minds

In everyday life, people often coordinate their actions. Common examples include walking with someone at a set pace, playing team sports, dancing, playing music in a duet or group, as well as a wide range of social bonding behaviors, such as gaze coordination between mother and infant or between partners. The developmental and social significance of these interpersonally coordinated behaviors is undisputed, but little, if anything, is known about the brain mechanisms that regulate their temporal dynamics. The *Interactive Brains, Social Minds* project investigates behavioral, somatic, and neural mechanisms that permit individuals to coordinate their behavior in time and space (see Figure 16).

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Sänger, J., Lindenberger, U., & **Müller, V.** (2011). Interactive brains, social minds. *Communicative & Integrative Biology, 4*(6), 655–663. https://doi.org/10.4161/cib.17934

The project has continued its major focus on analyzing electroencephalographic (EEG) data of skilled musicians playing music together. In our initial study with guitar duets, we discovered that interpersonally coordinated actions are preceded and accompanied by within-brain synchrony and between-brain oscillatory couplings (Lindenberger et al., 2009). We replicated and extended these original findings in a series of follow-up studies. In analyses of hyper-brain networks based on EEG data from a guitar quartet (Müller, Sänger et al., 2018), we found that within-brain connections tend to operate at higher frequencies (e.g., beta, gamma) than between-brain connections (e.g., delta, theta)—

Figure 16. A forward model of interpersonal action coordination. Drawing on the work of Steven M. Boker, Wolfgang Prinz, Daniel Wolpert, and others, our model assumes that interpersonal action coordination is based on a set of linked representational layers. The single-person layer is shaded in gray. Individuals acting together attempt to synchronize their forward model regarding their own actions with their forward model regarding the other person's actions. Highly skilled individuals, such as dancers or musicians, may represent jointly performed activities as a unified suprapersonal action with a joint forward model and partially joint sensory feedbacks. The various representational layers of the actors are intertwined by sensorimotor feedback loops (see also Sänger et al., 2011).

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in line with our previous results on guitar duets. Furthermore, we observed evidence for hyper-brain modules that include nodes from two, three, or even four brains (see Figure 17). We also extended our analyses to explore the dynamics of interpersonal action coordination at neural and behavioral levels of analysis during free guitar improvisation. We found that guitarists' brains were in sync with slow-frequency modulations of guitarists' acoustic signals. This provides evidence for brain–behavior entrainment reflecting temporal dynamics of coordinated music performance (Müller & Lindenberger, 2019).

We also explored the utility of hyper-frequency, hyper-brain networks in a data set of couples engaged in romantic kissing that was originally published in 2014. Oscillations in the alpha band played a central role in coordinating the two brains. Also, hyper-brain network strengths were higher and characteristic path lengths were shorter when individuals were kissing each other than when they were kissing their own hand. Between-brain strengths of theta oscillations (around 5 Hz) were reliably associated with reported partner-oriented kissing satisfaction, especially over frontal and central electrodes. Given our earlier observations of fronto-central between-brain synchronization in guitar players, we suggest that these couplings reflect cell assemblies representing movement coordination among interacting partners. During the reporting period, we also re-analyzed the cardiac, respiratory, and vocalizing data from 11 singers and 1 conductor engaged in choir singing, originally published in 2011. We showed in greater detail how cardiac, respiratory, and voice production subsystems interact among each other both within and across singers as a function of whether a canon is sung in unison or in different voices. Notably, we found that the conductor's hand movements are synchronized with each of the three subsystems (Müller et al., 2018). With regard to network topology, we found that clustering coefficients as well as local and global efficiency were highest and characteristic path lengths, correspondingly, shortest when the choir sang a canon in parts

as compared to singing it in unison. Furthermore, network metrics revealed a significant relationship to individuals' heart rate, presumably indicating arousal, and to an index of heart rate variability, reflecting the balance between sympathetic and parasympathetic activity. Based on this work, we propose that network topology dynamics capture essential aspects of group behavior and may represent a potent biomarker of social interaction dynamics (Müller et al., 2019).

In a related line of work, the project has sought to devise new EEG paradigms that are suited to observe the behavioral functions of inter-brain synchrony under experimentally more controlled conditions (Dissertation Caroline Szymanski). In one of these studies (Szymanski, Pesquita et al., 2017), participants were asked to perform a visual search task either alone or with a partner. Local phase synchronization and between-brain phase synchronization were generally higher when partners attended to a visual search task jointly than when they attended to the same task individually. Also, between-team differences in behavioral performance gain during the joint condition were associated with between-team differences in local and inter-brain phase synchronization. These results suggest that phase synchronization is a neural correlate of social facilitation that might help to explain why some teams perform better than others. A second study has tested whether same-frequency, same-phase transcranical alternating-current stimulation (tACS) is associated with greater behavioral synchrony in a dyadic drumming task than no stimulation or stimulation that differs in phase and frequency. Contrary to expectations, both stimulation conditions were associated with greater dyadic drumming *asynchrony* relative to the sham (no stimulation) condition. No influence of hyper-tACS on behavioral performance was seen when participants were asked to drum separately in synchrony to a (Szymanski, Müller et al., 2017). These results indicate that the interactions between externally triggered and intrinsically generated frequencies and phases require further theoretical and empirical work.

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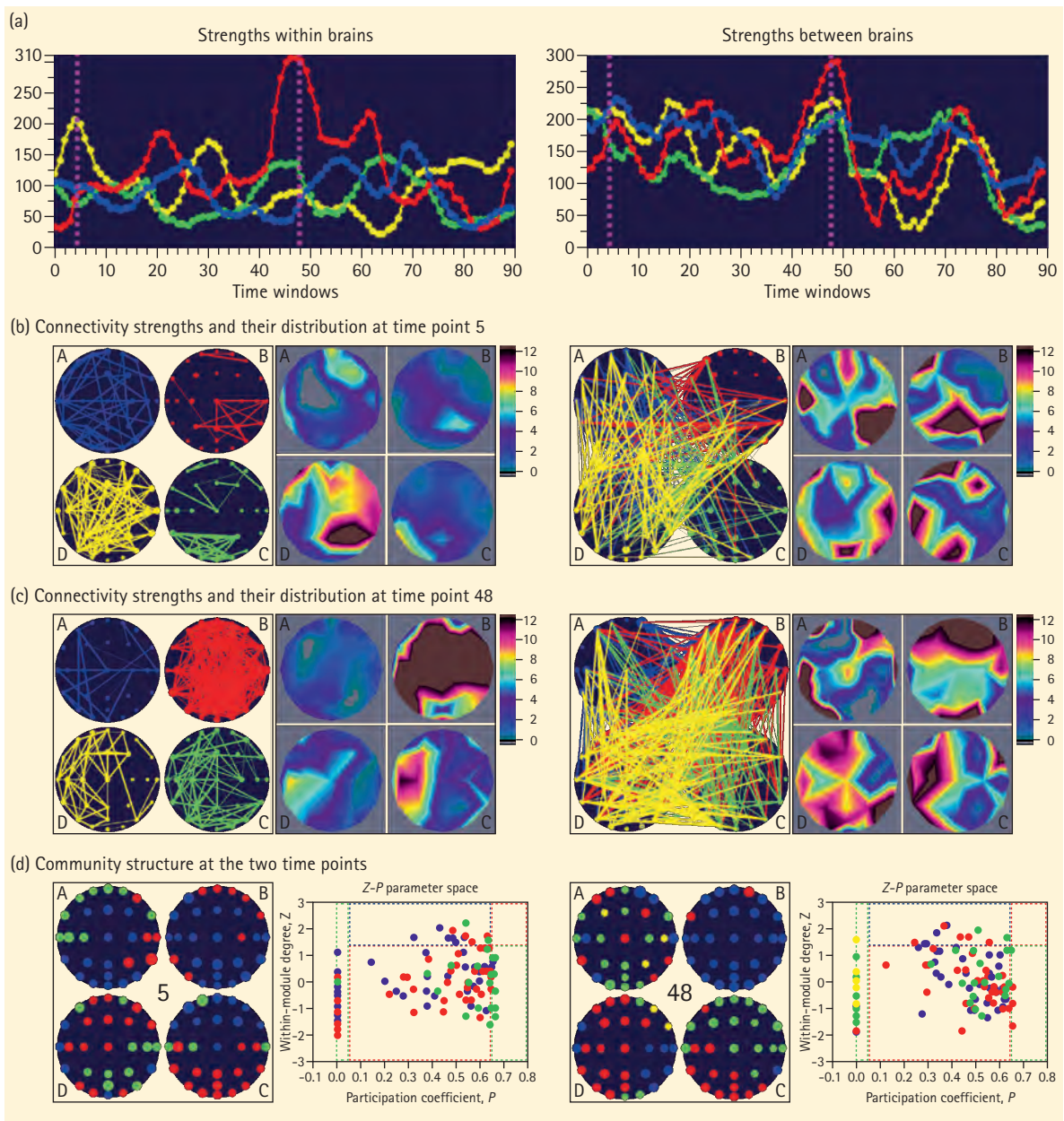
Figure 17. Coupling strengths and connectivity brain maps while playing guitar in a quartet, assessed in a moving window approach. (a) Time course of within- and between-brain out-strengths in the four guitarists. (b) Brain connectivity maps and distribution of strengths within (left panel) and between (right panel) the brains at time window 5. (c) Brain connectivity maps and distribution of strengths within (left panel) and between (right panel) the brains at time window 48. Note that the colors in (a) to (c) correspond to the different guitarists. The time windows are indicated by dotted vertical lines in (a). Strong within- and between-brain connectivity is evident in the first time window (5), when guitarist D (shown in yellow) is playing alone. In the second time window (48), when the musical theme begins to be repeated, strong within- and between-brain connectivity is evident in guitarist B (shown in red). (e) Modularity or community structures of hyper-brain networks with *Z-P* parameter space across the same time windows. Modules are coded by color. Note that most modules share nodes across two, three, or even four brains (adapted from Müller, Sänger, & Lindenberger, 2018).

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Research Project 6: Brain Imaging Methods in Lifespan Psychology

Research on human development seeks to delineate the variable and invariant properties of age-graded changes in the organization of brain–behavior–environment systems. In this vein, various magnetic resonance imaging (MRI) modalities, including magnetic resonance spectroscopy (MRS), have become indispensable, as they allow for the noninvasive assessment of brain function, anatomy, microstructure, and metabolism.

Research Scientists

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The two main goals of the *Brain Imaging Methods* project are to: (a) ascertain and improve the measurement quality of standard brain imaging protocols at the Center; and (b) complement the standard imaging repertoire by advanced sequences with enhanced interpretability that hold promise in elucidating structural changes and physiological mechanisms related to maturation, learning, and senescence. In pursuing these goals, the project serves as a resource to other projects interested in imaging (e.g., Bender et al., 2018; Dahl et al., 2019; Keresztes et al., 2017; Kleemeyer et al., 2017; see Figure 18).
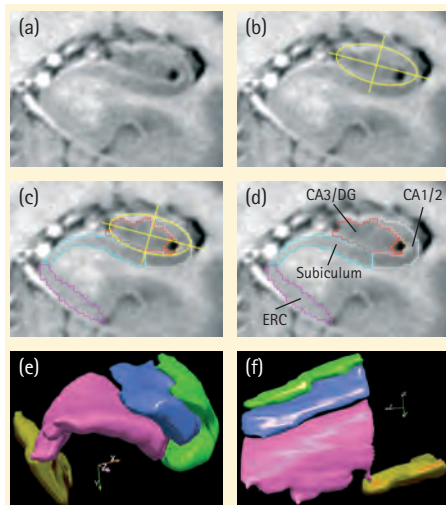
Figure 18. Illustration of the anatomic-geometric heuristic for manual morphometry. (a) A representative slice of anterior hippocampal (HC) body following the visualization of the uncal sulcus. To facilitate tracing, the T_2-weighted contrast has been inverted to mimic a T_1-weighted image. (b) Placement of the ellipse and bisecting lines (the major and minor axes of the ellipse). (c) The minor axis bisecting the ellipse marks the point from which a vertical line is dropped to create a boundary separating the subiculum from CA1/2, and CA 1/2 from CA3–4/DG, as shown in (d). Bottom: 3-D illustrations of sagittal (e) and oblique coronal (f) views of manual subfield labeling in the HC body from one participant (adapted from Bender et al., 2018).

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Structural and quantitative MRI methods occupy a central place in the project. During the reporting period, the project has focused on: (a) T_1-mapping by means of an MP2RAGE acquisition protocol to obtain estimates of laminar myelination across the cortical sheet; (b) myelin water fraction (MWF) imaging, which maps the fraction of short T_2 relaxation rates quantitatively and appears to yield more valid estimates of myelin than other widely used methods; (c) advanced methods in high angular resolved diffusion imaging (HARDI), from which maps of water diffusion in brain tissue can be deduced that permit estimates of local axonal orientation and thereby enable the identification of particular fiber tracts in white matter; and (d) neuromelanin-sensitive high-resolution imaging of the brainstem to determine the individual position and extent of the loci coerulei (Dahl et al., 2019). *Functional MRI and MRS* are used to provide maps and spectra of brain activity during task performance or at rest. The project takes special interest in: (a) functional imaging with high spatial or temporal resolution by exploiting multiband echo-planar imaging (MB-EPI) acquisition strategies; and (b) task-related, time-resolved applications of proton MRS, with a focus on glutamate. Work on MR spectroscopy and MWF imaging, on the one hand, and on T_1 mapping, on the other, has been done in collaboration with Jeffrey A. Stanley (Wayne State University, Detroit, USA) and José P. Marques (Donders Institute, Radboud University, Nijmegen, Netherlands), respectively. For more information about the Institute's MRI facility, see p. 298.

T_1 Mapping Using MP2RAGE With B_1 Map Corrections

The longitudinal relaxation time T_1 in the cortex is affected by the myelin content in the laminae. T_1 mapping offers a noninva-

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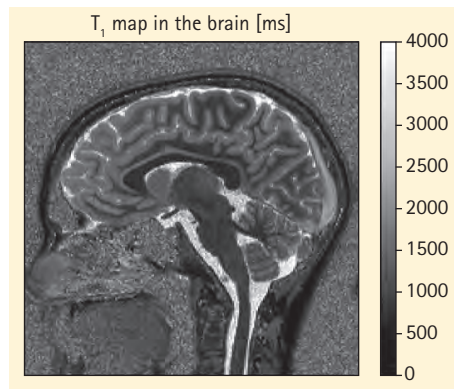
Figure 19. Typical T_1 map of a child's brain (1 slice out of a 3D volume) obtained with our protocol using MP2RAGE and B_1 map correction.

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sive method to determine cortical structures and their changes over time. We have been developing a new protocol that makes use of multiple MP2RAGE sequences developed by José Marques and colleagues for the accurate estimation of high-resolution T_1 maps in the full brain. We have chosen tailored paired values for the inversion times to cover the whole range of T_1 values in the brain. The resulting T_1 map is then corrected by a B_1 map to cancel hardware imperfections and radio frequency inhomogeneities across the brain (see Figure 19). The B_1 mapping method used (Santoro et al., 2011) was optimized in-house for our studies. The full protocol for a 1 mm isotropic T_1 map of the full brain of children takes about 16 minutes, with work in progress to reduce its duration.

Myelin–Water Fraction Imaging (MWF)

Based on a time series of T_2-weighted MR images with increasing echo-times acquired by a 3D GRAdient and Spin-Echo (GRASE) sequence, MWF imaging evaluates the transversal relaxation in a multiexponential manner by applying a nonnegative least squares (NNLS) fitting algorithm. The fraction of short T_2s (< 40 ms) provides an estimate of the portion of water molecules located between myelin sheaths, presumably reflecting the degree of myelination within white matter (Arshad et al., 2017).

High Angular Resolved Diffusion Imaging (HARDI)

Diffusion imaging captures the movement of water molecules, termed diffusion. Diffusion in tissue is hindered by cell membranes. Therefore, the orientation-dependent diffusion profiles provide information about tissue microstructure. For instance, when water molecules are observed in myelinated neuronal fibers, their diffusion is hampered less along than across fiber tracts. Hence, principal diffusion directions can be identified with the orientations of axonal tracts. Special MR protocols sensitized to the diffusion of water molecules in tissue allow to measure such diffusion orientation profiles. In his thesis, Maximilian M. Wichmann (2018), a master's student in our project, determined the precision and estimates of accuracy of the analyzed principal diffusion directions as a function of the diffusion-sensitizing gradient scheme and the model to describe diffusion profiles. The tensor model was significantly outperformed by two competing models (sticks-and-ball, constrained spherical deconvolution).

Research Project 7: Formal Methods in Lifespan Psychology

Since its foundation by the late Paul B. Baltes in 1981, the Center for Lifespan Psychology has sought to promote conceptual and methodological innovation within developmental psychology and in interdisciplinary context. Over the years, the critical examination of relations among theory, method, and data has evolved into a distinct feature of the Center. The overarching objective of the *Formal Methods* project is to test theories, develop methods, and explore research designs that articulate human development across different timescales, levels of analysis, and functional domains. The temporal resolution of data relevant for lifespan research varies widely, from the millisecond range provided by behavioral and electrophysiological observations to the small number of occasions spread out across several years provided by longitudinal panel studies. The project is based on the premise that a comprehensive understanding of human development across the lifespan requires a person-oriented, multivariate, and longitudinal approach. Such high-density, large data sets offer great opportunities for discovery and hypothesis testing, but also pose new theoretical and methodological challenges. The project meets these challenges by a strong emphasis on *methodology,* understood as the reciprocal interplay between concepts and methods that is at the heart of scientific progress.

In line with its interest in delineating and explicating individual differences in change, the project has continued and expanded its work on Structural Equation Modeling (SEM) and hierarchical state-space methods, both of which integrate a wide range of different multivariate analysis techniques. During the reporting period, project members have shown how these approaches can assist researchers in: (a) optimally planning longitudinal studies under constrained resources; (b) refining or modifying hypotheses through comprehensive exploratory data analysis; (c) appropriately modeling unequally spaced measurements, context effects, and individual differences in longitudinal research; and (d) modeling the dimensionality of age-related changes in cognition.

New Methods for Analyzing Change

Longitudinal panel studies are a key empirical method to chart between-person differences in behavioral and neural development. The project members have been working on developing and evaluating new methods to analyze change. Most dynamic models (e.g., cross-lagged panel models) currently in use in psychological research assume that measurement occasions are equally spaced in time. This failure to account for unequal spacing of measurement occasions may seriously bias parameter estimates. Driver, Oud, and Voelkle (2017) have developed a software package

for the estimation of hierarchical continuous-time system dynamics, called *ctsem* (continuous-time structural equation modeling). The package is suited for the analysis of panel data (repeated observations from more than one individual) and time-series data (repeated observations from one individual). Using stochastic differential equations coupled with a measurement model, *ctsem* accommodates any pattern of measurement occasions. *ctsem* can estimate relationships over time for multiple latent processes, measured by multiple noisy indicators with varying time intervals between observations (see Figure 20). With recent developments in hierarchical and nonlinear modeling, as well as Bayesian estimation (Driver & Voelkle, 2018a), parameters themselves can be modeled as slowly changing dynamic states. Coupled with the inclusion of event- and intervention-related effects over time (Driver & Voelkle, 2018b), this allows for the high level of model expressiveness that is necessary for developing and testing theories of development across multiple timescales.

Andreas Brandmaier and Timo von Oertzen have continued their work on Ωnyx, a freely available software environment for creating and estimating SEM. The software offers a graphical user interface to facilitate the specification of models and includes a powerful back-end for performing parameter estimation (von Oertzen et al., 2015).

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Charles C. Driver
Nina Karalija (09/2018–02/2019)
Maike M. Kleemeyer (as of 09/2019)
Ylva Köhncke (as of 07/2017)
Ulman Lindenberger

Manuel Arnold (COMP2PSYCH; as of 10/2017)

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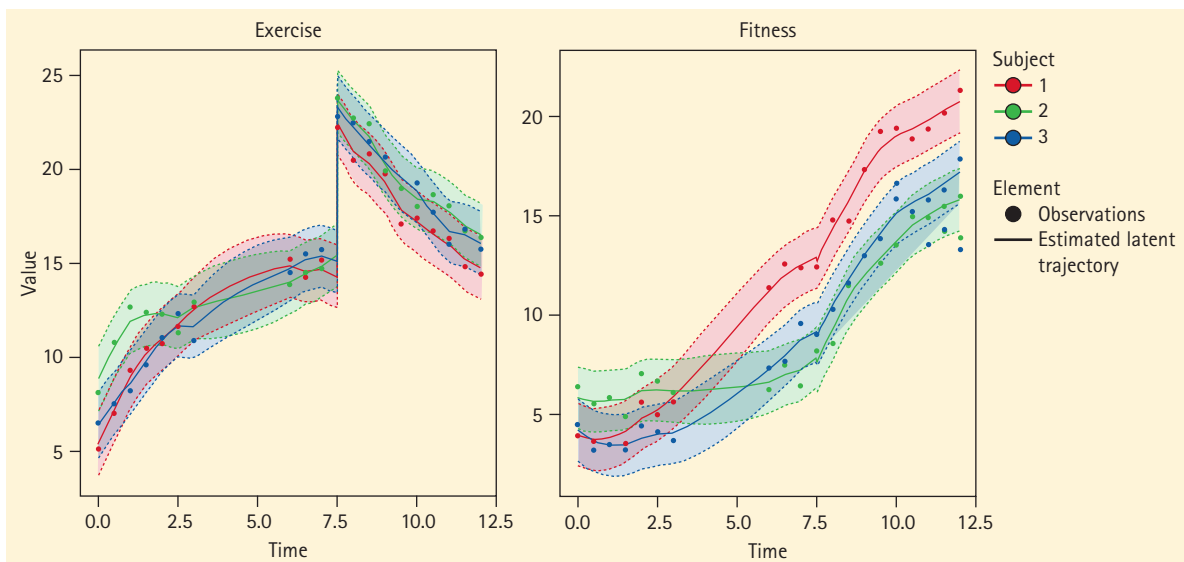
Figure 20. Estimated latent processes from a simulated hierarchical dynamic system of fitness and exercise. After a motivation intervention temporarily increasing exercise levels, fitness rises more quickly until exercise drops back to an equilibrium level determined by specific characteristics of the subject.

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Optimizing the Design of Longitudinal Studies

Longitudinal studies often require a large investment of resources. In earlier work, we have shown how design-related choices, such as the number of individuals or number of measurement occasions, affect statistical power and how optimal choices maximize the efficiency of longitudinal designs while keeping power constant (Brandmaier et al., 2015). In the meantime, we have extended this framework to arrive at an integrated understanding of measures of precision, reliability, and effect size for individual differences in change (Brandmaier, von Oertzen et al., 2018). Thus far, cognitive neuroscience has paid relatively little attention to questions of reliability and statistical power. For instance, surprisingly little is known about the psychometric properties of measures attained from structural and functional magnetic resonance imaging (fMRI) protocols. We have introduced the intraclass effect decomposition (ICED) framework to overcome this shortcoming (Brandmaier, Wenger et al., 2018). With ICED, researchers can separate and quantify the effects of different measurement characteristics, such as day, session, or scanner, on measurement reliability. Using this framework, we showed that some standard designs, such as 5 minutes of resting-state functional connectivity assessment, come with low reliability that hardly affords any kind of statistical inference about individual differences. We hope that ICED will encourage and assist researchers in delineating sources of unreliability and guide them in developing more efficient research designs.

To increase statistical power or achieve identical power with fewer measurements, planned missingness (PM) is a convenient but often overlooked design option. In PM designs, participants are tested on a random subset of all possible measurement occasions, thereby reducing potential resource bottlenecks, such as those arising from limited availability of an MR scanner, as well as research participants' testing load. To find optimal PM designs, we developed an asymptotic approach to generate, evaluate, and select optimal longitudinal designs for measuring change with PM (Brandmaier et al., 2020). In research on adult cognitive development, available theories of change often posit nonlinear (e.g., exponential) decline. However, growth models used for data analysis typically

test linear or quadratic polynomials, with less than 5% of the analyses being based on functions that are nonlinear in the parameters (Ghisletta et al., 2020). Given this apparent bias in favor of polynomial decomposition, Ghisletta and collaborators explored what conclusions about individual differences in change are likely to be drawn if researchers apply linear or quadratic growth models to data simulated under a conceptually and empirically plausible model of exponential cognitive decline. The simulation results show that fit statistics generally do not differentiate misspecified linear or quadratic models from the true exponential model. Moreover, power to detect variance in change for the linear and quadratic growth models is low, and estimates of individual differences in level and change can be highly biased by model misspecification. The authors encourage researchers to also consider plausible nonlinear change functions when studying behavioral development across the lifespan.

Exploration and Model Testing

Building models fully informed by theory is impossible when data sets are large and theoretical predictions are not available for all variables and their interrelations. In such instances, researchers may start with a core model guided by theory and then face the problem of which additional variables should be included. In earlier work, we have shown that SEM Trees and Forests provide a straightforward solution to this variable selection problem (Brandmaier et al., 2016). SEM Trees hierarchically split empirical data into homogeneous groups sharing similar parameters of a model by recursively selecting optimal predictors from a potentially large set of candidate predictors. SEM Forests aggregate predictive information over a set of trees

Coupled Cognitive Changes in Adulthood

With advancing adult age, cognitive abilities such as memory, processing speed, and reasoning tend to decrease. At the same time, there are marked individual differences in rates of change, with some adults showing maintenance and select improvements and others showing precipitous decline. To shed light on the dimensionality of cognitive aging, we revisited a classical question posed by Patrick Rabbitt more than 25 years ago: "Does it all go together when it goes?" Specifically, we conducted a meta-analysis to examine the degree to which changes in different cognitive abilities in adulthood and old age are correlated (Tucker-Drob et al., 2019). Across 22 unique data sets with over 30,000 individuals, a common factor of change accounted for 60% of the reliable variance in cognitive change (see Figure 21). The couplings among rates of changes increased with advancing adult age, presumably reflecting "dynamic dedifferentiation" or the increasing importance of an ensemble of common causes on cognitive change. Notably, abilities showing little average decline, such as verbal knowledge, contributed to common change to about the same extent as abilities showing pronounced average decline, such as perceptual speed. Hence, individuals who improve more on verbal knowledge relative to others are likely to decline less in perceptual speed. This generalized pattern of change adds to an important qualification to two-component theories of intellectual development in adulthood, such as the Cattell/Horn theory of fluid versus crystallized intelligence.
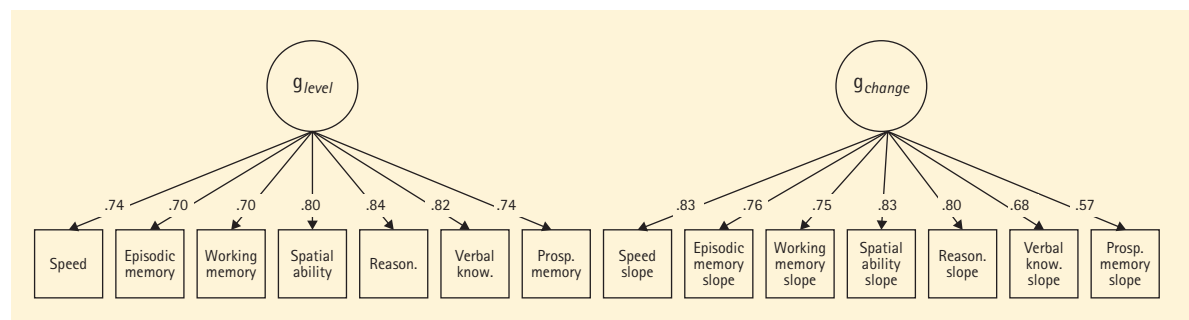
Box 1.

Figure 21. Path diagram representing meta-analytic estimates for standardized factor loadings of individual cognitive abilities on a general factor of levels (left) and standardized factors loadings of longitudinal slopes for individual cognitive abilities on a general factor of changes (right). Variances were omitted from the diagram. Reason. = Reasoning; Verbal know. = Verbal knowledge; Prosp. memory = Prospective memory (adapted from Tucker-Drob et al., 2019).

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and yield a measure of variable importance that is more robust than corresponding measures from single trees. Variable importance guides researchers on what variables may be missing from their models and the underlying theories. In a recent application of SEM Forests, we investigated longitudinal trajectories of well-being toward the end of life using data from the German Socio-Economic Panel study. We found that individual differences in the decline of well-being are associated with factors related to physical health, social participation, and perceived control (Brandmaier et al., 2017).

Longitudinal data sets with dense observations generally offer great opportunities for discovery and hypothesis testing. Therefore, we have merged the *ctsem* approach described above with SEM Trees into CTSEM Trees (Brandmaier et al., 2018). When the goal is variable selection to build predictive models with linear effects only, we introduced a further method, regularized SEM, that brings the idea of regularization to SEM and allows one to build simple models from high-dimensional data while optimizing predictive accuracy (Jacobucci et al., 2019).

Ongoing work in this area extends the model of interest from SEM to any statistical model and seeks to quantify the mismatch between the specified model and the "best possible" model using information theoretic approaches. Inferences drawn from models are generally contingent on the models being "correct," at least in certain ways. However, checking this premise often occurs ad-hoc based on a variety of misspecification indices. Levels of mismatch between model and data

that derived from information theory might guide model refinement more efficiently than currently available approaches.

Between-Person Differences and Within-Person Changes in Cognition

Over a century of research on between-person differences in cognitive performance has resulted in the consensus that human cognitive abilities are hierarchically organized, with a general factor, termed general intelligence or "g," uppermost. Surprisingly, it is unknown whether this body of evidence, which reflects between-person differences, is informative about how cognition is structured within individuals. It is likely that many factors contributing to differences between individuals vary less, or differently, within individuals. For instance, allelic variations of the genome contribute to differences between but not within individuals. To overcome this lacuna, Schmiedek et al. (in press) analyzed data from 101 young adults performing nine cognitive tasks on 100 days distributed over six months (see Box 2). The structures of individuals' cognitive abilities were found to deviate greatly from the modal between-person structure, and to vary among each other. The g factor was much less prominent within than between persons. Working memory contributed the largest share of common variance to both between- and within-person structures. The results show that between-person structures of cognitive abilities cannot serve as a surrogate for within-person structures. To reveal the development and organization of human intelligence, individuals need to be studied over time.

Overview of the COGITO Study   **www.mpib-berlin.mpg.de/cogito**

In the COGITO study, 101 younger adults (20–31 years of age) and 103 older adults (65–80 years of age) participated in 100 daily sessions in which they worked on cognitive tasks measuring perceptual speed, episodic memory, and working memory, as well as various self-report measures (see Schmiedek et al., 2010, 2020). All participants completed pretests and posttests with baseline measures of cognitive abilities and transfer tasks for the practiced abilities. Brain-related measures were taken from subsamples of the group, including structural magnetic resonance imaging (MRI), functional MRI, and electroencephalographic (EEG) recordings. A central goal of the COGITO study was the comparison of between-person and within-person structures of cognitive abilities. Further, the COGITO study qualifies as a cognitive training study of unusually high dosage and long duration because of its 100 sessions of challenging cognitive tasks.

Box 2.

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Harding Center for Risk Literacy
(Concluding Report)

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Overview

Our aim is to provide people with clean information to empower them to make better decisions. A main focus of our research is to develop tools to make citizens more risk savvy in navigating the health care system, consumer decisions, and the digital world. At the heart of our work is the ideal of a democratic society that knows how to calculate risks and live with uncertainty.

Core Mission

Increasing the risk literacy of both experts and laypeople is as relevant today as it was in 2009, the official founding year of the Harding Center. In fact, one could argue that in an age of fake news, social media, and new digital technologies, risk literacy has become even more crucial for today's citizens. The relevance of our core mission of helping citizens understand and deal with risk and uncertainty is thus steadily growing. We aim to increase the breadth of topics to digital risk literacy and decision-making under uncertainty, where reliable statistical evidence is not available. In such cases, robust heuristics such as fast-and-frugal trees may be superior to fine-tuned statistical analysis.

I. Past Achievements (Selection)

In this section, we look back at what we have achieved and highlight six important contributions toward improving experts' and the general public's risk literacy as well as our milestone projects within the reporting period. (1) *Fact boxes* designed by the Harding Center have been disseminated to patients and doctors in the US, UK, Canada, Australia, Brazil, Germany, Austria, Switzerland, Spain, France, Italy, Japan, and Korea. A fact box communicates the current state of medical evidence on a specific intervention in a transparent and complete way. When, in 2015, eleven fact boxes were presented at a press conference at the AOK (the largest German health insurer) in Berlin, there was an enormous media response

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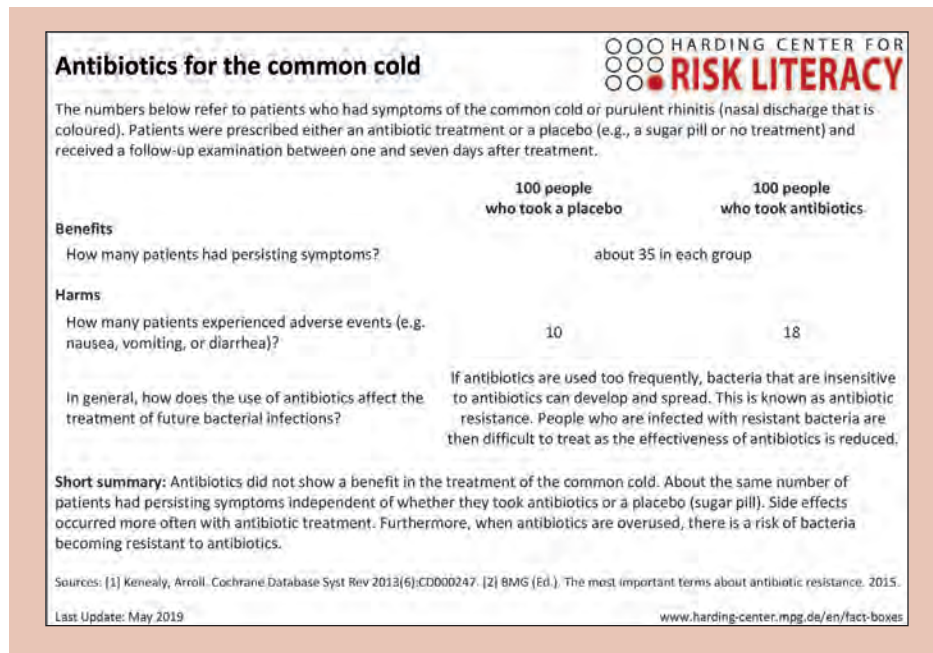
Figure 1. A fact box on antibiotics for the common cold. The top part of a fact box specifies the reference class, followed by a table that compares the most important benefits and harms between a control and an intervention group. The measures of the effects are presented as absolute numbers out of a total sample of 100, 1,000, or 10,000. A fact box also includes a summary sentence describing the benefits and harms without making a recommendation. The sources and the date the fact box was last updated is stated at the bottom.

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Key Reference

McDowell, M., & **Jacobs, P.** (2017). Meta-analysis of the effect of natural frequencies on Bayesian reasoning. *Psychological Bulletin, 143*(12), 1273–1312. https://doi .org/10.1037/bul0000126

that resulted in articles in more than 100 newspapers, nearly all of them mentioning the Harding Center. Since 2016, the Swiss health insurer Helsana has offered video clips of fact boxes available in English, French, Italian, and German on the company's website. Ongoing research at the Harding Center investigates how to design fact boxes so that various target groups (e.g., people with low numeracy skills) can understand benefits and harms of treatments, tests, dietary supplements, imaging methods, and vaccinations.

(2) *Natural frequencies,* an intuitive tool we developed for making Bayesian inferences (such as inferring the probability of a disease from a positive test result), have been adopted by major medical societies and entered the vocabulary of evidence-based medicine. Communicating information in *natural frequencies* to doctors and patients is now recommended by:

- The Cochrane Collaboration
- The International Patient Decision Aid Standards Collaboration
- The Medicine and Healthcare Products Regulatory Agency

In 2018, natural frequencies were introduced into the school curricula of 11th-graders in Bavaria.

(3) A campaign led by Gerd Gigerenzer and Odette Wegwarth succeeded in eradicating all misleading statistics from most cancer screening pamphlets in Germany. We helped the German Cancer Aid (Deutsche Krebshilfe), the largest private health organization in the country, rewrite their pamphlets in an evidence-based and understandable way; other organizations in Germany and Europe have since followed suit. The effort took years, and resistance to transparent and evidence-based information was—and still is—strong, but clean information about benefits and harms of cancer screening has now become the rule rather than the exception.

(4) The "Century of the Patient" was launched by Sir Muir Gray and Gerd Gigerenzer at the British Medical Association in London, 2011. Fiona Godley, editor of *BMJ,* chaired the launch and the book presentation of *Better Doctors, Better Patients, Better Decisions* (Gigerenzer & Muir Gray, 2011) and invited Gerd Gigerenzer to write regular columns on risk literacy in *BMJ,* which have appeared since 2011. The launch was repeated in Berlin, with more than 40 journalists and multipliers attending. Creating the "Century of the Patient" entails a major health-care reform in which patients are given access to clean information. The concept of knowledgeable patients is a fundamentally democratic ideal that remains our long-term project.

(5) *Continuing medical education* (CME) of physicians and other health-care professionals in risk literacy has taken place on a large scale. Members of the Harding Center have taught about 5,000 health professionals. The problem is that medical departments do not efficiently teach how to understand health statistics; in fact, we have shown that final-year students at the Charité do not understand the basic concepts needed to evaluate a test result (see Figure 3). Since 2017, the Harding Center and the Charité Universitätsmedizin Berlin has developed a class on "Navigating Numbers in Medicine—Statistical Literacy for Everyday Clinical Practice" at Charité Universitätsmedizin Berlin. In 2018, it became an official PhD class at the Charité. Currently, we are setting up a course in risk literacy for the National Association of Statutory Health Insurance Physicians (KBV) that has the potential to reach most German
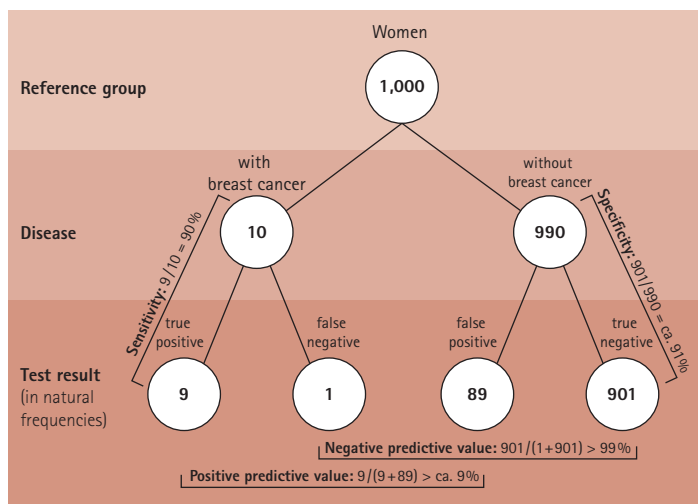

Figure 2. Natural frequency tree for breast cancer early detection with mammography. Conditional probabilities make it much more difficult to infer the positive predictive value than with natural frequencies as shown in this image. The four test result numbers at the bottom of the tree are all natural frequencies.

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family physicians. Niklas Keller is collaborating with the AMBOSS training platform, the largest and fastest growing medical training platform, with currently over 300,000 student members. Since 2018, AMBOSS has offered a course on risk literacy for the first time.

(6) Teaching risk literacy to the general public. We have established a portfolio of measures to increase risk literacy outside the health domain. In 2012, the "Unstatistik" was launched (unstatistik.de), a monthly series on media reports that misinterpreted or twisted facts and statistics. This blog is covered by numerous magazines and newspapers. More recently, the German Ministry for Law and Consumer Protection supported the Harding Center in developing a web-based "RisikoAtlas" to increase risk literacy among consumers, and elected Gerd Gigerenzer to its Advisory Council of Consumer Affairs to evaluate the *consequences of consumer* scoring and digitalization in general. Since 2017, Mirjam Jenny and Michelle McDowell have led a joint initiative with the German Federal Institute for Risk Assessment to communicate risks more efficiently to the public.

Milestone Projects 2017–2019

April 2017: Mirjam Jenny launched a joint research project with Microsoft Research: Mirjam Jenny spent two weeks at Microsoft Research Labs in New York City as a visiting researcher to kick off a joint research project with Dan Goldstein and Jake Hofman on eliciting risk estimates with different numeric formats and on how *perspective sentences* can help people better understand and recall risks.

August 2017: The Harding Center received a grant for the project VisRisk: Visualizing and Communicating Complex Evidence in Risk Assessment *with the BfR:* In this project, led by Mirjam Jenny and Michelle McDowell in cooperation with the German Federal Institute for Risk Assessment (Bundesinstitut für Risikobewertung, BfR), we examine how statements from risk assessments can best be presented both verbally and visually so they can be easily understood by laypersons.

October 2018: The Harding Center received a grant for the project Drohnenrisiken verstehen (Understanding Drone Risks) *by the Federal Ministry of Transport and Digital Infrastructure:* In this project, we develop different transparent, evidence-based communication formats on drone risks and uncertainties targeted at drone users and regulating authorities. The project is led by Felix Rebitschek.

October 2019: Mirjam Jenny was entrusted to assess flood risk for the Advisory Council for Consumer Affairs: Consumers in Germany

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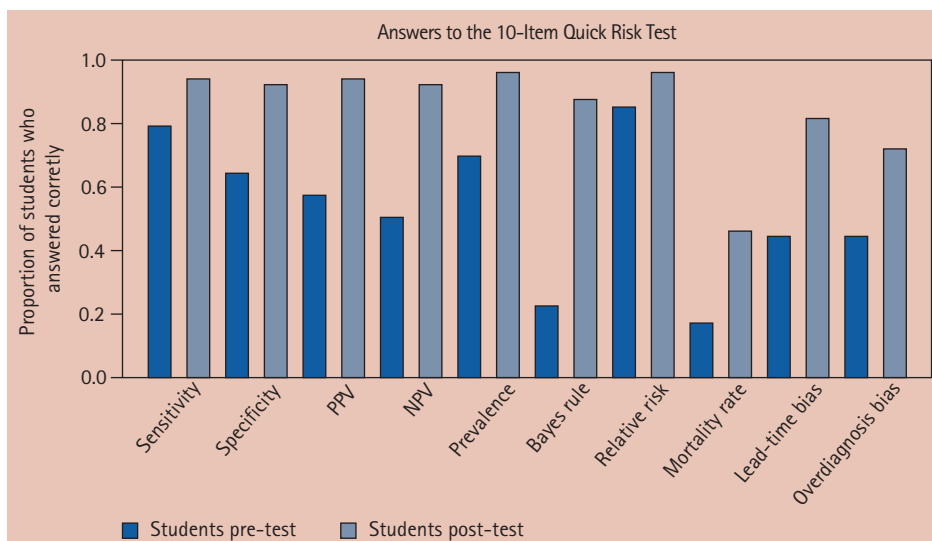
Figure 3. Dark bars: A Quick Risk Test with 10 basic concepts showed that the final-year medical students at the Charité could answer on average only 50% correctly (multiple choice with four alternatives, resulting in a 25% chance of randomly picking a correct answer). Light bars: Performance after a 90-min training session in risk literacy and diagnostic risk assessment (Jenny et al., 2018a; original image licensed under CC-By 4.0).

are facing increasing damage due to severe weather conditions and associated rising costs. Mirjam Jenny and Nadine Fleischhut, research scientists at ARC, were commissioned to investigate how communication to the general public regarding floods and other natural hazards can be improved.

II. The Harding Center Within a Broader Scientific and Political Context

The Harding Center bridges the gap between basic and applied research by establishing concrete applications of empirical research and implementing them in the field. The Center collaborates with internationally renowned research institutions, including the Max Planck Society, Charité Universitätsmedizin Berlin, the Robert Koch Institute (the German Center for Disease Control), Microsoft Research, and the Winton Centre at the University of Cambridge, a sister institution of the Harding Center. It is also tightly networked with policy makers, including the European Food Safety Agency, the German Federal Institute for Risk Assessment, German ministries, and the "wirksam regieren" ("effective governing") unit at the German Chancellor's office that aims to improve government strategies using insights from the social sciences.

Our approach is particularly timely given that more and more governments and organizations are creating their own behavioral insights' ("nudging") units based on a "whatever works" approach that is often devoid of theory. Our projects are deeply rooted in scientific theory and are founded on empirical work with strong methodological and scientific rigor. Rather than assuming passive citizens who simply need to be nudged into the "right" direction, our approach assumes that people are able to learn and make their own decisions if provided with education and tools that enhance their competence. In doing so, we move closer to our vision of a society that knows how to calculate risks and deal with uncertainty. To this end, we see ourselves as evidence translators, educators, and tool developers who strive to empower both the public and public institutions.

III. The Future of the Harding Center

The Harding Center will leave its offices at the Max Planck Institute for Human Development at the end of 2019 to further pursue its research at the University of Potsdam. We will continue to dedicate our minds and resources toward risk literacy in health care, with an additional focus on digital risk literacy. The latter will address the communication of risks associated with *emerging technologies* such as algorithms, robots, and self-driving cars. As with health care, the topic of artificial intelligence is fraught with a myriad of misconceptions and exaggerated hopes and fears.

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Max Planck UCL Centre
for Computational Psychiatry
and Ageing Research

Photo: Centre members in Berlin

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Ulman Lindenberger (MPI for Human Development, Berlin, Germany)

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Overview

The behavioral neurosciences and related disciplines have seen spectacular scientific advances that make them rich in scientific opportunity. These advances have made it possible to work toward a mechanistic understanding of behavioral aging and psychopathology, two empirically overlapping fields of great importance to science and society. In both fields, it is of key importance to take a personalized lifespan approach by identifying neural and behavioral parameters that predict more or less favorable trajectories, with the intent to intervene in time when undesirable outcomes are expected.

With these goals in mind, the Max Planck Society and University College London (UCL) established the Max Planck UCL Centre for Computational Psychiatry and Ageing Research. The Centre's opening ceremony took place in London at the Royal Society on 1 April 2014; the Max Planck Society and UCL provided an initial 5 years of funding. In 2019, the Centre was positively evaluated by the Max Planck Society and extended for another 5 years (2019–2024). The Centre has two sites, one in London (Russell Square) and the other in Berlin-Dahlem (MPI for Human Development). The Centre's foundation was preceded by a 3-year preparatory phase, which also included the organization of the *First Symposium and Advanced Course on Computational Psychiatry and Ageing Research* in 2012 at Ringberg Castle, Bavaria. During the reporting period, the Centre organized a similar symposium in 2018, again at Ringberg Castle. Following the 2016 launch of the *International Max Planck Research School on Computational Methods in Psychiatry and Ageing Research* (COMP2PSYCH) to extend the Max Planck UCL Centre's reach into graduate education (see pp. 287 ff. for details), the COMP2PSYCH program has continued to grow both in scope and number of students. In Berlin, three research groups form part of the Centre: The project *Formal Methods in Lifespan Psychology,* led by Andreas Brandmaier at the Center for Lifespan Psychology, see pp. 151 ff.); the Emmy Noether Group *Lifespan Neural Dynamics Group,* led by Douglas D. Garrett (also affiliated with the Center for Lifespan Psychology, see pp. 195 ff.); and the Max Planck Research Group *Neural and Computational Basis of Learning, Decision Making and Memory,* led by Nicolas Schuck (see pp. 227 ff.). A full overview of the Centre's activities, including those primarily based in London, can be found on the Centre's website.
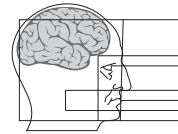
Researchers (Berlin Site)

Andreas M. Brandmaier
Douglas D. Garrett
Ulman Lindenberger

Figure 1. Participants of the 4th Symposium and Advanced Course for Computational Methods in Psychiatry and Ageing Research, Castle Ringberg, Tegernsee, Germany.

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Berlin Site Publications 2017–2019/20

(last update: April 2020)

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Lise Meitner Group for Environmental Neuroscience

Head: *Simone Kühn*
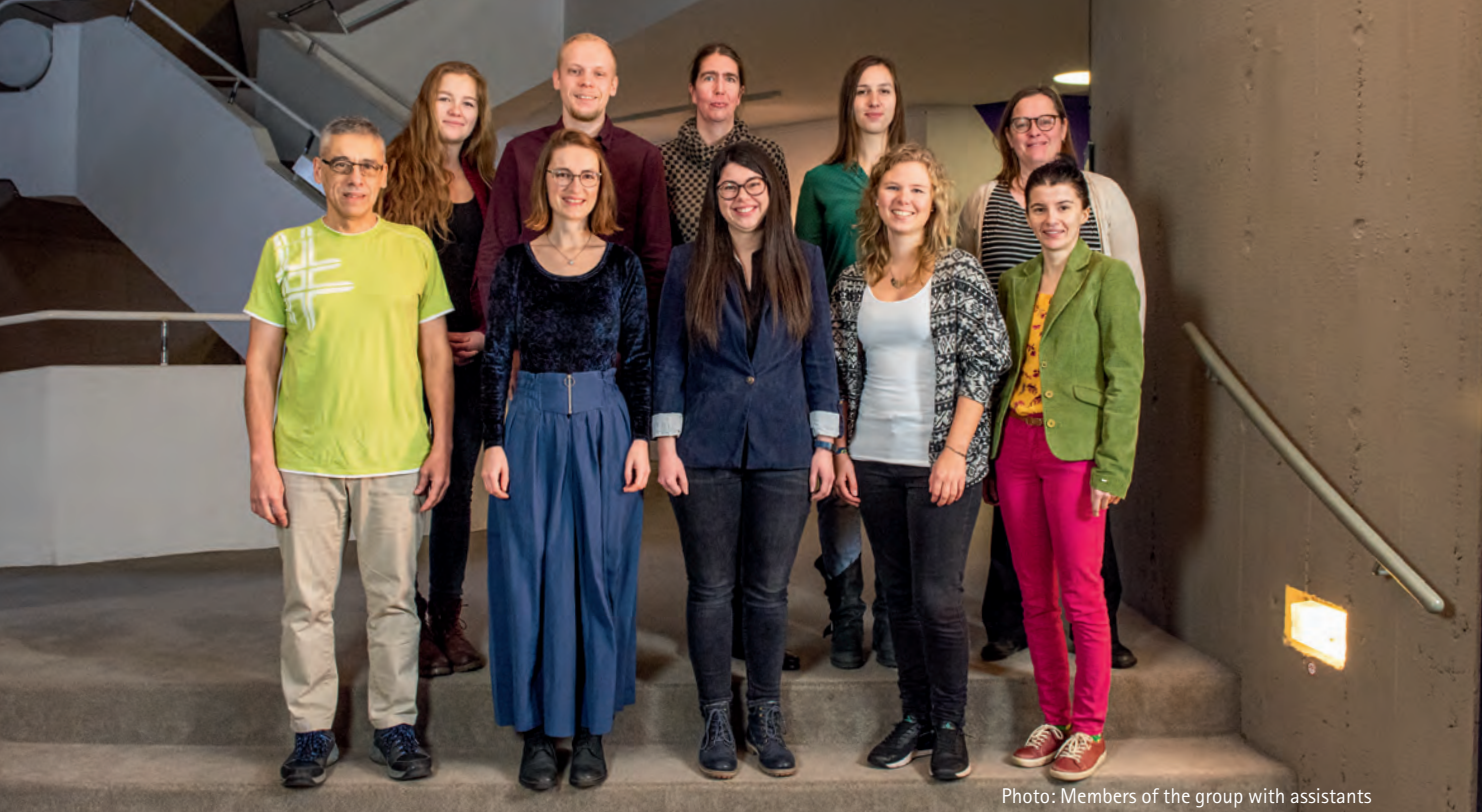
Photo: Members of the group with assistants

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Introductory Overview

To what extent and how does the physical environment affect human beings? This overarching question is the foundation of the Lise Meitner Group for Environmental Neuroscience (LMG EnvNeuro), which was established in July 2019. It is now well known that the environment has a major impact on well-being, but the neural mechanisms of this relationship remain to be explored. Therefore, our goal is to unravel how the brain processes different kinds of surroundings and adapts to long-term exposure to environments.

Humans tend to underestimate the influence that the physical environment and the contextual surroundings exert on our behavior and also on well-being, a phenomenon that has been termed "fundamental attribution error" in social psychology. In view of the multitude of environmental problems we are facing, such as climate change, elevated pollution, and destruction of habitats, a better understanding of the effects of the physical environment on the individual is urgently needed. Global urbanization processes with large population shifts from rural to urban areas are leading to a gradual increase in the proportion of people living in cities, with more than 55% of the world's population currently living in urban areas. In Germany, this proportion is already at 77%. Since urbanization is a fairly recent trend, largely confined to the past 200 years, it is still unclear what consequences this has for the individual and society at large. Urbanization seems to be a large-scale experiment offering windows of opportunity to study how individuals are affected by changes of their physical environment. Epidemiological studies have shown that the risk for many major mental illnesses (e.g., anxiety disorders, mood disorders, schizophrenia) is higher in cities—in particular, the environments experienced during childhood and early adolescence seem to play a crucial role. These findings have sparked interest in studying the negative effects of urban environments on well-being, physical health, and cognitive functioning as caused by air pollution, noise pollution, and crowding. However, there is also evidence on the other side of

the continuum, showing that the exposure to rural areas and green spaces (even within urban areas) can have positive effects on the individual such as improvements in cognition, well-being, and physical health, but the causes of this are less clear. Our research goal is therefore to unravel the neural mechanisms underlying the previously reported negative effects of urban exposure and positive effects of green exposure. Since we spend 90% of our time indoors on average, we also focus on investigating the influence of interior design on humans. By providing a better understanding and quantification of the relationship between out- and indoor environments and the brain, we hope to make an impact on the design of physical environments, urban planning, and architecture in ways that will optimize well-being and cognitive functioning as well as mental and physical health.

Our Research Program

The research conducted in our group is organized around four main topics: (1) investigating the acute effects of environmental stimuli, such as images, sounds, smells; (2) investigating the effects of interiors and architecture; (3) exploring long-term effects of outdoor living environments; and (4) examining the effects of extreme environments.
We use (quasi-)experimental, longitudinal observational and cross-sectional study designs, and a combination of neuroimaging, Geographic Information System (GIS) methods and virtual reality (VR).

Research Area 1: Acute Effects of Environmental Stimuli

Within the scope of this research area, we experimentally expose participants to real or virtual (multimodal) environments. We also attempt to dissect environments into their modalities by using images/videos of environments, sounds, or odors.

Previous studies have demonstrated that taking a walk in a natural landscape versus in a city environment can lead to improvements in mental health outcomes such as mood and stress, and improvements in cognition, in particular in working memory and cognitive flexibility. Different theories such as Attention Restoration Theory (ART) by Kaplan and Kaplan and Stress Reduction Theory (SRT) by Ulrich posit that nature has positive effects on human beings. Both theories assume that these effects are restorative and presuppose that individuals have to be fatigued or stressed before the salutogenic effects of nature can be observed. However, SRT emphasizes that the beneficial effects are initially via affect, whereas ART assumes that the effects are brought about via cognitive processes, namely the restoration of directed attention.

To test these theories, we use functional magnetic resonance imaging (fMRI) to investigate whether beneficial effects of nature onto subjective well-being and cognition are accompanied by activation in brain regions associated with stress and affect or by attentional cognitive processes. In one of our studies, we randomly assigned adult participants to a 1-hour walk in the forest (Berlin-Grunewald) or in the city (Schloßstraße in Berlin-Steglitz) and assessed brain activation in a stress-eliciting fMRI paradigm before and after the walk (Sonja Sudimac). In another study, we measured changes in cognitive performance (digit span task and dual n-back) and associated brain activity elicited by exposure to soundscapes recorded in urban or natural environments (Emil Stobbe). At the time of writing, data collection has been completed but the data has not yet been analyzed. We expect the results to be informative as to whether the exposure to natural landscape and/or soundscapes act more strongly on stress/affect associated or on cognitive brain networks.

In a recent online study, we collected data using three implicit experimental paradigms to test the so-called Biophilia Theory by Wilson, which hypothesizes that humans possess an innate tendency to seek connections with

nature and other forms of life. We used (1) the approach and avoidance task (AAT) to measure the speed with which participants approached or avoided photos of natural versus urban landscapes; (2) the implicit association task (IAT) to detect implicit associations between the nature versus urban photographs and words that needed to be classified as belonging to an approach or avoidance category; and (3) a dot-probe task (DPT) in which participants needed to respond to a lateralized cue that was preceded by the display of two lateralized photographs, one urban, one natural. Based on Biophilia Theory, one would expect that photos of nature should elicit stronger approach tendencies and attentional biases than urban photos. We did indeed observe a stronger attentional bias for nature than for urban pictures in the DPT, evidence for stronger association between the concept of approach and nature pictures/avoidance and city pictures in the IAT and a nature-approach bias in the AAT. All these findings support the Biophilia Theory, namely the existence of an automatic tendency to approach nature.

Based on findings from the Japanese discipline of Forest Medicine showing that the exposure to essential oils from the cypress tree Hinoki *(Chamaecyparis obtuse),* which is a frequent tree in Japanese forests, either diffused in the air or naturally in the forest, can improve the immune response, reduce physiological parameters related to stress (blood pressure, heart rate) as well as increase positive mood, we plan to test its effects on cognitive performance. Based on previous evidence, we chose the Hinoki oil, but in order to compare it to a domestic tree odor we added a condition with Douglas fir *(Pseudotsuga menziesii)* oil. We hypothesize positive effects on cognition in both tree odor conditions in comparison to a water vapor condition. In case we do find effects, our goal will be to disentangle to what extent the effects are driven by prior beliefs by manipulating participants' beliefs with different cover stories (e.g., "forest odors harm performance because they elicit anxiety" or "forest odors improve performance because the forest is our natural habitat").

Research Area 2: Interiors and Architecture

In this line of research, we are investigating the effects of architectural elements on people's experience and behavior. For example, we examine the influence of sharp and curved shapes, ceiling height, or room size in their effects on affect and cognition as well as underlying brain functioning (Izabela Sztuka). We make use of VR technology, since VR makes it possible to place participants in completely different environments. As VR technology generates strong feelings of presence and so-called immersion effects, it has great value for research purposes. Moreover, VR enables us to systematically manipulate distinct aspects of the environment. We have recently initiated a study in which we compare how much time participants spend in rooms with curvilinear versus rectilinear interior design including furniture, carpets, lamps, and paintings. After having visited various parallel rooms, knowing that they will have to perform a memory task at the end,

participants are shown pictures and have to decide whether these pictures depict the rooms they have previously visited or whether the arrangement or objects were changed. In another study, we use a VR environment of an office workplace where the participant is seated in front of a computer monitor. What we manipulate between conditions is the view out of the window. Either participants see nature including trees, bushes, and a lawn or they see a city context with several buildings. In a baseline condition, they only see a blinded window. Participants undergo all conditions and perform tasks assessing working memory and creativity in these different settings.

The final goal of this area of research is to find VR environments that replicate differences in behavior and/or affect that have previously been reported in response to real exposure and to implement these VR setups in the fMRI environment to investigate its neural basis.

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We have made first attempts using stereoscopic visual presentation in fMRI (Forlim et al., 2019). However, we are currently developing more advanced technical solutions that reach beyond simply presenting different visual input to the two eyes of the participant, including magnification lenses. This VR-fMRI setup could also enable us to show 360° video material taken in natural contexts to investigate brain activity during nature exposure in fMRI (see Research Area 1).

Research Area 3: Long–Term Effects of Outdoor Living Environments

In this research area, we explore larger MRI databases that also contain information about the daily living environment of participants, either acquired by means of questionnaires or by means of address data that we then process further using Geographic Information System (GIS) methods to extract geographical information. A first region of interest analysis on structural brain data of the Berlin Aging Study II (BASE-II; cf. pp. 138 ff.) revealed a positive association between the amount of area covered by forest within a 1 km radius around the home address of participants and the integrity of the bilateral amygdala, quantified as a latent factor with indicators from grey matter volume, mean diffusivity and magnetic transfer ratio (Kühn et al., 2017). The amygdala as well as the perigenual anterior cingulate cortex (pACC) are brain regions that have previously been related to stress processing and in particular to differences between functional brain responses of urban versus rural inhabitants.

In a recent follow-up analysis on the same data set, we conducted a whole brain analysis on the land use classes Urban Fabric and Urban Green. Urban Fabric has previously been used as a measure for urbanicity as it describes areas where buildings, urban structures, and transport networks dominate the surface area. Urban Green mostly comprises inner city green spaces such as parks, gardens, and zoos. We observed a negative association between Urban Fabric and a positive association between Urban Green and grey matter volume in perigenual/subgenual anterior cingulate cortex (p/sACC). The p/sACC volume correlated positively with memory performance in a scene-encoding task. Although the p/sACC has repeatedly been associated with depressive symptoms, neither brain structure nor land use categories were related to any measures of mental health. In the present literature, authors often focus on either the beneficial effects of green spaces or the detrimental effects of urbanicity, a trend that is likely driven by the fact that the respective land use categories are mutually exclusive. However, Urban Green and Urban Fabric are only two of many land use categories, and are empirically only mildly anti-correlated. By means of regression analyses, we revealed that it is worthwhile considering Urban Green as an additional factor over and above the potentially negative effects caused by urbanicity, since it explains additional variance in p/sACC grey matter. This is first evidence showing that green spaces may harbor salutogenic elements that go beyond the mere absence of potentially detrimental effects of urban contexts.

Within a sample of adolescents from the IMAGEN study (http://imagen-europe.com/), we were able to compare brain structural differences between individuals aged 14 years raised exclusively in rural regions with those exclusively raised in cities. We observed higher grey matter volume in the left hippocampal formation of adolescents exclusively brought up in rural regions compared with those raised in cities. Interestingly, the left hippocampal formation was positively associated with cognitive performance in a spatial processing task. In addition, we observed group differences in spatial processing performance (Rural > City). The results are in line with previous studies reporting earlier and more intense spatial exploration opportunities in children raised in rural areas compared with cities. Therefore, the observed effects may be the result of a spatial

cognitive training history accompanied by a volume increase of the brain areas underlying navigation in space, namely the hippocampal formation.

We are planning to continue this line of research using various large data sets that have been acquired with a focus on neuroimaging data. One data set consists of different European lifespan neuroimaging cohorts that have been harmonized within the Lifebrain project (https://www.lifebrain.uio.no/ funded by Horizon2020; cf. p. 139). Another study we are involved in is the Hamburg City Health Study (http://hchs.hamburg/), which is the largest local health study worldwide and will comprise 45,000 individuals (neuroimaging on n = 8,000) who will be extensively characterized with respect to health factors but also to their home and workspace environment. Moreover, we have started to analyze brain data of the German National Cohort Study (https://nako.de) (n > 10,000 at present) and are working on data from the Adolescent Brain Cognitive Development Study (ABCD, https://abcdstudy.org/) acquired in the United States. Our long-term goal is to go beyond cross-sectional correlation analyses by using follow-up assessments to relate environmental changes to neural changes over time.

Research Area 4: Extreme Environments

A major challenge of our research topic is that the environments of participants are difficult to manipulate and difficult to assign randomly. Therefore, we have started to study individuals who assign themselves to spending time in extreme environments. In collaboration with Alexander Stahn (Center for Space Medicine and Extreme Environments at Charité Universitätsmedizin Berlin and University of Pennsylvania), who conducts studies in different human analog missions that simulate aspects of long-term space missions, we have the opportunity to acquire brain data of individuals before and after they overwinter in Antarctica or spend weeks to months in confinement-simulating missions to Mars (e.g., bedrest studies simulating microgravity or actual space flight missions; funded by Deutsches Zentrum für Luft- und Raumfahrt [DLR], European Space Agency [ESA], and National Aeronautics and Space Administration [NASA]).

In a recent study, we have investigated the effects of extreme physical and social environments on the human brain (Stahn et al., 2019). Animal studies have shown that these forms of exposure have deleterious effects on the brain, particularly in reducing the generation of new neurons in the dentate gyrus of the hippocampus. In order to explore whether stressors associated with prolonged isolation lead to similar impairments in human brain plasticity, we regarded polar expeditions during which individuals spent 14 months in Antarctica. These expeditions are characterized by environmental deprivation and prolonged physical as well as social isolation, and therefore offer an opportunity to study the effects of these factors on brain structure. In line with our hypothesis, we observed volume reductions in the dentate gyrus of the hippocampus. Most interestingly, those changes were associated with decreases in brain-derived neurotrophic factor (BNDF) in blood serum samples, which has previously been associated with brain plasticity processes, and with lower performance in a spatial cognition task. In a whole brain analysis, we found additional reductions in dorsolateral prefrontal cortex, orbitofrontal cortex, and parahippocampus. This vulnerability of the dentate gyrus to environmental deprivation in comparison to other hippocampal subfields resembles findings from animal models, suggesting a possible link between hippocampal neurogenesis, stress-induced behavioral changes, and environmental deprivation. However, since the sample size of this study was rather low, we are continuing this research.

In a similar vein, we are planning to study prisoners in correctional facilities. Prisons likewise constitute an extreme environment, often with very limited access to nature. Potential longitudinal effects of this kind of

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(a) Hippocampal subfield changes

(b) Whole-brain gray matter decreases

(c) BDNF before, during, and after expedition

Mean BDNF Feb to Post:
13.8
(95% CI: 12.0, 15.5)

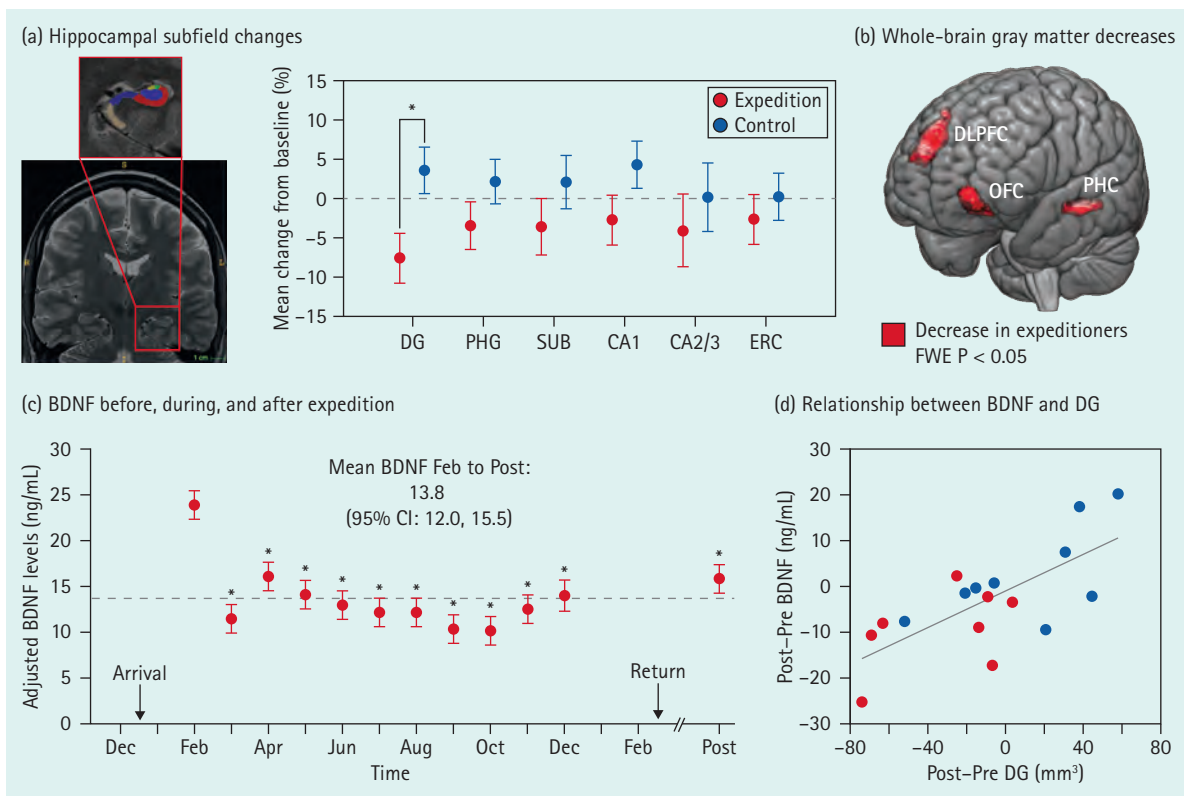**(d) Relationship between BDNF and DG**

Figure 2. Panel A (left): Example of a single slice from high resolution imaging sequence and delineation of hippocampal subfields. Panel A (right): Changes in hippocampal subfields in Antarctic expeditioners (red, $n = 8$) and sex- and age-matched controls (blue, $n = 9$). Data are shown as means $\pm$ SE adjusted for changes in cardiopulmonary fitness (VO2max). CA, cornu ammonis; DG, dentate gyrus; ERC, entorhinal cortex; PHG, parahippocampal gyrus; SUB, subiculum. The *p* values refer to the within-subject comparison of change from pre to post ($p = 0.02$) for the expedition group and the between-subject comparison of change scores between the expedition and control group ($p < 0.01$). Panel B: Whole-brain analysis based on T1-weighted MRI data using voxel-based morphometry. Red regions indicate decreases in right dorsolateral prefrontal cortex (DLPFC), left orbitofrontal cortex (OFC), and left parahippocampal gyrus (PHG) in expeditioners compared to controls. Panel C: Brain-derived neurotrophic factor (BDNF) levels during, and after 14-month Antarctic expedition ($n = 115$ blood samples, $n = 9$ individuals) adjusted for baseline measured before going to Antarctica. Data depicted are adjusted means and standard errors. BDNF was significantly decreased in Antarctica at all time points compared to the first data collection after arrival (Feb) ($p < 0.001$, Bonferroni-corrected for multiple comparisons) compared to baseline. * $p < 0.05$. Panel D: Relationship between changes in BDNF and dentate gyrus volume in expeditioners (red) and controls (blue) (adapted from Stahn et al., 2019).

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detention on brain plasticity but also on cognition are of high societal relevance and have as of now not been investigated.

Summary and Future Directions
Our long-term goal is to integrate the knowledge gained in our separate research areas to characterize the neural mechanisms by which the environment impacts well-being and cognition in humans across different scales and contexts. Moreover, we are planning to examine potential differences across the lifespan with a particular focus on the influence of environmental factors on children and adolescents.

Publications 2017–2019/20

(last update: April 2020)

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Emmy Noether Group: Lifespan Neural Dynamics Group

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Overview

Various subdisciplines within neuroscience have long shown that the brain is inherently dynamic and variable across moments at every level of the nervous system. The Lifespan Neural Dynamics Group (LNDG) pursues the general hypothesis that neural variability may be highly functional for neural systems, indexing important benefits such as greater dynamic range, systemic flexibility, and adaptability (see Garrett et al., 2013). Viewed from this perspective, and in contrast to earlier notions of "neural noise," normal cognitive aging can be reframed as a generalized process of increasing system rigidity and loss of dynamic range that manifests in reduced brain signal variability. The group tests this conceptualization by examining a wide range of brain signal variability phenomena in relation to cognition, network dynamics, neurochemistry, brain structure, and brain stimulation.

LNDG research has been financially supported by a five-year Emmy Noether grant from the German Research Foundation (DFG) to Douglas D. Garrett (2017–2021). Research highlights of the group are summarized below.

A relatively new direction for the group is marrying computational neural modeling, human neuroimaging, and behavior to understand how the complexity of sensory input maps may drive the variability of neural responses across the adult lifespan. Initial work by LNDG on faces and houses is the first to examine the link between complexity of sensory input, neural variability, and behavior (Garrett et al., 2020). Humans are "face processing experts" who can reduce faces to a limited number of perceptual dimensions, yet still discriminate and remember them, thus potentially requiring lower processing fidelity and minimal neural dynamic range. Houses, are intuitively a much more differentiated stimulus type, with relatively few constraints on their form relative to faces, potentially increasing required processing fidelity. We had 46 older adults free-view face and house stimuli during fMRI and found that participants expressing greater upregulation of BOLD variability in areas V1/V2 for house relative to face stimuli also exhibited faster and more consistent behavioral performance on a battery of nine offline visuo-cognitive measures (see Figure 1). Computational modeling of ventral visual stream responses showed that faces were much less "feature-rich" than houses, especially in V1/V2-like model layers, convergent with our fMRI results. This work establishes first evidence that individual differences in tuning of signal variability to visual input differentiation are key proxies for trait-level visuo-cognitive behavior. In a series of subsequent studies, we continue to probe the link between stimulus and neural complexity using EEG, fMRI, and single spiking data in younger and older adults.

Another new direction for the group involves the use of computational modeling of behavior to understand brain dynamics during per-
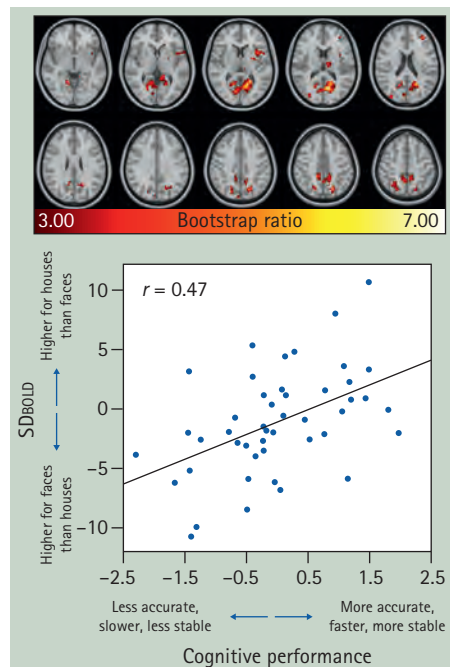
Figure 1. Multivariate latent model showing greater SD$_{BOLD}$ upregulation during house compared to face conditions (house_SD$_{BOLD}$ minus face_SD$_{BOLD}$) as a function of more accurate, faster, and more stable offline cognitive performance (adapted from Garrett et al., 2020). BSR = bootstrap ratio.

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ceptual decision-making. In particular, work by postdoc Niels Kloosterman has focused on how decision biases are dynamically implemented in the human brain. Strategically adopting decision biases allows organisms to tailor their choices to environmental demands. For example, a liberal response strategy pays off when target detection is crucial, whereas a conservative strategy is optimal for avoiding false alarms. Typically, decision bias is conceptualized as a fixed "internal reference" against which sensory evidence is compared. However, we instead showed that individuals implement decision bias by *shifting the rate of sensory evidence accumulation* toward a decision bound. Participants performed a visual target detection task (with reward) while EEG data were recorded. Drift diffusion modeling revealed that a liberal strategy optimally biased sensory evidence accumulation toward target-present choices, and that liberal biases were driven by a trade-off between alpha oscillations and gamma power in visual cortex. Our findings showed that observers can intentionally control cortical "excitability" to strategically bias evidence accumulation toward the decision bound that maximizes reward.

Expanding to systems-level accounts of brain signal variability, the LNDG has also begun to elucidate the extent to which "local" (within-region) variability is a function of its communication with other regions. Inspired by animal work demonstrating that local temporal variability may be largely driven by synaptic input rather than locally-generated "noise," we recently used publicly-available high-temporal-resolution fMRI data (100 adults, 18–85 years) to test in humans whether greater BOLD variability in local brain regions was associated with functional network integration (estimated via spatiotemporal PCA dimensionality; Garrett et al., 2018). Multivariate modeling revealed that individuals with higher local temporal variability had a more integrated (lower dimensional) network fingerprint. Notably, temporal variability in the thalamus (one of the most connected structures in the human brain) showed the strongest association with functional integration. Our findings indicate

that local variability primarily reflects functional integration, and point to the potentially fundamental role for the thalamus in how the brain fluctuates and communicates across moments. Interestingly, we found that approximately 50% of the aging-related variance in these resting state data could be attributed to individual differences in network integration, providing an immediate basis for hypothesis testing in future cognitive neuroscience studies of aging-related differences in signal variability.

Relatedly, LNDG further participates in analyzing data from Cognition, Brain, and Aging (COBRA), an on-going large-scale longitudinal data collection in Umeå, Sweden. In COBRA, 188 older adults aged 64–68 years are followed over 10 years with MRI and dopamine positron emission tomography (PET) assessments. Initial analyses again reveal that thalamic fluctuations are related to network integration while performing a working memory task (see Figure 2). Specifically, we observed that within-person increases in thalamic variability under cognitive load tightly reflect within-person load-based increases in network integration ($r = .70$). Individuals whose thalamus showed a greater load-related increase in variability also showed faster behavioral responses and higher dopamine binding potential.

Finally, the LNDG continues to examine and develop novel methods for computing brain dynamics in cognitive neuroscience. In collaboration with the Center for Lifespan Psychology's former project *Cognitive and*
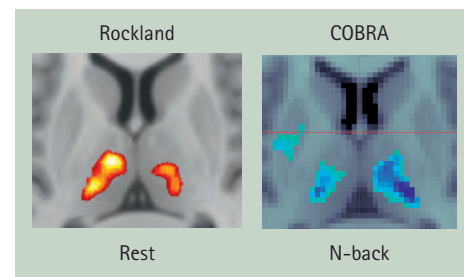
Figure 2 Replication of the positive resting-state relation between thalamic variability and network integration (Rockland sample; Garrett et al., 2018) in task (n-back) data from COBRA (*n* = 188 older adults).

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Neural Dynamics of Memory Across the Lifespan (ConMem), PhD student Julian Kosciessa has developed a novel method for detection of "oscillatory episodes" in brain data. In past work, the average power of rhythmic neural responses as captured by magnetoencephalography (MEG), electroencephalography (EEG), and local field potential recordings has typically been used to estimate oscillatory activity in a given frequency band. However, average power actually conflates rhythmic and arrhythmic components. To overcome this confound, we recently extended and optimized an existing rhythm detection algorithm (extended Better OSCillation Detection; eBOSC; Kosciessa, Grandy et al., 2020) to derive state-of-the-art estimates of neural rhythms and to systematically investigate boundary conditions of estimating such rhythms at the single-trial level. This work highlights the general feasibility of separating (transient) rhythms from arrhythmic 'noise' in time, magnitude, and space.

As another example, Julian Kosciessa has further focused on revealing outstanding computational and interpretational issues with standard entropy algorithms in cognitive neuroscience. Multiscale Entropy (MSE) is often used to characterize the temporal irregularity of neural time series patterns. Due to its presumed sensitivity to non-linear signal characteristics, MSE is typically considered a complementary measure of brain dynamics to signal variance and spectral power. However, the divergence between these measures is often unclear in application. Furthermore, it is commonly assumed (yet sparingly verified) that entropy estimated at specific time scales reflects signal irregularity at those precise time scales of brain function. Using simulated and empirical electroencephalogram (EEG) data from 47 younger and 52 older adults, we showed that these entropy-based assumptions are not tenable when standard MSE algorithms are used (Kosciessa, Kloosterman, & Garrett, 2020). However, we demonstrated how such methodological and inferential problems may be alleviated by carefully accounting for scale-dependent signal variance via a series of algorithmic adjustments and statistical controls. In so doing, we provide a first set of best practices for the use of entropy algorithms in cognitive neuroscience, ideally permitting the valid estimation and interpretation of neural signal irregularity at time scales of interest.

All our newly developed pipelines and analysis routines are openly available (github.com/LNDG) and applicable to a wide range of neuroimaging data collected at the MPI for Human Development and beyond.

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Max Planck Research Group

iSearch |
Information Search, Ecological
and Active Learning Research
with Children

Head: *Azzurra Ruggeri*

Photo: Members of the group with assistants

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Introductory Overview

How can I fix my leaking kitchen sink? What's the gestation period of kangaroos? What's the title of that TV series with dragons and blue-eyed zombies? When did Hannibal cross the Alps with his elephants—and did this really happen? The Internet has made learning new content easier than ever: You just Google your questions in natural language, as you would if asking your mother, teacher, or nerdy best friend, and you get reliable answers. However, having potential access to any type of content does not make information search necessarily simpler. Indeed, to acquire new information effectively, learn, and make decisions based on the information acquired, one has to know what kinds of questions to ask, how to ask effectively and reliably, how to filter and interpret the results, when to stop querying, and how to evaluate which answer or solution should be selected or trusted. From this perspective, the learning process nowadays relies more on the ability to make effective and appropriate inquires than on the availability of the answers.

Since March 2017, the MPRG iSearch takes a novel developmental and computational approach to explore four main themes: (1) the emergence and developmental trajectory of children's active and ecological learning strategies; (2) the individual factors driving their effectiveness and adaptiveness; (3) the role of active learning to navigate the social environment, with the aim to (4) develop interventions that tap into and boost children's learning potential. With these goals, the MPRG iSearch conducts experiments in the laboratory, at schools, and at several museums in Berlin, for example, the Natural History Museum Berlin and Labyrinth Children's Museum (see Figure 1), as well as cross-cultural field work in collaboration with colleagues from universities and partner institutions around the world.

Figure 1. Our studies in the museums and other settings are designed to be game-like and fun for children.

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Emergence and Developmental Trajectory of Active and Ecological Learning

The MPRG iSearch investigates theoretically and empirically how children actively seek information in their physical and social environments to test and dynamically revise their hypotheses and theories. We explore the effectiveness of children's information search and hypothesis-testing strategies, such as question asking and active exploration, tracing their emergence and developmental trajectory. Crucially, the effectiveness of such active learning strategies cannot be measured in absolute terms. Instead, their effectiveness depends on the characteristics of the task at hand, the available resources, as well as on the learners' prior knowledge and expectations. In this sense, to maximize learning effectiveness, it is crucial to be able to adapt one's active learning strategies to the current situation—an ability we refer to as *ecological learning*. For example, the quality of a question has been traditionally tied to whether it is hypothesis scanning or constraint seeking. Research investigating children's active information search has used variants of the "20-questions game," where the task is to identify a target object/cause or a category of objects/causes (e.g., "What kind of objects can be found on Planet Apres?" or "Why was the man late for work today?") within a given set by asking as few yes–no questions as possible, either generating the questions from scratch or selecting them from a list of given alternatives. Hypothesis-scanning questions are tentative solutions, that is, single objects

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Ruggeri, A., Sim, Z. L., & Xu, F. (2017). "Why is Toma late to school again?" Preschoolers identify the most informative questions. *Developmental Psychology, 53*(9), 1620–1632. https://doi.org/10.1037/dev0000340

or hypotheses that are tested directly (e.g., "Was he late because he woke up late?"). Constraint-seeking questions, instead, aim to reduce the space of possible hypotheses by targeting categories or testing features shared by several different hypotheses ("Was the man late because he could not find something?"). Constraint-seeking questions have been generally considered more informative than hypothesis-scanning questions because they allow the question-asker to rule out multiple hypotheses at once, thus reducing the number of questions needed to identify the solution. However, this is not always the case. Indeed, this qualitative distinction does not necessarily reflect the questions' actual informativeness, as can be formally measured for example by calculating their Expected Information Gain (EIG), that is, their expected reduction in uncertainty .

From this perspective, we were able to provide the first evidence to demonstrate that ecological learning emerges early on. Seven- and 10-year-olds generate different types of questions depending on the likelihood distribution of the hypotheses under consideration in order to maximize the questions' informativeness. Also, by age 7, children are as sensitive as adults to the causal sparsity (i.e., the number of variables that are likely to impact an outcome) of an unfamiliar causal system and use this information to tailor their testing strategies (for the computational framework and results with adults, see Coenen et al., 2019).

We recently extended this investigation to explore younger children's ecological learning abilities and found that 5-year-olds already rely on different types of questions depending on the likelihood of the available hypotheses (Ruggeri et al., 2017). In this study, we presented 4- and 5-year-old children with a storybook describing the reasons why the monster Toma had been late for school on several days. Children in the *uniform* condition learned that Toma had been late equally often for different reasons (see Figure 2, left), whereas children in the *skewed* condition learned that Toma had often been late for one particular reason (e.g., on 5 of 8 days he was late because he woke up late; see Figure 2, right). Children then learned that Toma was late yet again: Two of Toma's monster friends wanted to find out why, and children were asked to indicate which of them would find out first why Toma was late again—that is, which friend asked the most informative question. In both conditions, one of the friends asked a *constraint-seeking* question that targets several different hypotheses, whereas the other friend asked a *hypothesis-scanning* question that targets only one hypothesis. In the uniform condition, because all reasons for Toma being late were presented as equally likely (i.e., all occurred exactly once), a constraint-seeking question that targets three of six hypotheses ("Was he late because he could not find something?") is most informative (i.e., has the highest EIG). However, in the skewed condition, a question that targets
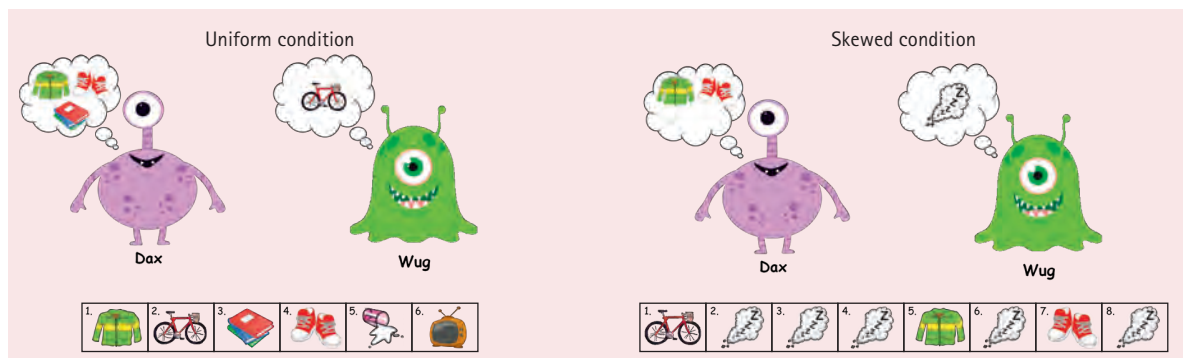
Figure 2. Monster Toma's history of reasons for being late (bottom, left: Uniform condition; right: Skewed condition) and sets of hypotheses tested by two question askers using different strategies (top); Dax's questions target multiple hypotheses at once (so-called *constraint-seeking questions*); whereas Wug's questions target a single hypothesis (so-called *hypothesis-scanning questions*) (adapted from Ruggeri et al., 2017).

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the single most likely hypothesis (i.e., "Was he late because he woke up late?") is most informative. In both conditions, the majority of children selected the monster asking the most informative question, regardless of the question type: In the uniform condition, 70% of the children selected the friend who asked the constraint-seeking question, whereas in the skewed condition, 73% selected the friend who asked the hypothesis-scanning question. These results suggest that already by age 4 preschoolers have the cognitive abilities required to support and implement flexible and successful question-asking strategies.

By implementing a nonverbal version of this question-asking paradigm, we were able to demonstrate that even 3- and 4-year-olds are already able to adapt their exploratory strategies to the statistical structure of a given task (Ruggeri, Swaboda et al., 2019). In this study, children had to find an egg shaker hidden in one of four small boxes, which were in turn contained in two larger boxes. They were allowed to *open only one large box,* but they could shake the large boxes first if they wanted to. Crucially, before this test, children either learned that the egg was equally likely to be found in any of the four small boxes (uniform condition) or that it was most likely to be found in one particular small box (skewed condition). Results show that pre-schoolers as young as 3 successfully tailored their exploratory actions to the different likelihood distributions: Compared to the skewed condition, where children had a strong intuition as to where the egg shaker would be hidden, children in the uniform condition were more likely to shake a large box first. This way, they could *hear* which large box contained the small box with the egg shaker without risking to open the wrong one. We are currently exploring the early emergence of ecological learning by implementing spatial search and eye-tracking paradigms, in which we investigate whether 12- to 36-month-olds are sensitive to the relative informativeness of different search strategies.

Finally, the work presented in this section shows that children engage in meaningful and effective exploration, but it does not address the question of whether, in general,

the opportunity to gain information is enough to motivate children's search. In a recent study, we let toddlers (age 24–52 months) play a game in which they had to search for an animal behind a (potentially infinite) series of doors and measured their persistence in the absence of explicit rewards. Crucially, we either told children which animal they were searching for (*known animal* condition, e.g., "Find the lion"), so that they gained no additional information when finding it, or we told them that it could be one out of eight different animals (*unknown animal* condition). Although, regardless of their search efforts, children could actually not find an animal, our measures converge in indicating that they were more persistent in the unknown animal condition, where there was more information to be gained. This line of research has the potential to extend our understanding of children's intrinsic motivation and set the stage to investigate algorithms that explore as children do.

Modeling Individual Differences

The great pioneer of computer science, Alan Turing, famously believed that, in order to build a general artificial intelligence, one must create a machine that can learn like a child. However, this dream seems to be still quite out of reach, as we still do not know much about how children actually explore and in what ways their behavior differs from that of adults. In Schulz et al. (2019), we tested three different hypotheses put forward to explain developmental differences in exploration behavior: Children sample more randomly, they explore uncertain options more eagerly, and they generalize more narrowly than adults. To disentangle the unique contributions of each of these mechanisms, we developed a novel computational model that captures the extent of generalization, the amount of directed exploration, and the extent of random exploration. Children (age 7–11) and adults had 25 clicks to search for rewards by exploring the tiles of a grid (see Figure 3a). Rewards were distributed such that similar rewards clustered together. In particular, participants were randomly assigned to either *smooth* or *rough* environ-

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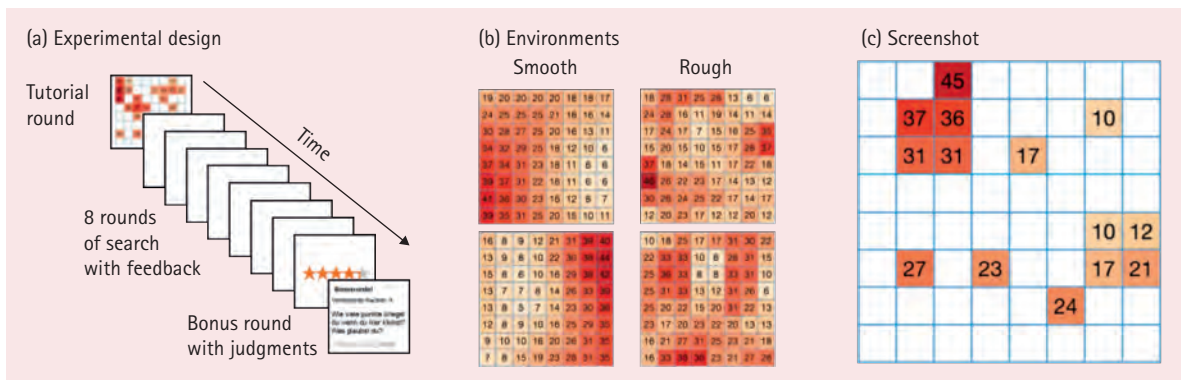
Figure 3. Overview of our grid-based task. (a) An overview of the experimental design. Participants first completed a tutorial round and then eight rounds of search with feedback. Finally, they completed a bonus round that also included judgments about unobserved tiles. (b) The two types of environments used in the experiment: Smooth environments had stronger spatial correlations than rough environments. (c) Screenshot from the experiment with the grid partially revealed (adapted from Schulz, Wu et al., 2019).

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ments, with *smooth* environments having stronger spatial correlations than *rough* environments (see Figure 3b). To search for rewards, participants could either click on any of the unrevealed tiles or click again the tiles that they had revealed before, in this case obtaining a reward that was just slightly higher or lower (see Figure 3c). We also compared participants' search behavior with the choices that various computational models would make when facing the same particular grid state that the participants saw. In general, searchers' behavior was best captured by a model that generalizes from limited observations to the structure of the environment and makes adaptive search decisions by optimistically inflating the expectation of rewards in cases of greater uncertainty. However, children differed from adults in their specific search strategies. Using a computational model with parameters directly corresponding to the three hypothesized mechanisms of developmental differences, we were able to observe that children generalized less and that their sampling behavior was more directed toward uncertain options than that of adults. Children did not, however, explore more randomly than adults. As a result, adults gained higher rewards and exploited at a higher rate, whereas children sampled more unique options, thereby gaining lower rewards but exploring the environment more extensively. These results provide strong evidence for developmental differences in directed exploration driven by both expected rewards and the associated uncertainty. Furthermore, the results demonstrate how reward expectations and uncertainty interact to produce decision-making behavior that balances the exploration–exploitation trade-off adaptively as a function of age.

In the study described above, children and adults had to balance the search for information with the collection of rewards. In related research (Meder et al., 2019), we investigated children and adults' effectiveness in the 20-questions game, a pure information search task where the goal is to identify an unknown target with as few questions as possible. By performing computational modeling analyses, we showed that a model that focuses only on the immediate next search step, identifying the available query with the highest stepwise information gain, does not necessarily also identify the most effective sequence of questions, that is, the shortest path to the solution. Across two studies, we contrasted stepwise methods with globally optimal strategies and investigated whether, and to what extent, children (age 8–10) and adults plan ahead in sequential search, considering not only the immediate next question, but the scenarios the available questions would lead to. To do that, we designed a version of the 20-question game in which thinking more than one step ahead was required to identify

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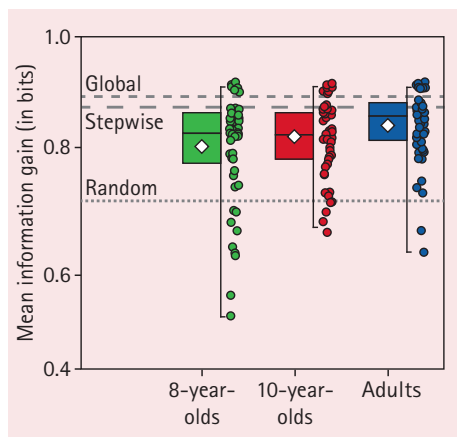
Figure 4. Information gain analysis of all questions. Each dot is one subject; box plots show interquartile range with median (line), mean (diamond), and range of data (whiskers). Horizontal lines show average information gain of random, stepwise-optimal, and globally optimal models (adapted from Meder et al., 2019).

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the most effective sequence of queries. Our results showed that, rather than planning ahead, both children and adults tended to rely on myopic search strategies, asking questions that were most informative in the immediate next step but disregarding how asking those questions would impact the availability of informative queries afterward (see Figure 4). These findings demonstrate that adults are not necessarily better than children at planning ahead when acquiring information and highlight the importance of better understanding the cognitive processes underlying searchers' effectiveness when planning a sequence of queries.

Effective information search also strongly depends on how people represent and organize the space of hypotheses under consideration. For example, asking questions that rule out multiple hypotheses at once requires being able to organize the available hypotheses (e.g., whether the target is an owl, parrot, shark, or goldfish) into hierarchically nested categories (e.g., birds and fish; animals). Markant et al. (2018) investigated in a multiple-cue inference task whether developmental differences in children's search patterns and prediction accuracy are attributable to how the hypothesis space is structured

and organized. In this task, 5- to 7-year-old children were presented with four different monsters and tasked to find out which kinds of monsters were faster. Children could select which monster pairs they wished to see running in a race in order to learn how two cues (color and shape) predicted the monsters' relative speed. Using computational modeling, we tested various models of children's active search, which were based on different ways to organize and represent the hypothesis space about the cue–outcome relationships. We found that young children's search was most consistent with a model that was based on an exemplar-based representation of the hypothesis space, that is, a model that represented the hypothesis space in terms of the relative speed of individual monsters, rather than a cue-abstraction model that assumes a more effective, high-level representation based on the crucial features of the cue–outcome relationship. However, when memory aids were provided during the search, older children were more likely to base their predictions on a cue-abstraction model. Our results highlight the crucial importance of the hypothesis-space representation for search, provide the first evidence for a shift in hypothesis-space structure between search and test, and suggest that young children already possess the cognitive abilities required for abstracting hypothesis-space representations. Most, if not all, research on active learning has focused on identifying developmental differences in the effectiveness and adaptability of search. However, we do not yet fully understand why these changes occur. More specifically, we do not know precisely which factors are most important in driving developmental changes in active learning, how they interact with each other, and how their relative importance changes at different developmental stages. In an ambitious cross-cultural collaboration with partners in Cuba, Egypt, India, and the United States, we are currently collecting data on the project *Contributing Factors to Active Learning,* conceived as an exploratory analysis aiming to identify and map the factors contributing to active learning performance, beyond the broad developmental differences captured in previous

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research. On the one hand, the project aims to measure different aspects of active learning (e.g., effectiveness, adaptiveness, speed, accuracy) on a wide range of tasks (e.g., question asking, question evaluation, spatial search) to comprehensively assess 6- to 11-year-old children's active learning performance. On the other hand, we systematically examine the cognitive, social, motivational, cultural, and socioeconomic factors impacting and contributing to active learning performance to identify the sources of the developmental differences and interpret the individual differences observed. In this sense, the cross-cultural design allows not only to examine a broader range of cultural variability (e.g., type of education) and to assess the robustness of our methods, but also to generalize our results to populations usually not represented in psychological research.

Active Learning to Navigate the Social Environment

Throughout children's development, a crucial source of information is other people. Previous research demonstrates that children as young as 3 already have an idea of what makes a good teacher and strategically choose to learn from and trust some people more than others. To do that, they rely on a rich set of inferences drawn from the quality of the information provided by an informant (e.g., their accuracy in labeling a familiar object) and from the informant's characteristics (e.g., age, familiarity, culture).

Yet, beyond the knowledge that people demonstrate, *how* they acquired their knowledge and skills may also have implications for their reliability and trustworthiness as teachers. For instance, someone who has acquired knowledge actively, for example by asking questions or exploring the task hands-on, might have a deeper understanding of the problem than someone who has acquired the same knowledge through passive observation or instruction. In a series of new projects, we investigate whether and how children identify *effective* active learners, whether they use this information to select models to *learn how to learn,* and when this sensitivity and selectivity emerge developmentally.

In a first project, we investigated whether 3- to 8-year-old children are sensitive to the process by which people have learned how to activate a novel toy (Bridgers et al., 2018). We introduced children to three adult learners who had learned how to activate the toy in different ways: One learner had acquired the relevant knowledge on her own through active exploration; one had the opportunity to explore the toy, but was eventually shown how to activate it; one learned by passively observing someone else's active-learning process. Children where then presented with three toys, one at a time: The *same* toy they had seen the learners play with in the videos, a *similar* toy, and a *different,* much more complicated toy. Children were given a few seconds to try and activate the toys and, when they failed, we suggested that they ask one of the three learners they have seen in the video for help. Children preferentially sought help from the active learner when presented with the toy *similar* to the one she had been able to figure out on her own, assuming her demonstrated competence to be relevant for the problem at hand. However, they showed no systematic preference when asking for help with the other two toys. In two additional experiments, we used a similar paradigm to further disentangle the cues that children rely on when evaluating others' active learning competence. Our results suggest that younger children's preferences might be driven by more superficial cues, such as being alone while learning, and that only older children distinguish between intentional and accidental active learning behavior when attributing competence. Together, these experiments indicate that children ascribe problem-solving competence to an active learner, but it is only around age 6 that a more abstract understanding develops of what the process of active learning can tell about a person's competence.

In a second project, we investigated how children and adults generalize question-asking competence to other personal traits, characteristics, and abilities (De Simone & Ruggeri, 2019). We presented participants with one monster who always asked informative questions and one who always asked

uninformative questions. Participants had to choose which monster they thought was more likely to possess/was better at 12 different characteristics/abilities. Our results show a clear developmental trend. Three- and 4-year-olds draw unsystematic inferences from the monsters' question-asking expertise. Five- and 6-year-olds identified the better question asker as better at everything, suggesting a limited understanding of the domain-specificity of question-asking expertise. Seven- to 9-year-olds showed adult-like response patterns, selectively associating the ability to ask good questions to related characteristics/abilities with different strengths, but not to others (e.g., liking ice cream).

These projects are a first step in understanding whether and how children use their sensitivity to others' active learning competence to navigate the social world, identifying good sources of knowledge, but also good active learning models. We are currently exploring whether and how being exposed to good active-learner models can boost children's motivation to learn or directly improve their exploration and question-asking strategies. For example, do infants and toddlers preferentially and selectively imitate active-learner models? We also recently started investigating children and adults' competence when navigating the digital world, for example when searching for information on the web or when interacting with virtual assistants and social robots.

Interventions to Boost Learning

How can we boost children's learning success in classroom settings and beyond? One way to do this is to develop interventions that enhance children's learning performance by supporting the effectiveness of their active learning strategies, for example helping them to ask more informative questions. Previous attempts to improve children's question-asking strategies have achieved only moderate success. Most children did not improve their performance over time and the modest training benefits, when present, did not generalize to other sets of stimuli or domains and were no longer apparent one week later. How-

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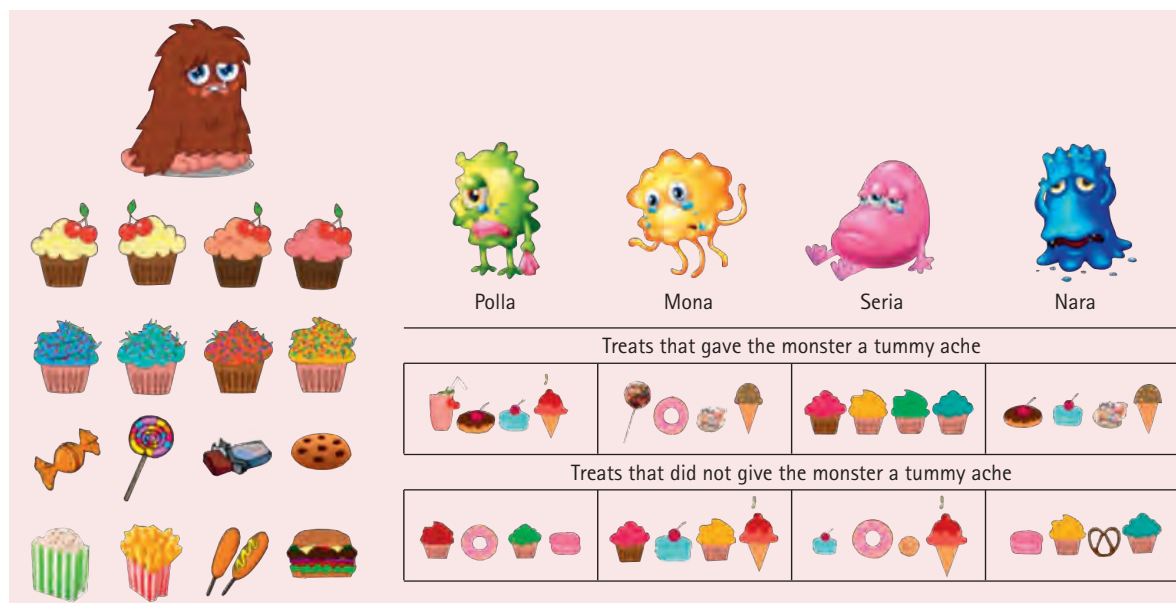
Figure 5. Test and training stimuli from Ruggeri, Xu et al. (2019). Four- to 7-year-olds were presented with a 20-questions task where the goal was to determine what kinds of treats give a monster a tummy ache by asking as few yes/no questions as possible (left panel). This task was preceded by a training phase in which children observed instances of treats that did or did not cause a tummy ache for four other monsters (right panel). Children in the explanation condition were prompted to explain (without feedback) why particular treats gave each of these four monsters a tummy ache (e.g., "Cupcakes give Mona a tummy ache"); those in the no-explanation condition were merely asked to observe and describe the training stimuli.

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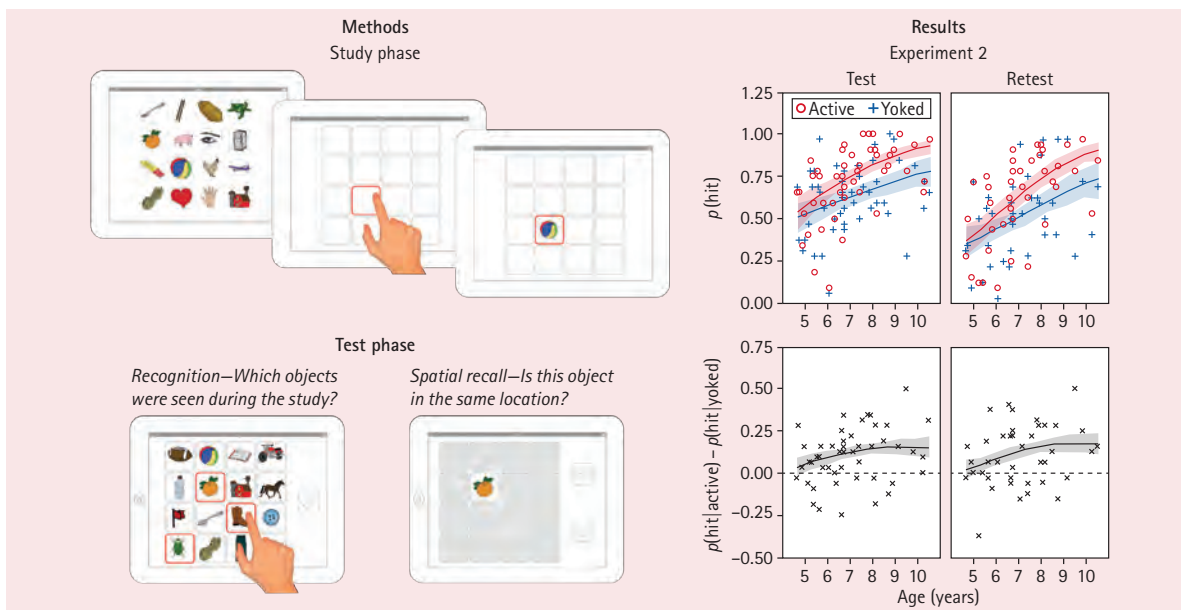
Figure 6. **LEFT:** Procedure used in Experiments 1 and 2. **Top:** Each study round began with all objects displayed for two seconds. After the objects disappeared, participants either selected a location to study (Active condition), causing a red frame to appear, followed by the object, or touched the location where the object appeared (Yoked condition), preceded by a red frame. **Bottom left:** During each test block, participants selected the objects that they recognized from the study phase. **Bottom right:** Spatial recognition test (Experiment 2 only). For objects that were recognized, participants judged whether they were presented on the test grid in the same location as where they appeared during study. **RIGHT:** Recognition accuracy for studied objects in Experiment 2. Individual points represent participants, solid line is fitted regression line, and shaded regions indicate 95% confidence intervals calculated through parametric bootstrapping. **Top:** Recognition of objects studied in active (red) and yoked (blue) conditions as a function of age. **Bottom:** Within-subjects difference between active and yoked recognition as a function of age. Dashed lines indicate no difference between study conditions.

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ever, our group has recently demonstrated that it is indeed possible to support children's question-asking performance even without extensive training. Across two studies, we presented 4- to 7-year-olds with a 20-questions task in which the goal was to determine what kinds of treats give a monster a tummy ache by asking as few yes/no questions as possible (see Figure 5, left panel). This task was preceded by a training phase in which children observed instances of treats that did or did not cause tummy aches for four other monsters (see Figure 5, right panel). Children in the *explanation* condition were prompted to explain (without feedback) why particular treats gave each of these four monsters a tummy ache (e.g., "Mona must be allergic to cupcakes!"); those in the *no-explanation* condition were merely asked to observe and describe the training stimuli. We found that prompting children to explain helped 6- and 7-year-olds, but not younger children, to ask more effective questions, that is, questions that targeted higher category levels and therefore allowed reaching the solution with fewer questions (Ruggeri, Xu et al., 2019). This explanation prompt was successful because it facilitated the identification of categorical features that applied to multiple objects and hypotheses (e.g., "cupcakes") and could therefore be used to ask more effective questions. Improving children's active inquiry skills at an early age has the potential to accelerate the development of their general information search strategies and problem-solving skills, boosting their later independent learning beyond the classroom. More work is needed to assess long-term impacts of these kinds of interventions on question-asking strategies and to examine whether the magnitude of this effect is mediated by individual factors, for example, verbal and categorization

abilities (see section on Modeling Individual Differences).

Another way to boost children's learning success is to design learning environments that enhance their performance. For example, in a series of studies, Ruggeri, Markant et al. (2019) found that active control of study leads to enhanced learning in 5- to 11-year-old children. In two experiments, children played a simple memory game with the instruction to try to memorize and later recognize a set of 64 objects in four study blocks (see Figure 6). In a third experiment, the goal was to learn the French names for the same objects. In two of the blocks, children could decide the order and pacing of study (active condition). In the other two blocks, they passively observed the study decisions of a previous participant (yoked condition). Recognition memory was more accurate for objects studied in the active as compared to the yoked condition. Our results show that the ability to actively control study develops during early childhood and results in memory benefits that outlast a week. We recently replicated these results with a population of children affected by autism (Perri et al., 2019). We were able to show that beneficial effects of active control

Figure 7. Colorful, but difficult: With the monster game on the tablet, 10- and 11-year-olds are asked to learn the connection between the properties of the monster—friendly, cheeky, funny—and the number of fruits picked, shown on the top right-hand corner of each card.

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of the study experience extend to other tasks as well. For example, participants were more accurate when actively selecting information in a function learning task, where they had to learn how continuous inputs (e.g., characteristics of a monster) map onto a continuous output (e.g., the monster's ability to pick magic fruit; see Figure 7).

Publications 2017–2019/20
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Max Planck Research Group

Naturalistic Social Cognition

Head: *Annie E. Wertz*

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Annie E. Wertz

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Introductory Overview

The Max Planck Research Group Naturalistic Social Cognition (Head: Annie E. Wertz) primarily investigates the cognitive and behavioral mechanisms that enable infants and young children to learn about plants. This is a novel research area that intersects with established research traditions investigating the evolution and development of threat avoidance, social learning, and culture. The group utilizes a combination of laboratory studies, naturalistic observations, cross-cultural studies, and comparative work. The work is divided into three research areas: (1) protective behavioral strategies, (2) selective social learning, and (3) learning in the wild. This group started its work in 2015.

Plants are an important, yet easily overlooked, part of human life and human evolution. Foraged plant resources were a critical component of human diets, plant parts were used to build tools and shelters, and chemicals were extracted from plants for medicinal and ritual purposes. Our modern circumstances can make it difficult to appreciate the complexity of the problems inherent in foraging and utilizing plants in these ways in wild environments. Nevertheless, our ancestors successfully negotiated these challenges and, as a result, we argue that plants have helped shape the human mind. This topic is the main focus of the research carried out by the MPRG Naturalistic Social Cognition.

Our research is based on a deceptively simple principle: Humans must be able to obtain the benefits that plants provide while avoiding the costs they can inflict. The benefits of plants for humans in the form of food calories and as sources of raw materials are relatively clear. The costs, on the other hand, may be less obvious. Many plants produce a variety of toxic chemicals that protect them from herbivores, some of which are quite dangerous to humans, causing serious illness and even death. Some plants also have mechanical defenses like thorns or stinging hairs. Plant toxins and mechanical defenses are targeted at all kinds of herbivores—from insects to ungulates to primates—and consequently the problem of obtaining plant benefits while avoiding plant costs is shared by many animal species.

Although the general principle may seem simple, the actual task of identifying the plants that are edible or otherwise useful to humans in natural environments is not easy or straightforward. Since plant life varies widely across the types of environments in which humans live, and because plants are in coevolutionary relationships with many different animal species, plants do not reliably signal whether they are edible or toxic to humans. That is, there are no specific fruit colors or leaf shapes that clearly indicate that a particular plant is safe (or dangerous). Therefore, humans living in a particular environment must identify the individual plant species around them that can be consumed and those that should be avoided. Consistent with this proposal, studies have shown that modern societies that rely on subsistence practices such as hunting, gathering, and small-scale horticulture can identify hundreds, and sometimes thousands, of different plant species.

Our research focuses on the cognitive mechanisms that enable individuals to safely acquire this kind of information about plants over the course of ontogeny. Given the prevalence of toxins in plants, a trial-and-error strategy in which an individual samples different plants and experiences the consequences could result in frequent illness and perhaps even death. Therefore, we have proposed that social learning is the best solution to the problem of obtaining plant benefits while avoiding plant-related dangers. Using social learning mechanisms to acquire information about plants from more knowledgeable individuals mitigates the risks from plant toxins and facilitates the construction of culturally specific knowledge banks tailored to particular environments (Wertz & Moya, 2019). More precisely, we argue that the human mind contains a collection of behavioral strategies and learning rules that are specialized to plants. We have called this collection

of cognitive systems Plant Learning and Avoiding Natural Toxins, or PLANT (Wertz, 2019). We investigate this proposal with infants to uncover the structure of these behavioral strategies and selective learning rules early in ontogeny, prior to vast amounts of specific experiences and formalized instruction (see Box 1). This novel research area connects to broader research traditions investigating threat avoidance, social learning, and cultural transmission from an evolutionary perspective.

Our research program is organized into three main topic areas. The first research area investigates the protective behavioral strategies that infants use to mitigate plant dangers such as poisoning and physical injury. The second research area examines the selective social learning rules that infants use to acquire relevant information about plants from others (e.g., edibility). The third research area explores how these plant specific behavioral avoidance strategies and selective social learning rules operate "in the wild" by using a combination of naturalistic observations and cross-cultural and comparative methods. In addition to our empirical research program, our group produces theoretical work concerning the evolution of learning and culture, and pursues collaborative projects to investigate core aspects of cognitive and social development from infancy to adulthood.

Methods of Studying Infant Cognition

We use a variety of techniques to investigate infant cognition. Infants are not capable of participating in the kinds of experimental paradigms used with older children or adults. However, by precisely recording what infants look at, what they reach for, and the kinds of behaviors they show in carefully crafted experimental situations, we can make firm inferences about infants' underlying cognitive processes.

Figure 1. **Visual attention techniques.** These methodologies measure where and for how long infants look at different experimental displays. Using precisely designed stimuli, infants' visual attention patterns reveal what kinds of changes they notice, what types of events they expect, and how they process visual information. We use two different visual attention techniques in our research. The first technique is live looking time coding, in which a trained observer sits out of view of the infant and records how long the infant looks at different events using a computer program. The second technique makes use of an eye tracker to record detailed information about where infants are looking within a particular display. The eye tracker emits a harmless infrared light and measures the reflections from the infant's cornea and pupil to precisely record the infant's gaze patterns.

Figure 2. **Reaching paradigms.** Infants' reaching behavior can be as informative as their visual attention. Choice paradigms present two objects to infants simultaneously and use their reaching behavior as an indication of their preference for one object over the other. Many of our studies use a "time-to-touch" paradigm in which we measure infants' latency to touch individual objects that are presented serially. By comparing infants' latencies to touch different types of stimulus objects, we can make inferences about the types of objects infants avoid. In general, we present our stimuli for a given experiment within subjects to account for individual differences in reaching speed, and we counterbalance the order in which the objects are presented across infants to mitigate order effects at the group level.

Figure 3. **Behavioral coding.** Video recordings of infant behavior can be rich sources of data. To standardize the types of behaviors we are interested in, we develop coding schemes that precisely operationalize what is counted as, for example, a "look" or a "touch" in a particular study. With the help of behavioral coding software, our research assistants comb through video recordings to identify when and how often behaviors of interest occur. This technique can be used with videos of our tightly controlled laboratory studies as well as with videos of infants and young children in naturalistic settings.

Box 1.

Research Area 1: Protective Behavioral Strategies

The first research area investigates the protective behavioral strategies that infants use to mitigate plant dangers. Plants have been a fundamental part of human life and human evolution, yet plant foraging can be a risky task given the dangers that plants pose due to the variety of toxic chemicals and mechanical defenses (e.g., thorns) they possess. Therefore, the primary dangers humans face when interacting with plants are poisoning and physical injury. Because plants are rooted to the ground, they can only inflict harm when an individual approaches and makes contact with them. Consequently, behavioral avoidance is a particularly effective way to avoid harm from dangerous plant defenses.

Accordingly, previous work from our group members has established that infants do indeed avoid touching plants compared to other object types (Wertz & Wynn, 2014a). Further, because fatally toxic plants can look harmless, the best behavioral avoidance strategy is to minimize contact with any unknown plant, regardless of how it may look, until one has some additional information about it. Therefore, in a set of new studies, we investigated whether, prior to receiving social information from adults, infants would be reluctant to touch plants regardless of their visual appearance by using plants with and without sharp-looking thorns. We also predicted that before infants make physical contact with a plant they would actively seek out information from other people.

We tested this proposal with two studies (Elsner & Wertz, 2019; Włodarczyk et al., 2018), in which a series of objects were presented to 8- to 18-month-old infants (total $N = 125$) one at a time by an experimenter seated across a table (see Box 1, Figure 2). These objects were real plants, realistic-looking artificial plants, novel man-made artifacts matching plants along perceptual dimensions (i.e., green color, presence of leaf-shaped parts), familiar man-made artifacts (e.g., spoons), and other naturally occurring entities (e.g., seashells; see Figure 4). In Włodarczyk et al. (2018), some objects were benign-looking while others possessed sharp-looking thorns or had thorn-like elements. The amount of time it took for infants to touch each stimulus object, and infants' subsequent manual exploration of the stimuli, were coded from videos of the sessions. In Elsner and Wertz (2019), infants' social information-seeking behavior was coded (i.e., instances

in which infants' gaze was first directed at a stimulus object and then immediately at the face of an adult; see Box 1, Figure 3). Additionally, in order to investigate the potential role of infants' prior experiences with plants, parents completed a Plant Experience Questionnaire (PEQ; adapted from Wertz & Wynn, 2014a, 2014b), assessing infants' prior experience with indoor and outdoor plants during the last month and during the last summer months.

As predicted, infants took longer to reach out and touch plants, both real and artificial, compared to all of the other object types, independently of their prior experiences with plants (Elsner & Wertz, 2019; Włodarczyk et al., 2018). Further analyses support the notion that this reluctance was specific to plants and not a function of lower-level features. For example, infants did not avoid all green entities nor did they avoid all objects with leaf-shaped parts. Interestingly, during the early stages of object exploration, infants treated all plants as potentially dangerous, whether or not they were benign-looking or possessed sharp-looking thorns (see Figure 5a; Włodarczyk et al., 2018). However, infants did show some sensitivity to visible plant threats (i.e., thorns) during the later phases of exploration: They touched the thorny parts of plants less often than any other parts of the stimulus objects (Włodarczyk et al., 2018). Additionally, as predicted, infants engaged in more social looking toward adults for plants compared to all other object types. Importantly, this increase in social looking occurred before infants touched plants, putting infants in the best position to glean information from others before making contact with potentially dangerous plants (Elsner & Wertz, 2019).

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Figure 4. Stimulus objects presented to infants in two behavioral avoidance experiments (adapted from Elsner & Wertz, 2019, and Włodarczyk et al., 2018).
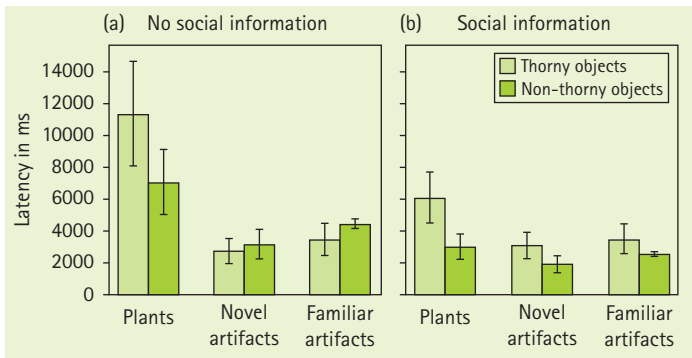
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Figure 5. Infants' time to touch (ms) the different types of stimulus objects when, from left to right, (a) no social information was demonstrated to infants (Włodarczyk et al., 2018) and (b) social information was demonstrated to infants (Włodarczyk et al., 2020). As predicted, social information reduced infants' reluctance to touch plants. Error bars depict standard errors (adapted from Włodarczyk et al., 2020).

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These findings show that the behavioral avoidance strategy toward plant threats in infancy operates without obvious social information that a plant is harmful to touch. In the studies outlined above, an adult simply places objects in front of the infants while saying *"Look what I've got,"* but remains otherwise neutral and motionless. Therefore, it was unclear whether this strategy could be further modulated by an adult providing additional social cues about plants or whether the existing findings instead represent a stable effect for infants' plant avoidance. To test this, in a follow-up study, we examined whether infants modify their behavior when social information about plant properties is presented (Włodarczyk et al., 2020).

In this study, 8- to 18-month-old infants ($N = 50$) were presented with 24 stimulus objects, one at a time in a counterbalanced order, across two experimental sessions separated by a short break. The stimulus objects were realistic-looking artificial plants, novel man-made artifacts, and familiar man-made artifacts (e.g., spoons). The stimuli presented in one of the sessions had infant-safe thorns or pointed parts, while the stimuli presented in the other session did not. Critically, the stimuli presented in the first half of each experimental session were accompanied by social information. This social information
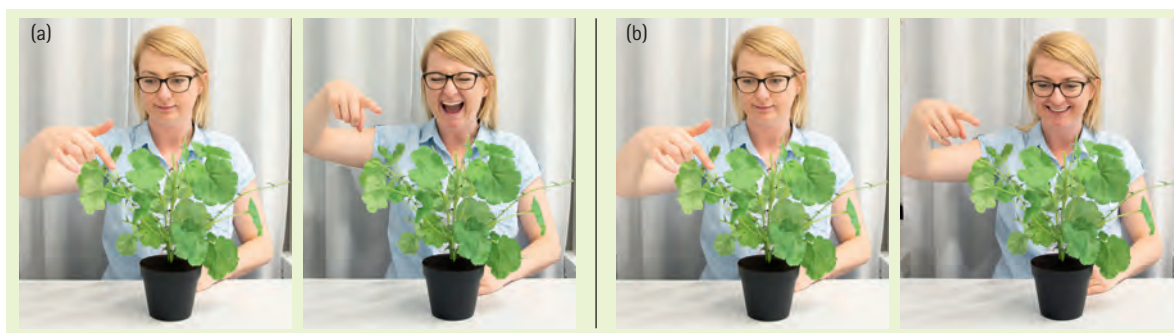
Figure 6. The sequence of the social information presentation in the experiment where infants were presented with social information. From left to right: (a) negative social information presentation. Experimenter touches the object and then reacts with a negative vocal and facial expression saying *"Ow!"* and (b) positive social information presentation. Experimenter touches the object and then reacts with a positive vocal and facial expression saying *"Wow!"* (adapted from Włodarczyk et al., 2020).

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involved an experimenter touching each stimulus object and then reacting with either negative social information (pain; see Figure 6a) or positive social information (delight; see Figure 6b); the type of social information (negative or positive) presented varied between subjects. Infants' latencies to touch each stimulus object, as well as the frequency and duration of their subsequent touches, were coded. In order to directly assess the effect of the presence of social information compared to a baseline condition, the current results were compared to Włodarczyk et al. (2018), which used a similar procedure and stimuli, but without presenting any negative or positive social cues.

The results suggest that, in comparison to the previous study in which no social information was demonstrated, the social information presented in this study reduced infants' reluctance to touch plants, but did not influence their reaching behavior toward the other object types (see Figure 5b). Nevertheless, infants remained relatively more reluctant to touch plants compared to the other object types even when the additional social cues were present (see Figure 5b). Further, infants remained more reluctant to touch the stimuli with thorns (see Figure 5b). Surprisingly, in-

fants did not respond differently to the plants or other stimulus objects in the negative and positive social information conditions. Instead, infants seemed only to react to the fact that the experimenter physically touched the objects.

Taken together, these results provide the first evidence that infants' plant avoidance can be reduced by social information from adults and connect to broader research in threat avoidance in infancy. We plan to expand this project in the future to include other types of social information, such as an adult not only touching the plant but also eating part of it, to examine whether directly observing plant consumption may further decrease infants' reluctance to touch plants. We have also recently submitted a paper validating the Plant Experience Questionnaire (PEQ), which was developed by our group and provides a measure of infants' and young children's experiences with plants prior to participating in our studies. This scale measures four aspects of plant experience: experience with indoor plants, outdoor plants, eating fruits and vegetables from plants, and parental prohibition from touching plants. The findings in this research area add a new dimension to the broader threat avoidance literature.

Research Area 2: Selective Social Learning

The second research area examines the selective social learning rules that infants use to acquire relevant information about plants from others. Thus far, we have focused primarily on edibility. Identifying the plants that humans can eat in natural environments is not an easy task. Plant features vary widely across human environments, and plants do not reliably signal human-relevant edibility or toxicity. Given the prevalence of toxins in plants, recent mathematical modeling work has confirmed that trial and error learning is not a tenable strategy (Oña et al., 2019). Instead, infants must rely on social learning rules that facilitate the safe acquisition of information about plant food resources from more knowledgeable individuals.

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We are currently pursuing two lines of research related to this proposal. First, we are examining how infants learn about ed-ible plants. Plants have been a foundational component of human diets over evolutionary time and therefore provide a fruitful avenue of inquiry for studies within the broader area of food learning in infancy and early child-hood. Second, we are examining how infants generalize socially learned information about plant edibility to similar-looking plants. Ap-propriately generalizing socially conveyed information is fundamental to avoid being poisoned by plants that look quite similar to edible plants, but may nevertheless be poison-ous (Oña et al., 2019).

One of our projects examines infants' re-sponses to plant-based foods like fruits and vegetables. We tested whether infants show a reluctance to touch plant-based foods like they do for whole leafy plants and whether social cues of processing plant parts for consumption (e.g., picking, cutting into slices) lessens their reluctance. To test this, we pre-sented a series of objects to 7- to 15-month-old infants (total $N = 56$). These objects were whole plants in their naturally occurring state, processed plant foods such as picked and cut fruits and vegetables, and control objects that matched the whole plants and processed plant food objects along perceptual dimensions (see Figure 7).

Infants' latency to touch each stimulus object as well as their social information-seeking be-havior was coded from videos of the sessions. Additionally, in order to investigate whether infants' responses to plant-based foods are related to later food neophobia (i.e., the rejec-tion of novel food items), we contacted the participants' parents one year later to com-plete the Child Food Rejection Scale question-naire (CFRS; Rioux et al., 2019).
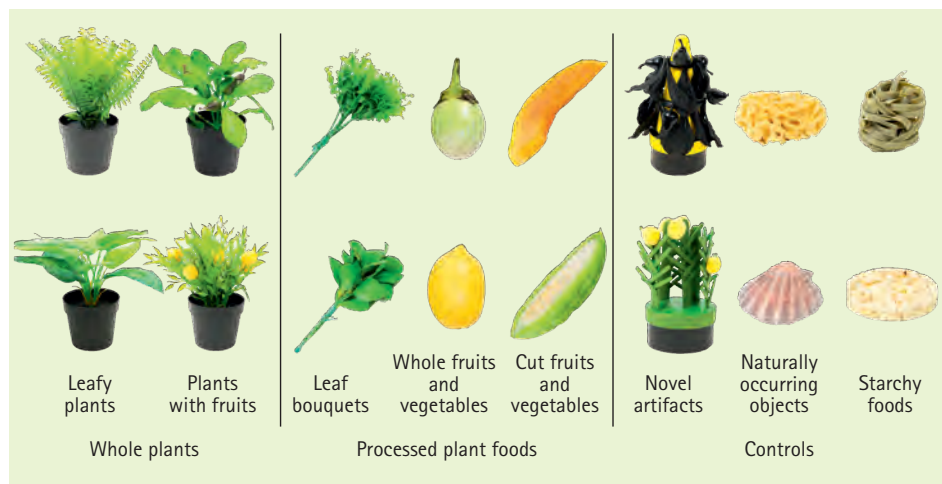
Figure 7. Stimulus objects presented to infants in the experiment testing whether infants respond differently to plant-based foods (e.g., fruits and vegetables) and whole leafy plants.

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We found that infants avoided touching both whole plants and processed plant foods and engaged in more social looking before touching these stimulus objects relative to their matched controls. Further, infants still took longer to touch whole plants than processed plant foods and engaged in more social looking before touching whole plants, suggesting that cues of food processing may signal food safety. These results indicate that infants' reluctance to touch plant-based foods can be mitigated by social cues of food processing. Finally, the results of the follow-up CFRS questionnaire suggest that aspects of infants' behavioral avoidance of plant foods are related to later food neophobic behaviors. These findings add to the broader literature on food learning and parallel findings showing that food neophobia is mitigated by social information (Rioux, 2019). The paper for this project is currently under review. We plan to expand this study in the future to include other types of social information about the different objects, such as an adult eating parts of them, allowing us to examine whether directly observing plant food consumption may decrease infants' reluctance to touch plant food.

In a different project, we investigated how infants generalize socially learned information about plant edibility and whether they restrict their generalization to similar-looking plants. Previous research showed selective social learning of plant edibility in infancy: 6- and 18-month-old infants selectively identified plants, over artifacts, as food sources after seeing the same food-relevant social information—an adult placing something in his or her mouth—applied to both object types (Wertz & Wynn, 2014a). Here, we explored the social aspect of edibility learning further by testing whether infants systematically extend socially learned edibility information to similar looking plants (Wertz & Wynn, 2019).

To this end, 18-month-old infants watched an actor eat fruits from one plant and were then given the choice between two new plants: One plant that was of the same type as that from which the actor ate and one plant that was of a different type (see Figure 8). We tested edibility generalization under two sets of conditions. In Experiment 1 ($N = 20$), infants watched an actor eat fruits from one plant (see Figure 8a) and were then presented with the choice between two new plants (see Figure 8c). In Experiment 2 ($N = 20$), infants watched the actor eat fruits from one plant and pick off and reject fruits from a different-looking plant (see Figure 8b) before they were presented with the choice between two new plants. Infants' choices and eating behavior were recorded.

The results of this study show that 18-month-olds systematically generalize edibility information. That is, when infants watch an adult eat from one plant, they recognize that
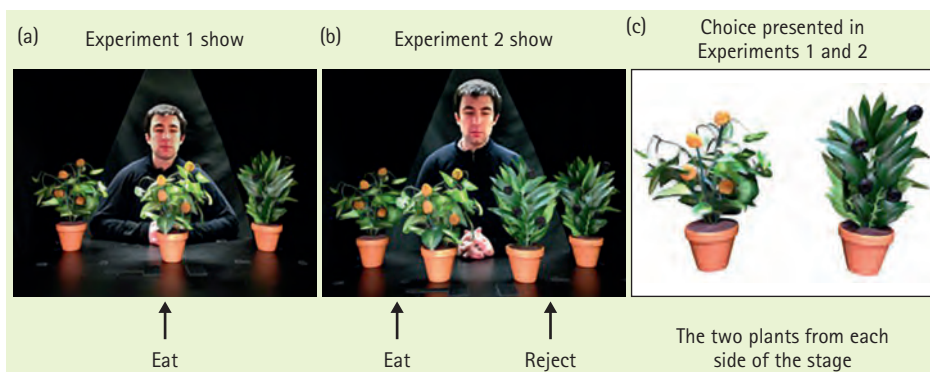
Figure 8. Schematic of the show and choice procedures used in in the edibility generalization experiments. From left to right: (a) Experiment 1 show, (b) Experiment 2 show, (c) choice presented in Experiments 1 and 2. Fruit color (orange and purple) and leaf shape (broad-leaf and narrow-leaf) of the plant the experimenter ate from were counterbalanced across participants, as was the side (right or left) of the same type and different type choice plants (adapted from Wertz & Wynn, 2019).

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other similar-looking plants are also edible (see Figure 9). This crucial aspect of food learning seems to be in place by the toddler years. It remains an open question whether younger infants are capable of this type of generalization as previous studies have found that preverbal infants do not appear to systematically generalize edibility information. Therefore, in the future, we plan to expand the investigation of edibility generalization to 12-month-old infants.

Research Area 3: Learning in the Wild

The third research area broadens the scope of our investigations beyond a laboratory context and explores how these plant specific behavioral avoidance strategies and selective social learning rules operate "in the wild." We draw together several approaches in this area. First, we conduct studies in naturalistic garden settings with infants and young children. Second, we employ cross-cultural methods to assess how different cultural contexts influence the way infants and young children respond to plants. Finally, we use comparative methods to observe the behavior of different nonhuman primate species toward plants, which provides important insights into the evolutionary roots of plant learning.

Learning in the Garden
In 2018, we completed data collection for a 3-year longitudinal gardening study investigating how 3- to 6-year-old children learn about plants from other individuals in a naturalistic setting and how they retain this information over time. In this study, small groups of children participated in gardening activities with one of our researchers every week for 8 weeks over the summer. This study was carried out at the Max Planck Society-affiliated Forschungskindertagesstätte "FRÖBEL-Kindergarten im Lützelsteiner Weg" from 2016 to 2018 (see Figure 10). The behavioral coding of the extensive video data from the gardening sessions is currently ongoing (see Box 1, Figure 3). Preliminary analyses of assessments of children's knowledge about plants before and after the gardening sessions indicate that children remember the different properties they learn about the study plants from one year to the next. Children use their

different senses to identify the study plants (smell, touch, vision) and perform best on tasks of visual recognition. These data will be assessed in conjunction with the behavioral coding data from the gardening sessions to examine how children's behavior during the sessions is related to social learning processes.

Cross-Cultural Investigations
We have conducted collaborative cross-cultural projects in two different communities: Indigenous Shuar infants and toddlers living in four rural villages in the Amazon basin in Ecuador (collaborator: H. Clark Barrett, UCLA) and a community of Indigenous iTaukei Fijians living on Kadavu Island, Fiji (collaborator: Rita A. McNamara, Victoria University of Wellington, New Zealand). These projects investigated whether infants and young children growing up in communities with extensive exposure to plants exhibit the kinds of plant avoidance behaviors we observed in

Structure of the gardening study sessions

1. Tidying up the garden beds

2. Review of last week's session

3. Sunflower dance

4. Focus on visual, tactile, or olfactory properties of the plants

5. Measuring the sunflower's growth

6. Watering the plants
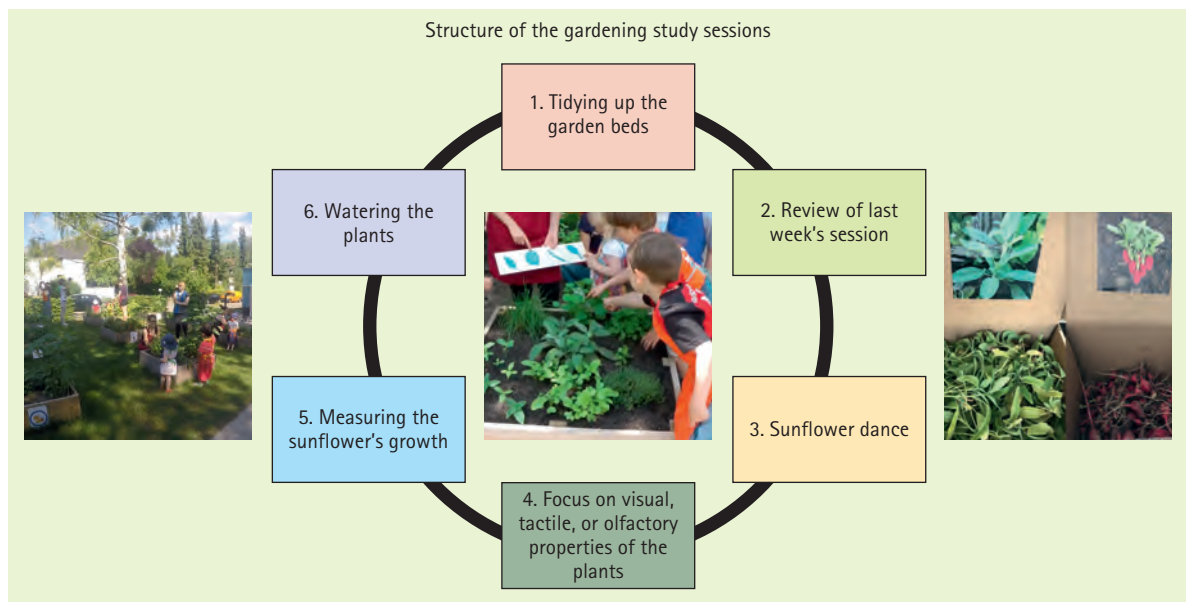
Figure 10. Structure of the gardening sessions in our longitudinal gardening program. Each session began with an introductory activity to tidy up the gardening beds and a review of the previous week's session. Next, the children did a "sunflower dance" that related plant parts to parts of their body to facilitate their engagement with the plants. This was followed by a lesson that focused on one particular feature of the plants: leaf shape, leaf texture, or olfactory properties. Then, children measured the height of the sunflower and marked its progress for that week on a growth chart. The session ended with a closing activity of watering the plants. In the last session, children harvested the plants they had grown and enjoyed snacks made from the fruits of their labor.

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infants growing up in urban and suburban areas of Germany and the United States. We tested children from these two communities using similar types of stimulus objects we used in our previous studies: real novel and familiar plants, novel realistic-looking artificial plants, novel man-made artifacts, familiar man-made artifacts (e.g., spoons), and other naturally occurring entities (e.g., seashells). The results of these two projects indicate that infants and young children in these communities do exhibit some avoidance behaviors toward plants, but show some interesting cultural differences. For example, in contrast to American and German infants, Fijian children did not show reluctance to touch familiar real plants, while Shuar children showed reluctance to touch all types of plants. Children from both communities did not engage in more social looking toward adults for plants compared to the other object types. The papers from these projects are currently under review.

These findings provide important convergent evidence for a behavioral avoidance strategy

for plants and underscore the importance of different cultural contexts for the development of cognitive mechanisms.

Comparative studies

The problem of obtaining plant benefits while avoiding the costs of exposure to plant defenses (i.e., toxic chemicals and injurious structures like thorns) is shared by all animals that consume plants as part of their diets. By examining the plant-relevant behavior of different species, we can shed light on the ecological and evolutionary factors that shape plant-relevant cognition. Accordingly, we collected data on five adult nonhuman primate species' responses to plants: all four great ape species (chimpanzees, bonobos, orangutans, gorillas) and a phylogenetically more distantly related species (capuchin monkeys). The ape data for our comparative study was collected at the Wolfgang Köhler Primate Research Center (WKPRC) in Leipzig in collaboration with the Max Planck Institute for Evolutionary Anthropology (see Figure 11) and the data from capuchin monkeys were collected in collabora-

Figure 11. The ape data for our comparative study was collected at the Wolfgang Köhler Primate Research Center (WKPRC) in Leipzig, which is a collaborative project between the Max Planck Institute for Evolutionary Anthropology (MPI EVA) and Zoo Leipzig. From left to right: (a) The great ape habitat, situated in the heart of Leipzig Zoo's "Pongoland" where all four ape species (chimpanzees, bonobos, orangutans, gorillas) live in large indoor and outdoor enclosures. (b) Individuals enter a testing room on a voluntary basis and participate in noninvasive behavioral studies; here a chimpanzee participates in our study.

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tion with the Comparative Cognition Laboratory at Yale University (New Haven, USA). We matched the study setting as closely as possible to the previous infant studies testing behavioral avoidance of plants. Therefore, we used the same stimulus objects used in the infant studies: real plants, artificial plants, novel man-made artifacts matched to features of the plants, man-made artifacts that were familiar to humans, and other naturally occurring entities. We also added a new object category: man-made artifacts that were familiar to apes.

Our results demonstrate that different nonhuman primate species exhibit different responses to plants. Chimpanzees and orangutans showed a similar behavioral pattern to human infants: They avoided touching plants compared to the non-plant objects. In contrast, gorillas and capuchin monkeys showed the opposite pattern: They reached for the plants faster than the non-plant objects. Bonobos did not show a difference in their behavior toward plants and non-plant objects.

Phylogenetic relatedness alone cannot account for these interspecies differences because we would expect the species more closely related to humans to behave more similarly to human infants. However, this is not what we found. Gorillas are more closely related to humans than orangutans, but orangutans' behavior in this context was similar to that of humans, while gorillas' behavior was more similar to the distantly related capuchin monkeys. Therefore, it is clear that other factors, such as species-typical dietary habits and ecologies, also influence behavior toward plants. For example, gorillas and capuchins, the two species that touched plants faster compared to the non-plant objects, show a high tolerance toward plant defenses in the wild.

These findings reveal the complex interplay of phylogenetic and ecological factors that shape each species' responses to plants and open many pathways for future investigations.

Additional Research Projects: Exploring Cognitive Development in Infancy

In addition to our primary research program, our group members conduct studies investigating core aspects of cognitive development in infancy. These projects examine whether cognitive and perceptual systems from infancy through adulthood are sensitive to certain regularities in the world (Falck et al., in press), investigate basic aspects of social cognition, and evaluate the methods used to examine cognitive development in infancy. For example, one recent project investigated factors that affect data quality during infant eye-tracking (Schlegelmilch & Wertz, 2019). In this study, we compared looking time and dispersion of gaze points elicited by stimuli resembling frequently used calibration animations and tested the effect of movements infants commonly exhibit during eye-tracking testing sessions (see Box 1, Figure 1). Our findings identified several features of calibration targets that result in higher gaze quality and revealed that body movements toward the screen such as bending forward had a particularly large impact on spatial accuracy (see Figure 12). We have implemented the findings from this paper in the infant eye-tracking studies we conduct in the BabyLab, including a recently completed study investigating the visual properties infants use to distinguish plants, man-made artifacts, and nonliving natural kinds.
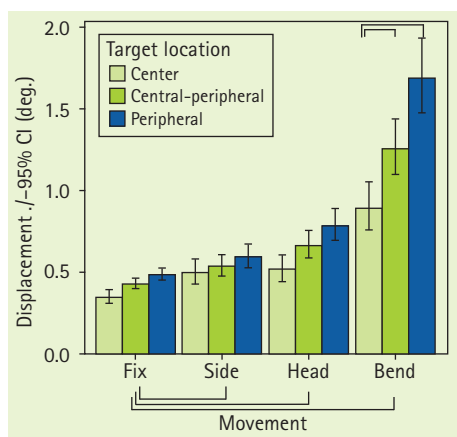
Figure 12. Effects of head and body movements typically exhibited by infants on adult eye-tracking accuracy, predicted by a GLMM; brackets indicate main effects and interactions (all $p < .001$). Accuracy was assessed as the displacement between a visual target and the measured gaze points (degrees of visual angle). Participants fixated the targets precisely after or during the movements. Fix: stable control condition; Head: head-turns toward the locations of the targets; Side: participants turned away from the eye-tracking camera and directly returned before fixating the targets; Bend: reduction of the head–camera distance by about 10 cm before fixation. Note that accuracy was also affected by the targets' locations on the screen (adapted from Schlegelmilch & Wertz, 2019).

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Summary and Future Directions

The research carried out by members of the MPRG Naturalistic Social Cognition has uncovered previously unknown behavioral avoidance strategies and selective social learning mechanisms in the human mind. When confronted with plants, infants minimize physical contact, differentially seek out social information, selectively learn certain types of information (e.g., edibility, touch), and generalize learned information in appropriate ways. These findings are consistent with our proposal that the human mind contains a collection of behavioral strategies and learning rules that are specialized to plants (i.e., Plant Learning and Avoiding Natural Toxins, or PLANT). Our ongoing work continues to interrogate this proposal and broaden the scope of our investigations to include naturalistic settings, different cultures, and different species. This novel research area intersects with established research traditions investigating threat avoidance, social learning, and cultural transmission, and demonstrates the utility of applying an evolutionary approach to the study of learning and development.

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Max Planck Research Group

NeuroCode |
Neural and Computational
Basis of Learning, Decision
Making and Memory

Head: *Nicolas W. Schuck*
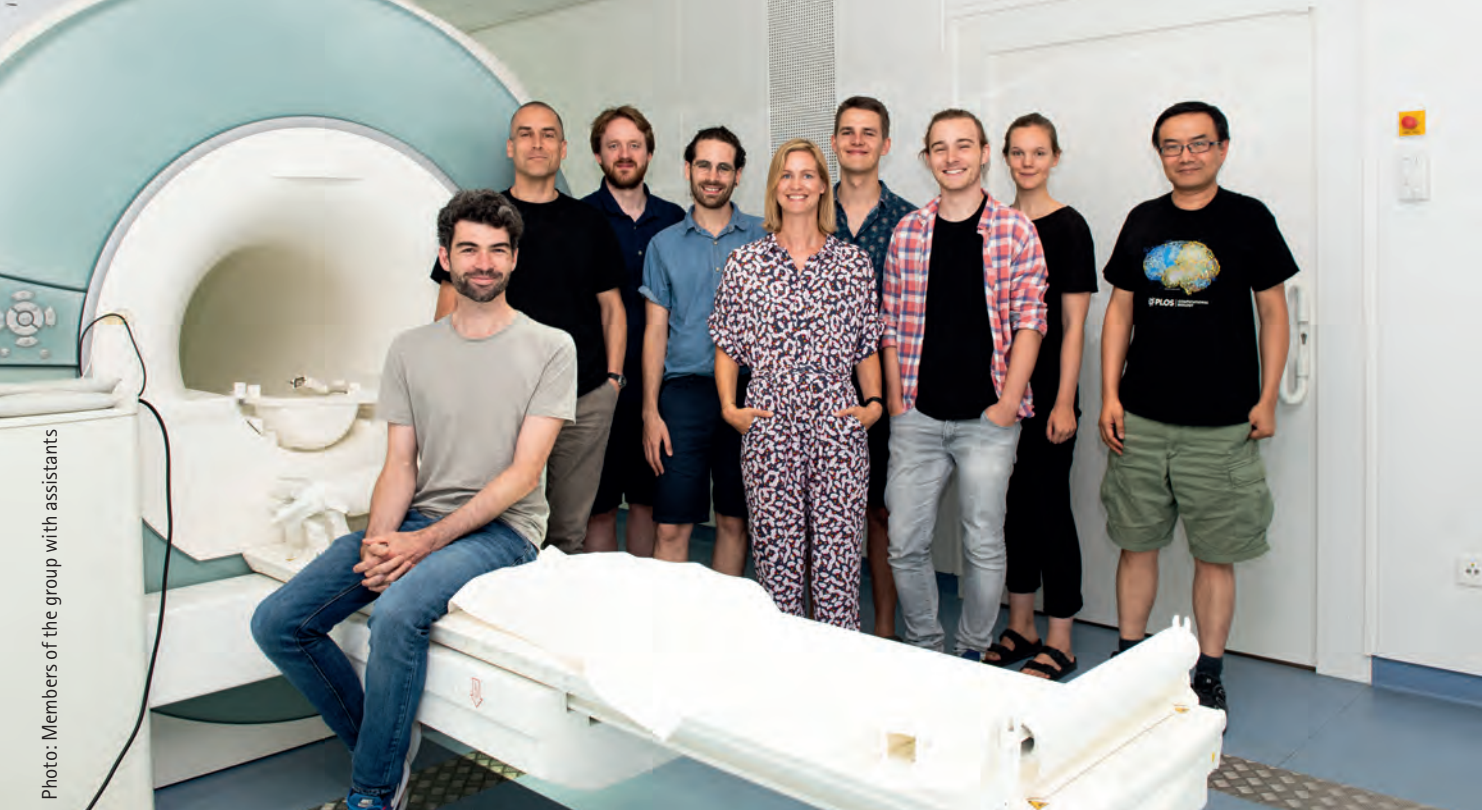
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Overview

Our everyday life is filled with choices. Should I take vanilla or chocolate ice cream? Will the subway or the bicycle be faster? Despite obvious differences between these decisions, they share a common challenge: the attempt to forecast the future consequences of our actions. But what exactly gives us this ability to predict the effects of our choices? Our research suggests the answer may lie in the brain's ability to construct internal representations of the environment that are optimized for decision-making.

How humans learn to make good decisions is the main focus of the Max Planck Research Group "Neural and Computational Basis of Learning, Decision Making and Memory" (NeuroCode). Established in September 2017, our research is based on the notion that the central challenge behind achieving our goals is to know what exactly in the environment will affect the outcomes of our choices, and what will not. Consider the above example: How satisfying will an ice cream flavor be on a summer night if you chose it based on experiences made in winter with a different vendor 10 years ago? Computer scientists have long realized that knowing how "to look at" a decision problem can make solving a hard task easy and looking at it the wrong way will make an easy task hard. The nature of internal representations of one's environment while making a choice, which reflects how a decision-maker "looks at" a problem, therefore has deep implications for decision-making.

The insight about the importance of internal representations has been many decades ago (e.g., by S. Amarel in the 1960s). But only recently has the interest in internal representations of agents begun to grow rapidly in cognitive neuroscience, where it today is one of the most intensely debated aspects of cognition. This rise is also fueled by the success of deep neural networks in artificial intelligence research that demonstrated a powerful link between rich internal representations of data and the ability to exhibit complex behavior. Most importantly, the combination of these developments has led to a focus on a computational description of the principles that make representations most useful, given a specific decision problem, and on how an agent can learn which representation will help its decision-making process.

Our group investigates the internal representations that guide decision-making in the brain. Building on the framework of reinforcement learning (RL), we refer to such internal representations as task *states.* To study internal task states, we use a variety of tools from different fields. Experimental approaches from cognitive psychology allow us to precisely measure and manipulate the sensory and temporal aspects of tasks and extract behavioral measures of learning and generalization. Using neuroimaging techniques gives us the opportunity to tap into the neural activation while humans make decisions. Methods from machine learning and statistics provide us with the tools to build models and artificial agents that reflect our hypothesis and to compare them to neural and behavioral data.

Our research agenda is structured into four different areas. In the *first research area,* we investigate the learning of state representations: How do humans learn what is relevant for a given decision? Which events lead to the updating of knowledge or beliefs about relevance? Which neural areas are involved in this updating, and which areas reflect the current assumption about the structure of the environment? In a *second research area,* we ask how the mechanism that delineates the states of the environment can cope with the fact that our knowledge about the world is partial and uncertain. Does the brain entertain multiple possibilities about the world when making decisions? In a *third research area,* we link the concept of state representations to another cornerstone in the cognitive neurosciences of decision-making: values, for example, the anticipated outcome or reward of an action, and their neural representation in prefrontal cortex and the basal ganglia. Finally, in the *fourth research area,* we aim

to understand which role inter-areal brain coordination plays in the neural solution to the representation problem. In particular, we focus on the connection between the mechanisms of encoding spatial information, linked to hippocampal activity, and the representations in orbitofrontal cortex observed during decision-making processes. One particular focus in this line of research is the link between fast hippocampal reactivation during rest, widely known as replay, and orbitofrontal state representations, for which the PI has been awarded an ERC Starting Grant (funding starts in April 2020, see section below). Finally, our laboratory deeply cares about open science practices and therefore posts all manuscripts as preprints prior to publication, releases the analysis code for each project and makes data associated with publications accessible if data protection laws permit. Our group is also working on an open fMRI preprocessing toolbox which we plan to release freely in Fall 2020. The following sections detail the research projects in each area.

Research Area 1: Representation Learning

Reinforcement learning (RL) has become a predominant framework for understanding how animals learn to make decisions that help achieve a given goal. While RL is a powerful approach to modeling even complex behavior, it often makes a simplifying assumption: that during learning and decision-making the brain keeps a perfect, internal representation of the present task-relevant state. While this may seem a legitimate assumption in simple experimental settings in which a controlled environment is characterized by a handful of stimuli, it remains unclear how exactly the brain learns to construct appropriate abstract state representations when humans interact with vastly more complex environments.

Learning States

This study investigates how these state representations form and evolve over time in complex environments, utilizing a computer-game-like task developed by us. Participants freely navigated a player through a maze consisting of several rooms, each of which contains several objects. Participants received no instructions other than to find out how to escape the maze through their own exploration. The crucial element of this experiment was that participants needed to learn how to convert the continuous and complex visual and motor sequences into a so-called Markov decision process (MDP)—a description of the sequence of events which allows the efficient usage of RL algorithms even in complex environments. The maze consists of eight levels, with six interconnected rooms each. Every room contains a chest and a lever that participants can interact with (see Figure 1a). A certain sequence of actions is required in order to advance through the maze, which participants have to learn by exploration. Specifically, they need to push the lever in the previous room to unlock the chest in the current room before proceeding to the next one. We modeled the participants' trajectories in the maze as an MDP and identified 5 main states necessary for completing the task within each room (see Figure 1b). Since the participants transition through all five states only in the four middle rooms, we used those data for subsequent analysis.

We tracked the participants' learning progress by the amount of time spent in each level (see Figure 1c). As expected, earlier levels, where participants still explore the maze to learn the rule, took longer to finish. To understand in which brain areas MDP-like state representations developed over time, we collected fMRI data and extracted voxel patterns from orbitofrontal cortex (OFC) and hippocampus (HPC), yielding two sets of time series for each level. After detrending and normalizing, we divided the fMRI time series into discrete periods corresponding to the different MDP states in different rooms. We separated the levels into an "early" block (levels 1–4) and a "late" block (levels 5–8). A crucial question regarding these data was whether activity patterns during similar states would become more correlated to each other, reflecting that the respective
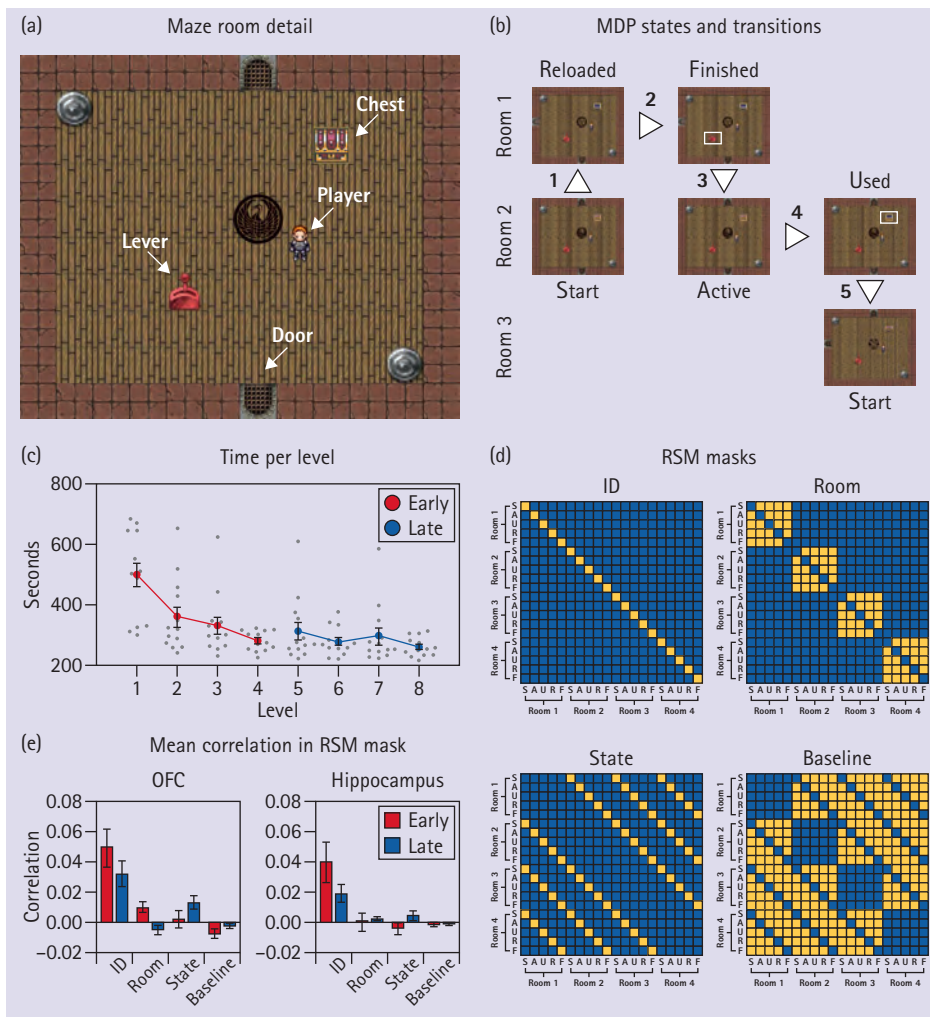
Figure 1. (a) Screenshot of a typical room in the maze, labeled with the key items participants can interact with. (b) MDP states and transitions: "Start," where participants enter a room for the first time; "Active," where participants reenter the room after pushing the lever in the previous room, activating the chest in the current room; "Used," where participants open the chest; "Reloaded," where participants reenter the room after visiting the next room, activating the lever; "Finished," where participants push the lever in the room, activating the chest in the next room. Each maze room is labeled with its state; white arrows indicate transitions; white rectangles indicate items changed. (c) Total time spent in each level of the maze, averaged across participants (error bars indicate SEM, grey dots are individual participants' data). (d) Four masks used to extract data from the Correlation matrix of 20 MDP states (states are abbreviated with their corresponding initials; yellow indicates the cells extracted): "ID" reflects correlations of identical states (e.g., room 1 state S and room 1 state S, cross validated); "Room," correlations of states within the same room (e.g., room 1 state S and room 1 state A); "State," correlations of similar states across different rooms (e.g., room 1 state S and room 2 state S); "Baseline," remaining correlations after removing the cells from the other three masks. (e) Mean extracted RSM values from the masks in (d), separated by early (levels 1–4) and late (levels 5–8) stages of the game. Colored bars indicate average across participants, error bars indicate SEM.

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brain areas begin encoding states and their similarities. We therefore correlated the representations of all 20 states (5 states per room x 4 rooms) with each other to derive a representational similarity matrix (RSM). To avoid temporal autocorrelation, the correlation was done across levels within each time block (e.g., level 1 correlated with 3, level 2 with 4). From the RSM, we extracted entries using masks corresponding to different hypotheses (see Figure 1d): first, that state identity is encoded ("ID"), for example, states are more similar to

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identical states, across runs; second, that room identity is encoded ("Room"), which should not be the case since room was irrelevant; and third, that higher level states are encoded ("State"), reflecting that the brain started to group together functionally similar time points during the task, a key aspect of representation learning. We averaged the correlations within each group to obtain a single mean per time block (see Figure 1e) and compared the correlation to the observed baseline calculated from all nonhypothesized correlations ("Baseline" see in Figure 1d). Of special interests are changes in participants' representations of the maze environment across time from both RL (state similarity) and spatial (room similarity) perspectives. Results (see Figure 1e) indicated that while the changes were not significant in the HPC ($p = 0.1$ for state similarity, $p = 0.8$ for room similarity), the OFC showed an increase in state similarity ($p = 0.05$) and a significant decrease in room similarity ($p = 0.006$). Previous research has demonstrated that the OFC plays an important role in RL state representations (Schuck et al., 2016, 2018; Sharpe et al., 2019), and our results further confirm this. In the early phase of the task, participants were not yet aware of the various RL states. The different rooms were the most prominent features, interpretable as proxies for the states, thus leading to a relatively stronger representation in the OFC. In later stages of the task, where participants have deciphered the rule and thus the RL states, the room representation became irrelevant and therefore weakened significantly in the OFC, while the RL state representation became stronger. These results shed light on how the brain develops task-relevant state representations. Data acquisition and analysis are currently ongoing. Data and code will be released upon publication.

State Finding

The above project asked how states develop during the active search for a solution to a task. While this process is crucial for all tasks that we begin to learn for the first time, in many other cases we might already know one solution. But what if there is a different way to solve the task, but finding this solution

can only arise from a different way of looking at the task, for example, different internal representations?

This consideration of cases in which an established representation needs to be changed is tightly linked to the concept of cognitive control, which allows us to concentrate on what is important for a current task and to simultaneously ignore distractors. Yet, while this process enables us to focus, it might also hinder us from learning new aspects about our environment. For example, if an environment changes, irrelevant information might become relevant and offer a more efficient strategy for the same task. This creates a tension between goal-directed attention and searching for potentially superior ways to achieve a goal. Building on our previous work (Schuck et al., 2015), in this project we aimed to identify factors making the discovery and use of such alternative strategies more likely. Subjects performed a Random Dot Motion Task and were instructed to indicate the predominant motion direction of a colored dot cloud. Dots moved with various degrees of coherence (see Figure 2a). Unbeknownst to the participants, after two blocks the irrelevant color dimension became fully correlated with the required response. Participants could thus use color to maximize efficiency.

We established a method for classifying which subjects switched to the alternative strategy based on color-based responses on low-coherence trials. First, we used a logistic model to capture the participants' increase of color use during the task. The model let us determine if and how fast each participant changed their behavior on low-coherence trials. We defined subjects as "switchers," who's logistic slope parameter deviated from that of a control group in which color remained uncorrelated from the response. The model's inflection points, that is, the points with the steepest increase of color use, yielded the estimated individual switch points. Aligning the data to these points showed that switches to a color-based strategy occurred abruptly (see Figure 2b).

We hypothesized that trial-wise feedback would increase the number of subjects switching to the color strategy by reducing uncertainty about internally generated feedback. Indeed, it increased the number of
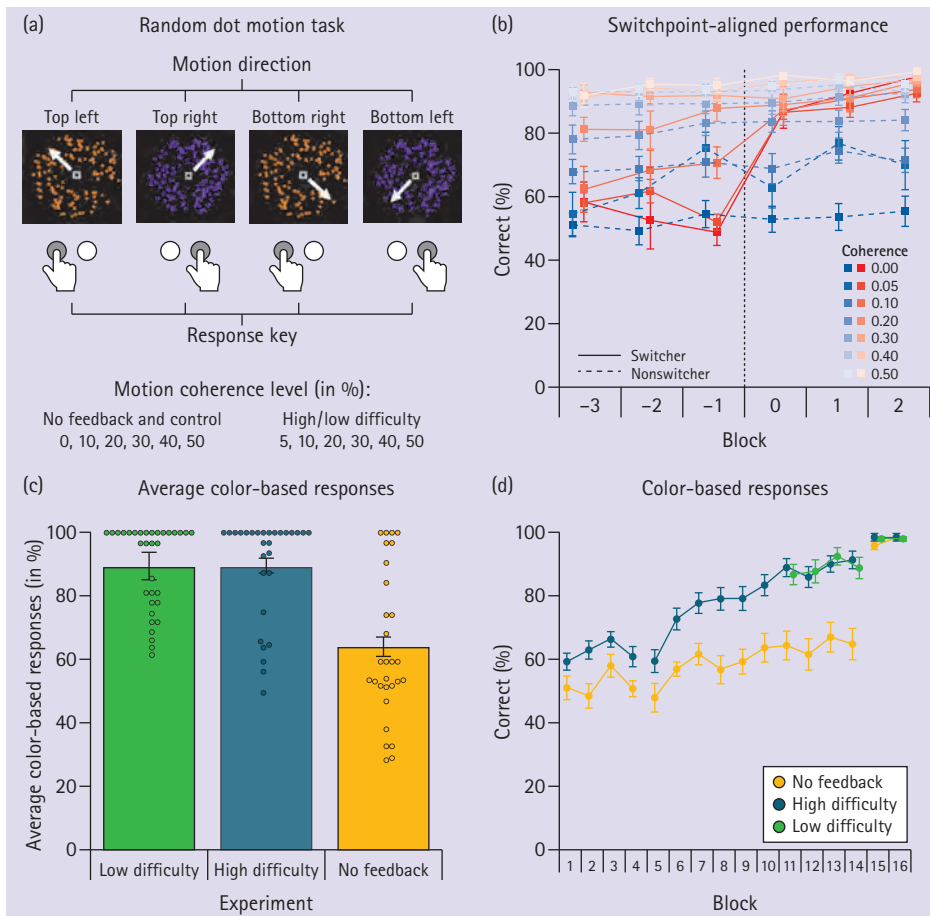
Figure 2. (a) Stimulus-Response contingencies of the Random Dot Motion (RDM) task. Motion coherence levels ranged between 0% and 50%. (b) Performance of switchers (red) and nonswitchers (blue) aligned to the individual switch points (dashed vertical line). On the lowest coherence level, performance is given in % of color-based responses and in % correct for all other coherence levels (see color shading). (c) Average percentage of color-based responses in block 6 and 7 on the respective lowest coherence level for the high- and low-difficulty feedback (5%) and the no feedback (0%) task versions. (d) Performance of color-based responses across the experiment of the same groups and coherence levels as described in (c). Low-difficulty subjects did not differ in performance on low-coherence trials from the performance of high-difficulty subjects after the late onset of those trials.

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subjects using color from 23% to 67%. In a next experiment, we probed a potential effect of difficulty on color use by introducing the two most difficult coherence levels only in block 6. We found no difference in color use between the two difficulty manipulations of the feedback task version, strengthening the hypothesis of feedback as a key factor driving the switches (see Figure 2c and 2d). Lastly, we examined behavioral parameters predicting strategy switches. Across experiments, lower reaction time standard deviations (RT std) and error rates in low-coherence trials predicted color use on the same block. We found a small effect of lower RT std in the previous block only in the feedback version. Hence, we could not identify a factor systematically predicting switches ahead of time. We therefore conclude that transitions to a color-based strategy occurred spontaneously, considering the possibility that these sudden strategy changes are not preceded by behavioral predictors. Data acquisition is completed and we are in the process of writing a manuscript. Data and code will be released upon publication.

Research Area 2: State Uncertainty

Projects in Research Area 1 are concerned with learning and updating representations that will efficiently guide decision-making. One additional problem that these projects did not deal with is that in many environments information might be hard to discern or are ambiguous, such as when bright light makes it difficult to see colors or when verbal statements from a person could be interpreted in one way or another. Uncertainty estimation is therefore is a dominant driver of human behavior. Napoleon Bonaparte attributed his political success to what he called "mastering luck," which in essence refers to a strategy of uncertainty minimization that allows one to make optimal decisions. Conversely, the inability to process uncertainty optimally has been associated with a number of behavioral deficits and psychiatric disorders such as generalized anxiety or schizophrenia. Research Area 2 therefore asks how agents can form states in environments in which information is uncertain or probabilistic.

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Uncertainty Sensitive State Representations in the OFC (Belief States)

Our previous work identified the orbitofrontal cortex (OFC) as the key region necessary to make optimal decisions by representing the current state of the world (Schuck et al., 2016). Yet, in real-world environments, the critical computational challenge consists not only in representing the task state, but rather in representing how likely which task states are, given our knowledge about the world. However, whether orbitofrontal task-space representations include different aspects of their uncertainty remains unclear.

In this project we thus investigate how perceptual uncertainty and outcome magnitude uncertainty are represented in the OFC. This corresponds to everyday decisions involving lack of perceptual clarity (e.g., when the sun is blinding us) and uncertainty about the result of an action (e.g., whether we will be on time if we take the train).

To test this hypothesis, we designed a behavioral study in which participants viewed a cloud of moving dots. Each dot cloud had a dominant color and motion, such that most dots either have a certain color or move in a certain direction (see Figure 3a). This allowed us to precisely control the degree of perceptual uncertainty. Outcome uncertainty was manipulated by associating one direction and one color with a very consistent (certain) reward and one direction and color each with a variable (uncertain) reward (see Figure 3b). Crucially, this design required participants to represent both uncertainty types at the time of the decision.
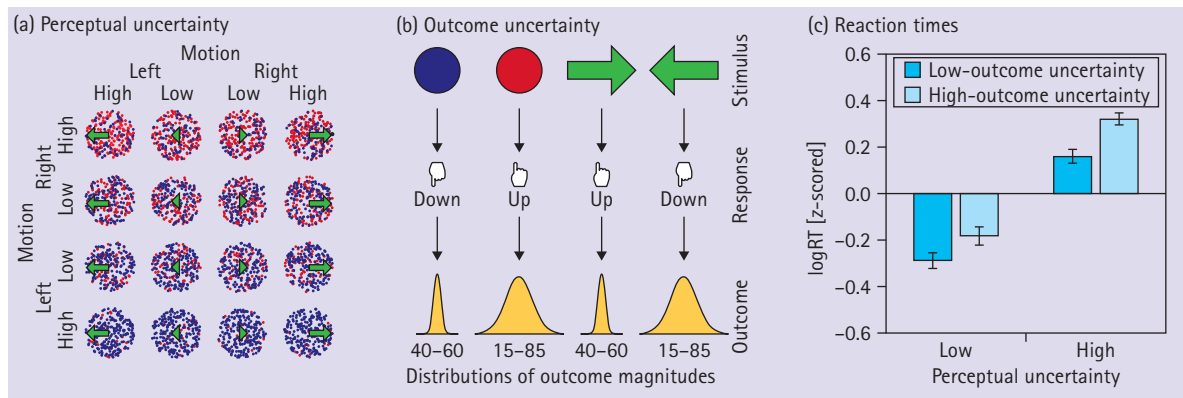
Figure 3. (a) Perceptual uncertainty is manipulated by controlling the color and motion direction coherence. The figure shows an example with red/blue as colors and left/right as motion directions. Participants were presented with different colors and directions. The design was fully counterbalanced. (b) Outcome uncertainty was created by associating different features (e.g., "red") with different outcome distributions that were either very narrow or wide. (c) Reaction times were influenced by both perceptual and outcome uncertainty.

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In preliminary results, we found that reaction times were modulated by both types of uncertainty (see Figure 3c), thus indicating that our paradigm allows to exert independent experimental control over both types of uncertainty. As a next step, we are conducting the same study in the fMRI scanner. We will use multivariate classifiers to identify regions processing the two uncertainty types separately and regions integrating them, focusing on OFC representations of stimulus features, outcomes, and their uncertainties. This work is crucial for understanding how the brain integrates uncertainty information into state representations that guide action selection. In the future, it can be used to elaborate our understanding of suboptimalities in uncertainty processing reported in psychiatric diseases. Data acquisition of this project is ongoing.

Structure Learning Preference in High Anxiety: Computational Evidence Form a Reversal Learning Task

Learning to accurately predict future negative events is a crucial survival skill. Accurate prediction can be achieved via two separable strategies: gradual updating and structure learning (i.e., "state switching"). Gradual learning involves updating subjective beliefs in a trial-by-trial manner while structure learning involves learning hidden states/contexts of the environment and using this meta-structure information to make predictions.

In this project, we test individual differences in anxiety and the tendency to employ gradual learning versus state switching. Anxiety has been associated with suboptimal learning from aversive stimuli, such as fear overprediction and relapse. We tested whether high trait anxiety is associated with either learning strategy, focusing on state switching as potential mechanism behind fear relapse. We developed a series of computational models representing different learning strategies that we then tested against performance on a probabilistic aversive learning task. Participants completed three blocks of 200 trials in which they had to predict the probability of receiving a shock on each trial (see Figure 4b). Unbeknownst to the participant, the probability of shock fluctuated between two levels that differed between sessions: 40%–60%, 25%–75%, and 10%–90% (see Figure 4a). Different environments were used to encourage different strategies, for example, jumps between 10% and 90% encourage a state switching strategy while hardly noticeable changes between 40% and 60% are optimally monitored by gradual updating. We found that high trait anxiety was associated with an improved ability to adapt to changes in the environment (see Figure 4c). Fitting a logistic model to performance indicated that switch steepness positively correlated with trait anxiety. Next, we tested whether this is due to faster gradual learning or learning the hidden structure of the environment. We put forward a novel state switching model that incorporates latent belief states and state switching. We show that the new model effectively captures the state switching strategy (see Figure 4d) and that the estimated switch threshold is lower for high anxious individuals.

These results indicate that high anxiety is associated with better structure learning, leading to improvement in some aspects of learning but also explaining some previously reported undesirable phenomena such as fear relapse. This finding provides a novel computational explanation of why anxiety is associated with fear relapse. Data acquisition and analysis are completed and the findings are currently being drafted for publication.
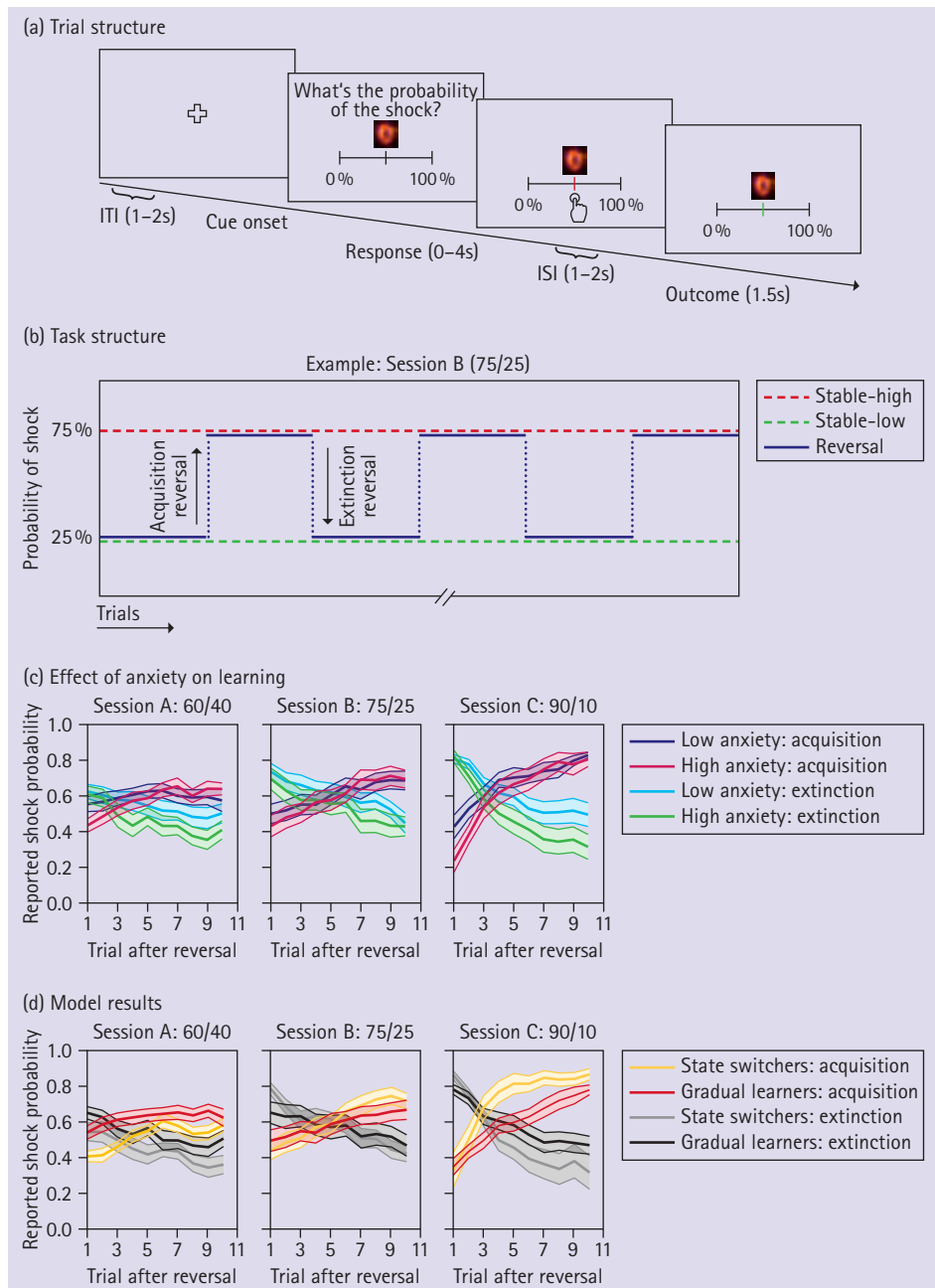
Figure 4. (a) Task structure: On each trial, participants were presented a cue and asked to report their subjective shock probability. (b) Trial structure: Participants went through phases of high- and low-shock probability, with the two levels being 40% versus 60%, 25/75%, and 10/90% chance of shock. (c) Subjective ratings as a function of trial after reversal: High anxiety reached a lower level in extinction, which is closer to the true reinforcement rate and the switches are on average steeper. (d) Our model classified subjects into "gradual learners" and "state switchers." The second group has steeper switches thereby validating the model.

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Research Area 3: Values and States

The central purpose of "useful" representations is to allow us to make decisions that lead to maximal goal achievement. In the framework of RL, goal achievement is usually quantified as the expected value, which makes the definition of "useful" critically dependent on the ongoing value learning process. One important question arising from this idea is that the neural processes underlying value expectations and state representations might be related. This is the topic of Research Area 3.

Value Learning

We often choose between objects with more than one feature, having for instance a color and a shape. Research has shown that in such cases decision-making involves attentional selection of contextually relevant features. This in turn enables the ventromedial prefrontal-cortex (vmPFC) to represent the expected outcomes associated with only these features (Sharpe et al., 2019). But is this selective value retrieval perfect or do the values of irrelevant features influence our choices and neural representations? We tested this question by utilizing a random-dot motion paradigm. Forty participants decided between two clouds of moving dots, each consisting of two features (one motion direction and one color). Color saturation and motion coherence were titrated beforehand, ensuring similar reaction times to each feature. Next, participants learned to associate each of four possible colors and motions with different fixed rewards. In the main task (see Figure 5a), participants

were cued to focus only on one stimulus dimension (color or motion) and received the reward associated with cued feature of their choice. Thus, only one feature dimension was relevant for every choice. Crucially, each trial entailed two pairs of features: two outcome-relevant features and two irrelevant features (see Figure 5b). The value difference between the pair of relevant features was always one. The value difference between the irrelevant pair could take on three different levels (but never impacted the outcome). In addition, the irrelevant feature with the higher associated value could be either paired with the object that had to be chosen or paired with the other object. These different feature combinations were thus governed by two orthogonal parameters: whether choosing based on relevant versus irrelevant features would lead to the same or a different response (congruent vs. incongruent, green vs. purple in Figure 5b) and the expected outcome if the irrelevant features could be chosen (individual shades
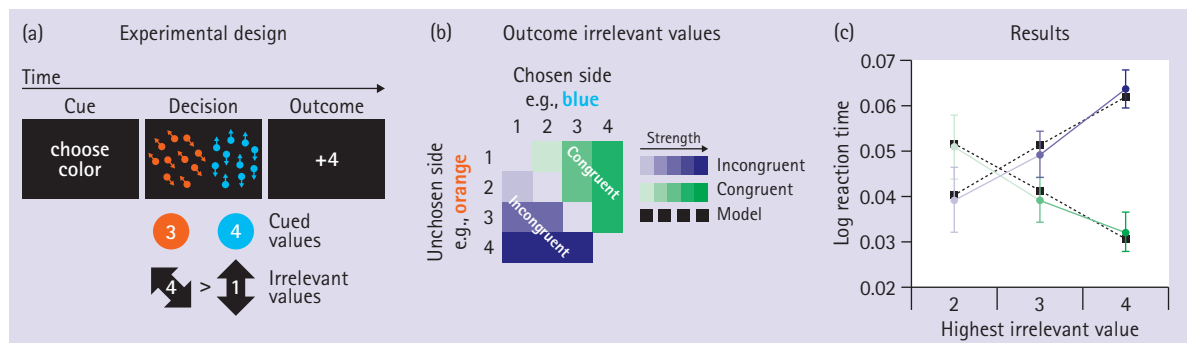
Figure 5. (a) Experimental design. Following a cue indicating the relevant context (left), participants made a choice between two dot-clouds (middle), each consisting of two features (motion and color), and received the outcome associated with the chosen cloud's cued feature (right). An incongruent trial is shown, that is, choice based on color is different from the choice based on motion. (b) Outcome irrelevant values. Each choice type (e.g., blue vs. orange) could have 1 of 12 combinations of outcome-irrelevant features that can be described in two orthogonal parameters: congruency and highest irrelevant value. (c) Results. Participants reacted slower in incongruent (purple) compared to congruent (green) trials. This effect was modulated by the highest irrelevant value, that is, increased the slowing effect of incongruent and the speeding effect of congruent trials (x axis, shades of colors).

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of green and purple, Figure 5b and 5c). In line with our hypothesis that irrelevant aspects influence choice, we found that participants reacted slower in incongruent than congruent trials. Furthermore, this effect was modulated by the expected outcome of the irrelevant features, indicating that not only irrelevant features, but their associated values, were processed (see Figure 5c). Preliminary fMRI analyses indicated neural processing of (1) the relevant feature value and (2) the highest irrelevant feature value in partially overlapping brain regions. This is initial evidence that contextually irrelevant features can influence expected value representation, thus laying the groundwork to identify the interaction between state representations (the features) and value representations that drive choice (the expected outcomes). Next, we plan to investigate the relations between these effects and attentional mechanisms using multivariate analysis and whether relevant and irrelevant values are processed in parallel or are integrated in vmPFC representations during choices. Data acquisition is completed and fMRI analyses are ongoing. Data and code will be released upon publication.

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Research Area 4: OFC State Representations and Hippocampal Cognitive Maps

The idea of state representations is closely linked to the notion of a "cognitive map," which was originally conceived as a spatial map that reflects the relationships between different possible states of the environment. The idea of a cognitive map has influenced psychology and neuroscience for decades, and a number of recent findings have generated new excitement for this idea. At the heart of the current debate is the question to what extent the brain uses domain-general encoding mechanisms that structure experiences according to their spatial, temporal, or nonspatial similarity, quite similar to the way in which researchers often think about state representations. A number of striking recent findings have supported the notion that neural codes in the entorhinal cortex and the hippocampus are sensitive to task relevant nonspatial information, including our own work (Schuck & Niv, 2019). The focus of Research Area 4 is therefore on cognitive and neural processes that reflect state similarity and guide spatial and nonspatial decision-making.

Representing Spatial and Nonspatial Structure

One crucial question arising from the above mentioned results is whether behavior, and in particular value-based learning, generalization, and exploration are guided by the same computational mechanisms in spatial and nonspatial domains (Kaplan et al., 2017). Here, we tested this idea by studying reward-learning of the same human participants in both spatial and nonspatial domains. We investigated how participants use spatial or nonspatial features when searching for correlated rewards in successive 64-armed bandit tasks (Wu et al., 2018, 2020; see Figure 6a). Performance analysis showed that participants learned the outcome structure in both domains, and profited when spatial or feature similarity had stronger relations to the outcomes (see Figure 6b, "Rough" vs. "Smooth"), and that the spatial as well as nonspatial relationships ("distances") were used to guide decisions (see Figure 6c). Using a Gaussian Process learning model, we find that the same model of generalization best captured human search decisions and judgments in both domains, connecting them via similar computational principles. Analyses of the parameters showed that participants had similar levels of generalization (λ) in both tasks (see Figure 6d, left) and did not differ in the shape of the generalization function (the so called Minkowski distance ρ; Figure 6d, middle left). However, participants showed clear signs of directed exploration (i.e., seeking out more uncertain options) in the spatial domain, which was notably reduced in the conceptual task (Exploration bonus β; Figure 6d, middle
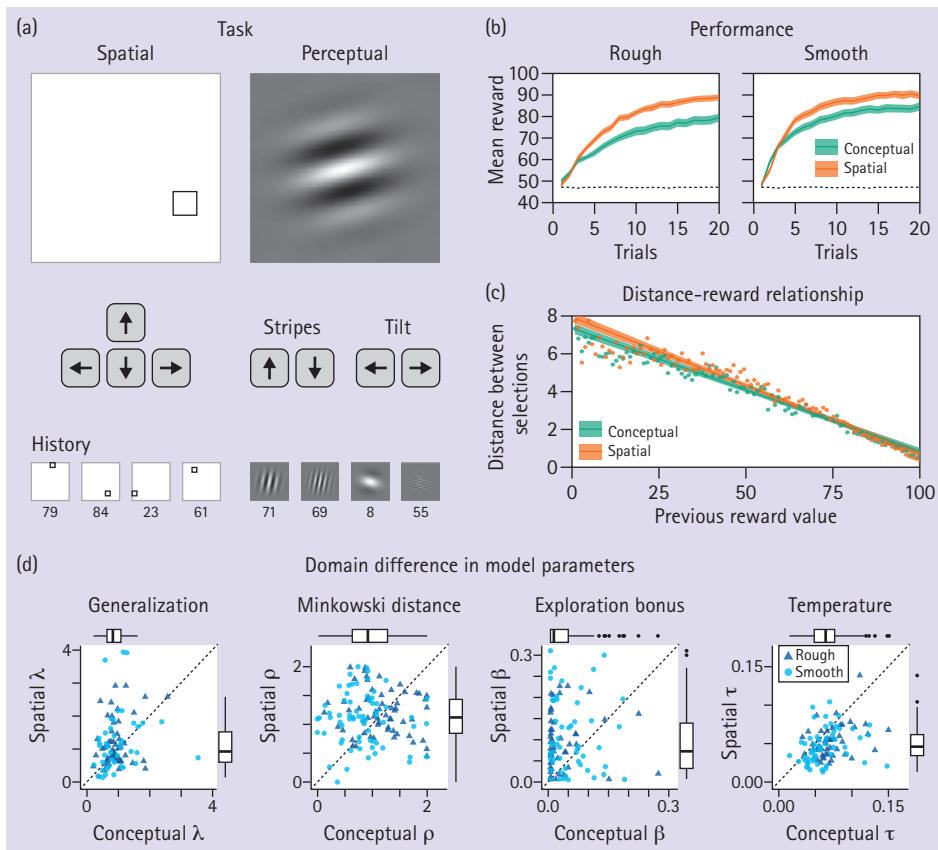
Figure 6. (a) Experimental Design. In the spatial task, options were defined as a highlighted square in a 8×8 grid, where the arrow keys were used to move the highlighted location. In the conceptual task, each option was represented as a Gabor patch, where the arrow keys changed the tilt and the number of stripes. Both tasks corresponded to correlated reward distributions, where choices in similar locations or having similar Gabor features predicted similar rewards. (b) Average learning curves over trials, showing the mean (line) and standard error (ribbon) aggregated across rounds and participants. The dashed line indicates chance performance. (c) Distance between selections as a function of the previous observed reward value, showing the means (points) and the group-level predictions of a mixed-effects regression, where the ribbons indicate the 95% CI. (d) Model parameter estimates from the conceptual (x-axis) and spatial (y-axis) tasks. Each point is the mean estimate for a single participant and the dotted line indicates y=x (adapted from Koch et al., 2020).

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right). Instead, participants increased their random exploration in the conceptual task (Temperature τ). Thus, even though the computational principles underpinning reasoning in both domains are indeed similar, how these computations are mapped onto actions can vary substantially. The manuscript of this project is submitted and a preprint posted on bioRxiv. Data and code will be released upon publication.

Spatial Aging

Apart from studying healthy young adults, our laboratory is also interested in under-

standing changes in cognition in aging and disease, in particular in relation to the above introduced case of spatial navigation. Human aging is characterized by impaired spatial cognition and reduced distinctiveness of fMRI activation patterns. But how does neural distinctiveness of spatial information change in older adults compared to younger adults? In this project (Koch et al., 2020), we asked if neural representations of walking direction, which inform spatial navigation, are less distinct in older compared to younger adults. To this end, we developed a novel method to measure fMRI pattern similarity during

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Koch, C., Li, S.-C., Polk, T. A., & **Schuck, N. W.** (2020). Effects of aging on encoding of walking direction in the human brain. *Neuropsychologia, 141,* Article 107379. https://doi.org/10.1016 /j.neuropsychologia.2020 .107379
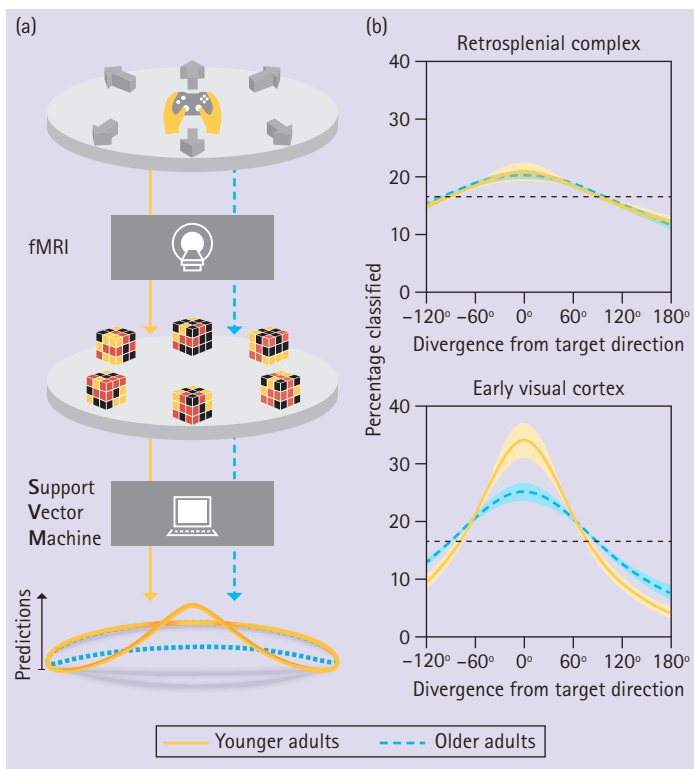
Figure 7. (a) Analysis scheme. Walking in different directions led to direction-specific activation patterns. If representations of neighboring directions are more similar than those with larger angular difference, false classifier predictions should become less prominent with increasing angular difference. The resulting confusion function should in turn follow a Gaussian shape and pose as a proxy measure for neural tuning. (b) Comparison of tuning specificity between age groups in the RSC and EVC. Each line represents the average over the fitted Gaussian models of the decoder confusions separately for each age group (yellow: younger; blue: older). Shadings indicate SEM.

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Schuck, N. W., Doeller, C. F., Polk, T. A., **Lindenberger, U.,** & Li, S.-C. (2015). Human aging alters the neural computation and representation of space. *NeuroImage 117,* 141–150. https://doi.org /10.1016/j.neuroimage .2015.05.031

free, virtual navigation and estimate neural tuning specificity. We expected lower tuning specificity in older adults, that is, activation patterns reflecting neighboring directions to be less distinct compared to nonadjacent directions.

We reanalyzed previously collected fMRI data (Schuck et al., 2015) where participants navigated a virtual environment and trained a classifier to predict participants' walking direction from fMRI data from visual and navigation-relevant brain areas (see Figure 7a). Focusing on the potential downstream consequences of less distinct neural representations, we then asked whether the classifier was more likely to confuse patterns reflecting more similar directions. This was done by relating the amount of false predictions to the angular difference between directions. Previous animal work has shown that this relationship should follow a Gaussian curve, and that aging may lead to the widening of these gaussian functions. To test this idea, a Gaussian curve was fitted to each participants' confusion function. This analysis was conducted in the retrosplenial complex (RSC) that has previously been linked to directional signals and early visual cortex (EVC) which supports direction estimation by providing the relevant visual information.

After confirming the functionality of the decoder and the Gaussian shape of the confusion function in the RSC and EVC, the width of the fitted Gaussians was compared between age groups. Results indicated that the visual input linked to each direction is represented less distinctly in older adults (EVC). Less visually dominated direction signals in the RSC showed no age-related difference (see Figure 7b).

The observed pattern of dedifferentiation across the continuous variable of direction reveals additional information about the mechanisms at play, as they converge with findings of cell recordings in nonhuman primates. Additionally, the developed method can prove useful for other investigations involving neural patterns over continuous variables. The paper of this project is accepted and in press. Data and code will be released upon publication.

Hippocampal Replay and ERC Funded Projects

The overarching question of our research group is how the brain uses past experiences to shape future actions. In addition to the above-mentioned projects about representation learning, we have recently taken an interest in a remarkable discovery made over two decades ago in rodents: Researchers found that, while rats were sleeping, activity in their hippocampus seemingly retraced the animals' previous trajectories in a maze, only much faster than in real time. This phenomenon, known as hippocampal replay, has become a major focus of neuroscientists and even artificial intelligence researchers over the past decades. Many researchers today believe that replay may be related to the construction of a cognitive map (see Research Area 4) and may ultimately help to learn how to map observations onto useful state representations (Research Area 1). The resulting research demonstrated that replay is prevalent during wakeful resting, related to memory, planning and reward processing, and shares similarities with machine learning algorithms. These findings suggest that replay may be a fundamental mechanism behind memory consolidation and the computation of optimal behavior. Yet, despite the significance of this phenomenon, little is known about replay in the human brain.

ERC Starting Grant

In 2019, the PI has been awarded an ERC Starting Grant that aims to improve the ways in which we measure replay in humans. This project aims to investigate fast sequential replay events in the human hippocampus and their role in memory and decision-making. Going beyond previous research, we will investigate replay noninvasively in the human brain using fMRI by using advanced statistical approaches that have recently been developed by the PI. This allows us to study sequential aspects of replay in humans using methods that also permit whole brain coverage and high spatial resolution. Our specialized methodology thereby allows the project to overcome previous hurdles for studying this important process in humans (see below). The grant is structured into four projects: Project 1 will investigate the coordination between replay in hippocampal and in sensory and prefrontal brain areas. We will compare sequential pattern reactivation during rest before and after a memory experiment involving spatially embedded sequences of either pictures or sounds in different brain regions. We hypothesize that differences in stimulus modality will affect replay events in corresponding sensory cortices and we will investigate coordination across multiple areas. Project 2 will elucidate the computational role of replay in planning and value computation and investigate the coordination between (a) hippocampal replay and (b) prediction error and value-related neural signals. Participants will collect rewards in a spatial maze and content of replay events following reward and during escape planning matches predictions from a computational model. Project 3 will study replay during sleep. We predict that fMRI pattern sequentiality is temporally linked to the occurrence of sleep spindles during NREM sleep. Using a similar visuo-spatial learning task as in Objective 1, we will also investigate the association of fMRI, EEG, and coordination-based replay markers with memory consolidation (recall before vs. after sleep). Project 4 aims to understand age-related changes in hippocampal and cortical replay following a memory task in younger and older participants and to study the link between (a) these changes, (b) age differences in memory, and (c) cardiovascular and metabolic risk factors.

While funding only began in April 2020, we have already made important progress toward a methodological foundation of this research. We have made significant progress in this area by showing that the transitions between successive fMRI patterns during rest or sleep exhibit nonrandom relations to the temporal structure of previous experiences (Schuck & Niv, 2019). Given this finding represented a major addition to our knowledge about replay in humans and methodological progress, it was published in Science and received much media attention. Since the publication of this study, we have continued to improve the fMRI

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methodology that allows us to measure fast sequential events, such as replay. This project is described in the next section.

Decoding Fast Neural Events in Humans

As described above, replay is a fast neural process that is anatomically localized and executed on subsecond time scales. Understanding this process therefore requires methods that offer sufficient spatial and temporal resolution. This poses a particular challenge for the study of the human brain because noninvasive methods have either high temporal or spatial resolution, but not both. In this project, we build on our previous work and introduce a novel multivariate analysis method for conventional blood-oxygen-level dependent functional magnetic resonance imaging (BOLD fMRI), that allows to study sequentially activated neural patterns separated by less than 100 ms with anatomical precision (Wittkuhn & Schuck,
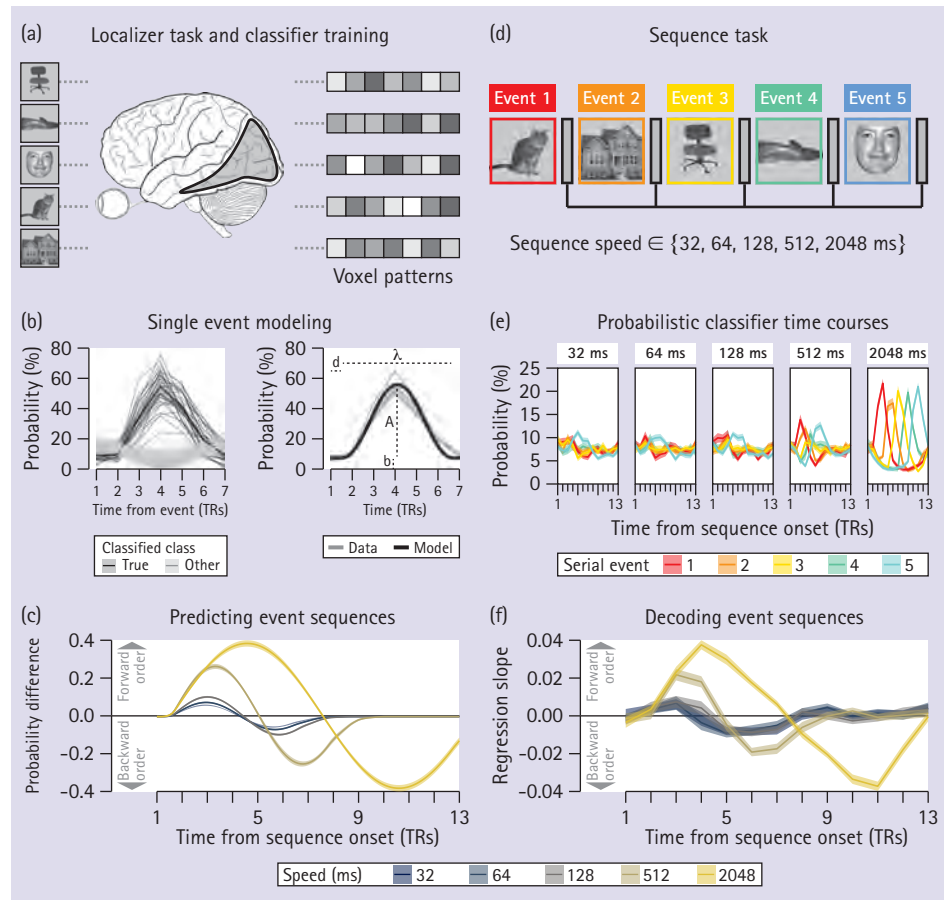
Figure 8. (a) Probabilistic classifiers were trained on voxel activation patterns in visual and ventral temporal cortex while participants viewed different visual objects. (b) Time courses of classifier probabilities for the presented stimulus (left, black lines) were modeled with a sine-based response function (right). (c) Predictions for event sequences were derived from the time courses of differences between two response functions time-shifted by increasing delays. (d) In the sequence task, participants were presented with sequences of the same five images seen during the Localizer task, but with either short or long temporal delays between images. (e) Applying the classifiers to the data recorded after sequence onset resulted in item-specific probabilistic classifier time courses. (f) The slope of a linear regression at every time point indicated the sequential ordering of serial events and their probabilities as predicted. Human brain sketch in (a) according to Hankem on Wikimedia Commons. Stimulus material shown in (a) and (d) are taken from Haxby et al. (2001), Science. The original authors of Haxby et al. (2001), Science, hold the copyright of this data set and made it available under the terms of the CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0/).

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2020). Forty human participants underwent two fMRI sessions each, in which they were presented with sequences of visual stimuli separated by 32 ms to 2048 ms. We trained separate probabilistic pattern classifiers for each visual stimulus to detect the presence of image-specific activation patterns in early visual and ventral temporal cortex on data from a separate localizer task (see Figure 8a). The classifiers were sensitive to pattern activation time courses as indicated by delayed and distinct increases in the probability of the true stimulus after stimulus onset (see Figure 8b, left). We captured the dynamics of these classification probability time courses by fitting a sine-based response function to the decoding time courses elicited by single events (see Figure 8b, right). Based on this fit, we approximated expectations for signals occurring during sequential events with different interstimulus intervals (see Figure 8c). The temporal delay between time-shifted response functions determines the magnitude and time courses of differences between them. This influences how well successive activation patterns can be differentiated from one another. Based on this model, we predicted that the first event will dominate the signal in earlier TRs (forward order), whereas in later TRs the last event will dominate the signal

and the activation strengths will be reversed (backward order). To test this hypothesis, we applied the trained classifiers to data recorded during sequences of the same images that were separated by time delays of 32 ms in the fastest case and 2048 ms in the slowest case (see Figure 8d). Examining the time courses of classifier probabilities during sequence trials showed that the time delay between events was reflected in sustained within-TR ordering of probabilities (see Figure 8e)—even when images were separated by only 32 ms. This impression was confirmed by a TR-wise linear regression between the serial positions of the images and their probabilities. In all speed conditions, the mean slope coefficients initially increased above zero (reflecting higher probabilities of earlier compared to later items) and decreased below zero afterwards (see Figure 8f). Together, our results show that probabilistic classifier time courses allowed the detection of neural representations and their order, even when images were separated by only 32 ms. Our method promises to lay the groundwork for novel investigations of fast neural computations in the human brain, such as hippocampal replay. The manuscript of this project is submitted and a preprint posted on bioRxiv. Data and code will be released upon publication.

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(last update: April 2020)

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Max Planck Research Group

Reading Education and Development (REaD) (Concluding Report)

Head: *Sascha Schroeder*

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Introductory Overview

Reading is one of the most important, but also one of the most complex, inventions in human history. In our modern, information-oriented society, it is vital to be able to read texts accurately and efficiently. People who lack these skills are at a serious risk of marginalization: Adults with functional illiteracy often find themselves socially isolated; adolescents who are unable to write a letter of application fail to find a job.

In contrast to learning to talk, children do not learn to read spontaneously, but need instructional help and support. Yet many children have problems with reading acquisition and remain unable to understand even simple texts by the end of their compulsory education. How can we help these children? Reading is a cognitive skill that involves a number of interacting component processes located at different levels within a general hierarchy. It is unclear which of these processes are important for children's reading development and how they interact. Furthermore, it is likely that children with reading difficulties have different types of deficits and thus need different kinds of support.

The Max Planck Research Group REaD investigates the underlying structure of reading skills and their development over childhood and adolescence from 2012 to 2018. We assessed the processes that underpin reading and analyze their interactions at different stages of reading development. This approach provided a detailed description of various components of the reading system and their role in reading development. These insights, in turn, will enable us to identify the processes to be targeted by effective intervention programs in reading education.

A distinctive characteristic of the REaD group was its holistic and integrative approach to the investigation of reading, combining elements from linguistics, psychology, and education and investigating the reading process as a whole—from lexical processes on the word level to discourse processes on the text level via syntactic processes on the sentence level.

The research agenda of the REaD group was structured around four internal projects. In addition, several externally funded projects complemented the research agenda of the group.

childLex: A Corpus of German–Language Writing for Children

childLex is a linguistic corpus that has been collected from a large number of children's books in order to investigate German-language writing for children. The project was conducted in collaboration with the Berlin–Brandenburg Academy of Sciences and the University of Potsdam. The complementary *InLex* project focuses on interindividual differences in the structure of children's mental lexicon.

childLex provides norms for children aged 6 to 8 (beginning readers, grades 1 to 2), 9 to 10 (intermediate readers, grades 3 to 4), and 11 to 12 years (experienced readers, grades 5 to 6). *childLex* is based on 500 books that vary widely in terms of length and content and comprises approximately 10 million words (tokens). A detailed description of the *childLex* database has been published (Schroeder et al., 2015) and an online version of the database is available to the scientific community on www.childlex.de.

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DeveL: The Developmental Lexicon Project

In the *Developmental Lexicon Project (DeveL),* we collected behavioral data for a selected set of words from children at different stages of reading development, as well as from adult samples across the lifespan. These data are critical for the development of the next generation of computational models of visual word recognition.

The impact of most word characteristics (length, frequency, etc.) on the reading process does change over time (see Figure 2). However, none of the current models of visual word recognition explicitly includes a developmental dimension. The aim of the *DeveL* project was to provide a database on word recognition in German across the lifespan. To this end, we selected 1,152 German words covering a broad range of linguistic characteristics that are considered crucial in developmental theories of written language acquisition. Overall, data from 430 children in grades 1 to 6 were collected in computerized single sessions. In addition, younger (20–30 years) and older adults (65–75 years) performance for the same words was assessed. Word recognition performance was measured using lexical decision and naming paradigms, which are commonly used in psycholinguistic research to assess lexical processing. The data of the *DeveL* project have been made available to the scientific community (Schröter & Schroeder, 2017a) and were used to investigate the development of linguistic marker effects in German native speakers (e.g., Hasenäcker et al., 2017) and second-language learners (e.g., Schröter & Schroeder, 2017b, 2018a, 2018b). In additional studies, we also investigated the effects of these variables on children's writing (Hess et al., 2019; Hess et al., 2020).
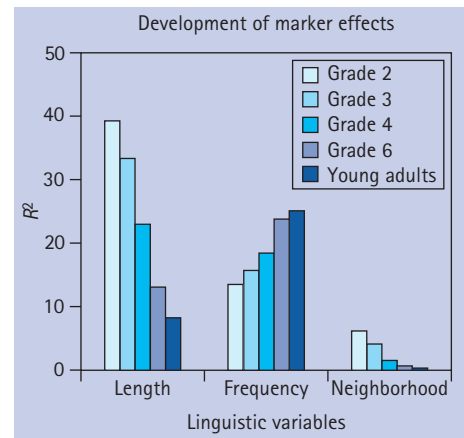

Figure 2. Percentage of variance accounted for by word length, word frequency, and orthographic similarity in the *DeveL* project.

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DevTrack: The Developmental Eye–Tracking Study

Reading is more than decoding single words. The *Developmental Eye-Tracking Study (DevTrack)* investigated children's natural reading processes by tracking their eye movements as they read sentences and texts. Reading is a complex task, in which words must be decoded, their meaning needs to be extracted, and inferences must be generated to connect words, phrases, and sentences. During reading, adult eye movements generally consist of saccades of 7 to 9 characters and fixations of 200 to 250 milliseconds. The characteristics of eye movements are also subject to developmental changes (see Figure 3), however, and the efficiency of eye movements during reading is strongly related to reading skills (Schroeder et al., 2015, for an overview).

DevTrack was one of the first longitudinal studies that investigated the development of children's eye movements by following 100 children from grade 2 to grade 4. We investigated children's parafoveal and foveal processing on both the word-level (e.g., whether they use orthographic and/or phonological information in the parafovea) and on the sentence- and text-level (e.g., how they wrap-up information, Tiffin-Richards & Schroeder, 2018a, or resolve pronouns or inconsistencies within texts, e.g., Eilers et al., 2018, 2019a, 2019b).
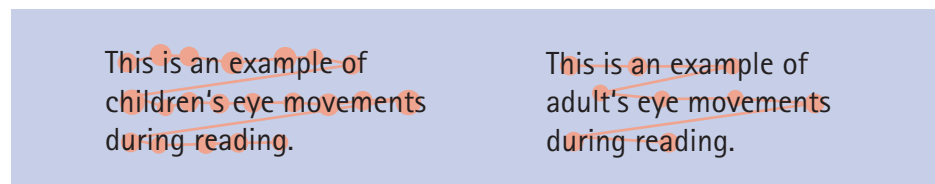
Figure 3. Eye movements of a beginning reader (left) and a skilled adult reader (right).

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Investigating Reading Longitudinally: OPeRA and PLAiT

Two interconnected longitudinal studies investigated interindividual differences in reading development (see Figure 4). The *OPeRA* project *(Orthographic Processing in Reading Acquisition)* focused on children's use of different orthographic grain sizes during reading development in school. The complementary *PLAiT* project *(Prerequisite Language Abilities in the Transitional Phase)* concentrated on the transition from kindergarten to grade 1, and investigated which precursor abilities predict children's later reading achievement.

The *OPeRA* project aimed to track the development of orthographic processing in German and to identify the grain sizes used by children at different developmental stages. To this end, we followed 120 students from Berlin elementary schools from grade 1 to grade 4. Data collection was completed in summer 2017. Analyses of the longitudinal data from the *OPeRA* project offer impor-

tant new insights into the developmental trajectories of the use of different reading units, especially graphemes, syllables, and morphemes (Hasenäcker & Schroeder, 2017; 2019; Hasenäcker et al., 2019; Hasenäcker et al., 2020).

The *PLAiT* project concentrated on the transition from kindergarten to school, and investigated which precursor abilities are linked to children's later reading acquisition. In this project, we followed 90 children from the 2nd year of kindergarten until the end of grade 1 of elementary school. At each measurement point, we assessed children's phonological, orthographic, and semantic abilities using different tasks. Data collection was completed in summer 2016. In different publications, we investigated children's developmental trajectories in the phonological (Schmitterer & Schroeder, 2019a), orthographic (Schmitterer & Schroeder, 2018), and semantic domain

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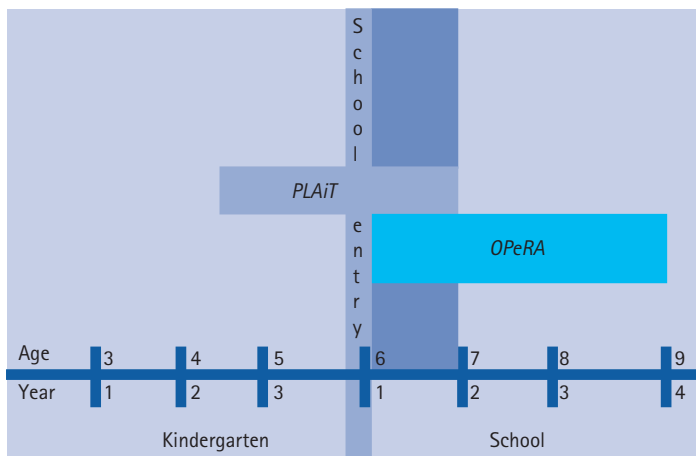
Figure 4. Time frame and overlap of the *PLAiT* and *OPeRA* projects.

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(Schmitterer & Schroeder, 2019b). In addition, an overall analysis demonstrates that children's early phonological skills seem to facilitate the build-up of high-quality orthographic representations, which are in turn related to children's later reading ability (Schmitterer & Schroeder, 2019c). Taken together, the results of the two studies allowed us to provide a comprehensive picture of the children's lexical development and its connection to later reading acquisition.

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Externally Funded Projects

In addition to the core projects of the group, we were able to obtain external funding for several additional projects from various funding agencies that complemented the profile of our goup.

MusiCo was a longitudinal project funded by the Rat für Kulturelle Bildung and the Stiftung Mercator (2014–2017). It studied transfer effects of musical training on cognitive and reading development during the transition from preschool to primary school. *MusiCo* investigated longitudinally a broad variety of competencies from both language and music to determine the central variables that cause and explain transfer effects from one domain to another. Publications focused on how to assess print exposure (Grolig et al., 2017; Grolig, Tiffin-Richards et al., 2020), the effects of language training in kindergarten (Grolig et al., 2019; Grolig, Cordes et al., 2020), and how to measure musical competencies in preschool children (Cohrdes et al., 2019).

ERIC was a collaboration project with the Institute for Educational Progress (IQB) and was funded by the German Ministry of Education and Research (2015–2017). It combined interests in the relationship between learning processes of individual students and teaching methods employed by teachers in German primary school classes. The aim of the project was to model the cognitive processes that un-

derlie reading performance in 4th-grade children, and to investigate how different teaching methods influence the development of these underlying mechanisms. ERIC comprised a sample of 60 4th-grade classes ($N = 800$ children). Students took part in a computer-based assessment of their reading processes and national assessment encompassing the domains of reading comprehension, listening comprehension, and orthographic proficiency. At the same time, teachers of the participating classes provided evaluations of their students' proficiency in specific reading processes and filled out an online logbook describing their teaching techniques and the learning opportunities provided to their students. First results show that both spelling and reading comprehension performance are primarily determined by individual differences in the efficiency of lexical, word-level processes (Tiffin-Richards & Schroeder, 2018b). In subsequent analyses of the data collected during the main study, we will focus on integrating student performance, teachers' diagnostic competence, and the availability of learning opportunities.

Morpheme is an ongoing collaborative project between the MPRG REaD and the Laboratoire de Psychologie Cognitive at Aix-Marseille University, funded by a joint grant from the German and French Research Society (DFG-ANR, 2016–2020). This project investigates

children's morphological development longitudinally and cross-linguistically. German and French children (*N* = 120 in each country) were followed-up from grade 2 to grade 4. First analyses show that morphological information is processed differently in both languages (Beyersmann et al., 2020) and more generally that the importance of morphological processing is influenced by the consistency of a language (Mousikou et al., 2020). In addition, we have shown that morphological effects found in single word reading generalize to the sentence level (Mousikou & Schroeder, 2019).

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Max Planck Fellow

Gert G. Wagner

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Overview

As a Max Planck Fellow, Gert G. Wagner works together with researchers from the Center for Adaptive Rationality, the Center for Lifespan Psychology, and the Harding Center for Risk Literacy. Wagner is on the faculty of the International Max Planck Research School on the Life Course (LIFE) and, together with Ulman Lindenberger, is Co-Principal Investigator of the Berlin Aging Study II (BASE-II) at the Institute. He is also a member of the Advisory Council for Consumer Affairs, on which both he and Gerd Gigerenzer served together from 2014 to 2018. Since 2017, Ralph Hertwig and Wagner are running the project *Origins and Determinants of Malleable Risk Preferences* with funding by the Max Planck Society until 2022 (Wagner et al. 2018, Arslan et al. 2019).

Wagner's research focuses on the causes of individual differences in life courses, with a special focus on risk preferences. He works primarily with the data of the German Socio-Economic Panel Study (SOEP), which he directed from 1989 to 2011. Findings from psychological research in a controlled laboratory environment often cannot be generalized to the world at large. Conversely, large-scale surveys in the social sciences rarely allow causal conclusions to be drawn on behavior and development at an individual level. Wagner addressed this methodological dilemma by integrating questions on psychological personality traits into the representative longitudinal SOEP study. Moreover, the SOEP Innovation Subsample (SOEP-IS) enables behavioral experiments to be administered in the context of a representative longitudinal survey. The SOEP study serves also as a reference sample for BASE-II, which is hosted at the Institute.

Together with international collaborators, Ralph Hertwig and Wagner launched a project in 2018 that aims at helping social and behavioral scientists to better understand the behavioral and health effects of genes. This project uses the SOEP-IS to collect genetic data in a manner that enables novel, genetically informed research designs. The project is based on so-called trios in the SOEP-IS, that is, nuclear families comprised of father, mother, and child[ren]. Genetic data of about 2,500 subjects will be typified, on the basis of which several research projects will begin in 2020.

Co-PIs are Philipp Koellinger (Vrije Universiteit Amsterdam, Economics) and Ralph Hertwig. He and four other collaborators have close ties to the LIFE graduate program: LIFE alumnus Rui Mata (University of Basel, Psychology), LIFE alumna Kathryn Paige Harden (University of Texas at Austin, Psychology), LIFE alumnus Elliot Tucker-Drob (University of Texas at Austin, Psychology), and LIFE faculty Gert G. Wagner (MPIB and SOEP, Social Science). Moreover, LIFE faculty David Richter (Freie Universität Berlin, Psychology, and SOEP) is managing SOEP-IS. A further team member is Pietro Biroli (University of Zurich, Economics).

Compared with the sample sizes of state-of-the-art genetic discovery studies (with n of 1,000,000 cases and more), the sample size of the SOEP-IS is marginal. However, the project is specifically not a genetic discovery study (GWAS) and a large number of "candidate genes" are known. For a targeted analysis of the significance of candidate genes, smaller case numbers than for genetic discovery studies are sufficient. Moreover, SOEP-IS makes it possible to apply study designs that dissect genetic and environmental channels of transmission of health, personal characteristics, and socioeconomic advantages across generations. Statistical analysis methods will be used that were developed for the analysis of "natural experiments" (e.g., changes in schooling regulations or drafting young men to the armed forces). This is possible because every single human being is in essence a natural experiment. During procreation, egg and sperm cells combine, and each of these two cell types contain only half the chromosome set of one parent. This is because the production of egg and sperm cells does not use both copies of each chromosome that a human carries in each cell. Instead, only about half of each copy is randomly "selected" by the body during the

production of the egg and sperm cells. With every single egg and sperm cell, which then collide during conception, a new random selection takes place. Because of this random process—a "natural experiment"—siblings differ.

For example, if an analysis shows that someone has the same high-risk tolerance as her father, even though the variants of the genes ("alleles") that play a role in risk preference were not transmitted, then the environment, such as informal education in the family—and not the genome—must be responsible for this similarity. With a larger sample of many individuals, it is possible to run statistical analyses and calculate the significance of the results. Household panel studies such as SOEP-IS have the appropriate sampling design to make this kind of analysis possible.

There is always a danger that genetically informed research may contribute to the stigmatization of specific groups based on their genotype or genetic ancestry. However, it is not possible to stigmatize people on their genotype if it is unknown or cannot be easily inferred by characteristics that are not observable without access to genetic information. And in the context of this study, the data access protocols ensure that anyone who is potentially in a position to discriminate against or stigmatize a person cannot obtain access to the genetic data and link them to the identity of an individual.

In 2019/20, when the fieldwork took place, the sample size of SOEP-IS constituted of about 6,000 people, both adults and children. First, an interviewer conducted the annual survey in a household. The adults in the household were asked to provide saliva samples. A flyer inviting respondents to participate in DNA collection explained the purpose of the study in a clear, nontechnical manner. Before saliva collection started, each participant who agreed to take part read a detailed information sheet and completed an informed consent form. If children were living in the household, they too were asked to provide a saliva sample, subject to the parents' consent.

All samples were collected by the respondents themselves with the help of cotton swabs, who took saliva from the oral mucosa. After about 1 minute of being rubbed against the inside of the cheek or the lower and upper gums, the swabs together with so-called Dri-Capsules containing special chemical substances were placed in a test tube, which later were sent to the laboratory for DNA analysis. These capsules dried the collected saliva without any risk of DNA cross-contamination and thereby maintained complete molecular biology integrity. With Dri-Capsules, bacterial growth and enzymes are inhibited so that samples can be analyzed without time pressure. This procedure proved to be extremely important in face of restrictions related to the COVID-19 pandemic, when the samples could not be analyzed directly after fieldwork.

Interviewers obtained saliva samples from about 47% of the people living in the survey households, amounting to 2,737 samples, 2,511 from adults (16 years and older) and 226 from children. Before the onset of the pandemic, a first batch could be analyzed, of which more than 90% contained enough saliva for the extraction of DNA.

The question may arise, what will we learn from this study other than what has always been suspected: that heredity is the reason for many things? However, we have yet to learn the mechanisms in detail, and knowing which molecular mechanisms play a role might make a difference in public debate. For instance, identifying that people are genetically more risk averse would have important implications for politics, namely, that we would need to adapt social and economic structures to this genuine risk aversion. So far, many economic policymakers have repeatedly called for more self-employed people. But this plea makes little sense if the genetic makeup of most people is such that they shun risk.

If it were shown that only a few sites in the genome are of outstanding importance for risk preference, then manipulation would certainly be a hazard. But this danger does not exist: We already know that if risk preference depended on very few specific points in the genome with big effect sizes, then these sequences would already have been discovered in the GWAS studies. In general, the results of the project will help us to learn as a society how to better deal with individual diversity.

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(last update: April 2020)

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Emeriti

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Jürgen Baumert's work focuses on the reform of the secondary school system in Berlin, schooling and the lifecourse, bilingual education in multicultural societies, and early foreign language learning. These research projects are conducted in cooperation with the German Institute for International Educational Research (DIPF; Kai Maaz), the Leibniz Institute for Science and Mathematics Education at the University of Kiel (IPN; Olaf Köller), the Christian-Albrechts-Universität zu Kiel (Jens Möller), and the Mercator Institute at the University of Cologne (Michael Becker-Mrotzek).

Reform of the Secondary School System in Berlin and Its Impact on Academic and Vocational Careers (BERLIN Study)

The BERLIN Study aims to evaluate the recent reform of the Berlin secondary school system and its long-term effects on students' individual development and career patterns. The study has a quasi-experimental, longitudinal design. It is being conducted in cooperation between the MPI for Human Development, the DIPF, and the IPN, and is jointly funded by the state of Berlin and the Jacobs Foundation.

Over the last decade, the secondary school systems of many German federal states have undergone major reforms. The traditional three-track system consisting of vocational-track *Hauptschule,* intermediate-track *Realschule,* and academic-track *Gymnasium* is no longer implemented in any of the 16 states. Instead, most states have switched to a two-track system with just one secondary school type alongside the academic-track *Gymnasium.* In Berlin, the structural reform of the secondary school system was initiated in the 2010/11 academic year. Its main objectives were to increase the number of students graduating with an intermediate school-leaving certificate or an *Abitur* and to reduce the number of those leaving school without qualifications. At the same time, the reforms were intended to weaken the link between family background and educational outcomes. The BERLIN Study was designed to investigate the effects of the structural reforms on students' learning outcomes and educational careers (see Figure 1).

The key findings of the cross-sectional part of the quasi-experimental study can be summarized as follows:

(1) In Berlin, the secondary school system was transformed from a five- to a two-track system in a single step by merging and reorganizing nonacademic-track schools. Both of the tracks now in place—*Gymnasium* and integrated secondary schools—allow students access to all school-leaving qualifications, including the *Abitur,* though the tracks have different curricular focuses and timetables (at integrated secondary schools, it takes a year longer to obtain the *Abitur*). These structural reforms form an important basis for the future-oriented development of Berlin's secondary school system, though traditional stratification patterns are still apparent—now as between-school differences in student recruitment and learning outcomes.

(2) In terms of educational outcomes, the Berlin secondary system has remained extraordinarily stable—the reforms have had very little bearing on patterns of achievement. Students' average performance has not improved in any school subject. There is no evidence for weaker students or particularly talented students being afforded more individualized instruction and support. It seems likely that the curricular and staffing measures accompanying the reforms need longer to take effect.

(3) Patterns of social and ethnic stratification have remained largely unchanged. The Berlin school system is still characterized by high social disparities in educational attainment.

(4) Educational aspirations have risen since the reforms were implemented and the new integrated secondary schools opened up another direct route to higher education. Accordingly, there has been an increase in the number of students entering the academic strand of upper secondary level, which qualifies for higher education.

(5) At the same time, the performance standards for access to the academic strand of upper secondary level have dropped dramatically.

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Level	Grade	Year of measurement												
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Elementary	6	ELEMENT control group						1	2					
Secondary	7								3	BERLIN Study Module 1: Reform group				
	8													
	9		PISA-E control group			BISTA control group	1				4 / 1			
	10							2			2 / 5			
Upper secondary/ vocational training	11								2a	BERLIN Study Module 3: Control group		2a	BERLIN Study Module 2: Reform group	
	12									3			3	

Note. BERLIN Study Module 1: Stage 1 of the BERLIN Study, reform cohort; BERLIN Study Module 2: Stage 2 of the BERLIN Study, reform cohort; BERLIN Study Module 3: Stage 2 of the BERLIN Study, control cohort; ELEMENT: data from the ELEMENT Study provide control data for the first assessment in Module 1 of the BERLIN Study; PISA-E: Berlin data from PISA Cross-State Comparison provide control data for the first assessment in Modules 2 and 3 of the BERLIN Study; BISTA: data from the assessment of educational standards in Berlin provide control data for the first assessment in Modules 2 and 3 of the BERLIN Study.

Figure 1. Design of the BERLIN Study.

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Schooling and Individual Development in Adolescence and Adulthood (BIJU)

The longitudinal BIJU Study on *Learning Processes, Educational and Occupational Careers, and Psychosocial Development in Adolescence and Adulthood* was initiated in 1991. The BIJU sample of school classes comprises some 8,000 students from 212 secondary schools of all types in the states of Berlin, Mecklenburg-West Pomerania, North Rhine-Westphalia, and Saxony-Anhalt. The eighth wave of data collection took place in 2017, when most participants were 38 years old. The longitudinal study is being continued in cooperation with the DIPF (Kai Maaz), the IPN (Olaf Köller), the University of Dortmund (Michael Becker), and the University of Michigan at Ann Arbor (Kai S. Cortina). The study was funded by the Strategic Innovation Fund of the President of the Max Planck Society.

The BIJU Study's five components are as follows:

(1) providing institutional and individual baseline data on the integration of the East and West German educational systems and on the cohort born in 1979 since 1991;

(2) analyzing domain-specific learning trajectories as a function of personal resources and institutional opportunity structures;

(3) analyzing the transition from school to vocational training or university and to the labor market;

(4) analyzing short- and long-term occupational career patterns as a function of social origin and education;

(5) analyzing trajectories of psychosocial development (including political engagement) from a lifecourse perspective.

Data collection began with a survey of the main cohort in the 1991/92 school year, dur-

ing which data were gathered from grade 7 students at three measurement points. The first point of measurement coincided with the transformation of the unitary school system of the former East Germany to the tracked system adopted from West Germany. The fourth wave of data collection was conducted in spring 1995, when the main cohort students were in the final grade of lower secondary school; the fifth wave in spring 1997, when they were either in vocational or upper secondary education; the sixth wave in 2001, after the transition from school to university or from vocational education to the labor market. The seventh wave in 2009/10 focused on occupational position and partnership; the eighth in 2017 on occupational careers, family life, well-being, and social and cultural integration. Our analyses currently focus on components (3), (4), and (5).

Bilingual Alphabetization in Multicultural Societies: Evaluation of Berlin's State Europe Schools (EUROPA Study)

The key objective of the EUROPA Study, which was initiated in 2013, is to examine whether bilingual alphabetization in two-way immersion is a suitable instrument for reducing the educational disadvantage of immigrant children. Drawing on a longitu-dinal, extended evaluation of Berlin's State Europe Schools (SESBs), we aim to derive benchmarks for the outcomes of two-way immersion for children from German-speaking and non-German-speaking families. In addition, we test the hypotheses that (a) positive transfer occurs from the first to the second language providing that a critical threshold of language proficiency has been reached and (b) children who learn to read and write in two languages are at a general advantage in terms of the development of executive functions. The quasi-experimental study includes a longitudinal component at elementary school level (see Figure 2), and is conducted in cooperation with the Christian-Albrechts-Universität zu Kiel (Jens Möller), the Leibniz Institute for Science and Mathematics Education (IPN) in Kiel (Olaf Köller), and the Mercator Institute for Language Training and German as a Second Language at the University of Cologne (Michael Becker-Mrotzek). It is funded by the state of Berlin and the Mercator Stiftung.

Berlin's State Europe Schools (SESBs) implement two-way immersion with the aim of developing students as balanced bilinguals. The key objective is for students to become competent in German and a partner language without adverse effects on their achievement

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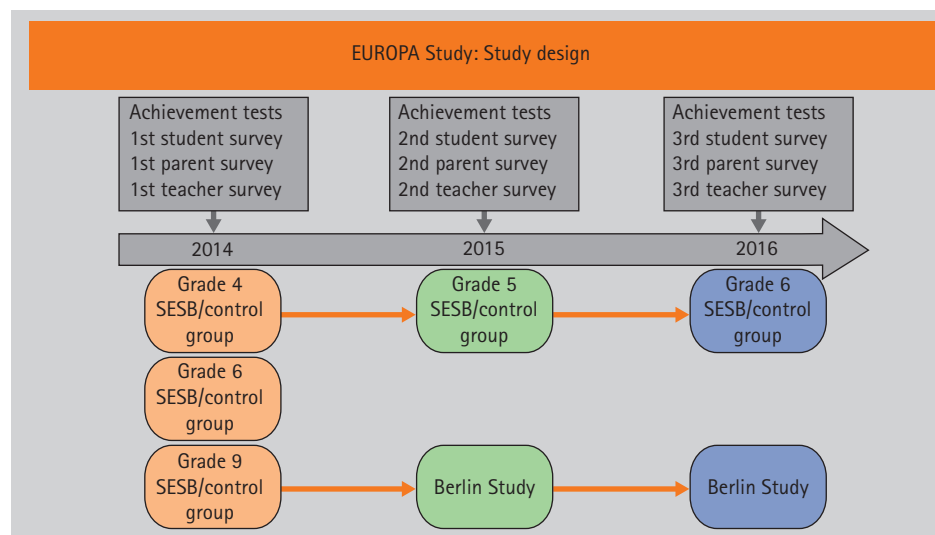
Figure 2. Design of the EUROPA Study.

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Preusler, S., Zitzmann, S., Paulick, I., **Baumert, J.,** & Möller, J. (2019). Ready to read in two languages? Testing the native language hypothesis and the majority language hypothesis in two-way immersion students. *Learning and Instruction, 64,* Article 101247. https://doi.org/10.1016/j.learninstruc.2019.101247

in other subjects. There are currently nine language programs at different sites: Students are taught in German and either English, French, Greek, Italian, Polish, Portuguese, Russian, Spanish, or Turkish. The languages have equal standing; half of the subjects are taught in German, the other half in the partner language.

Findings showed that, at both elementary and lower secondary level, the performance of SESB students in reading comprehension, mathematics, and science was neither higher nor lower than that of their peers in comparison groups drawn from monolingual schools in Berlin when testing was conducted in German. In other words, although they had learned to read and write in two languages and been taught in both of those languages, the SESB students showed no developmental disadvantages in subjects taught in German. These findings did not change when we controlled for the social, educational, and cognitive selectivity of the SESBs. Moreover, SESB students performed much better in English.

Two-way immersion thus lays a solid basis for learning a further foreign language. However, there was no evidence that immigrant students receive more individualized instruction that caters to their specific needs.

Grade 4 and 9 students were also tested in the partner language, using reading comprehension and science tests from international studies. This approach made it possible to compare the achievement of the SESB sample with that of their peers in countries where the partner language is the language of instruction. At first glance, the analyses confirmed that grade 4 students have not yet reached the achievement level of L1 speakers from the partner countries in reading comprehension in the partner language. However, a good two-thirds of them have a solid basic command of the language. In fact, almost half of them reached a level typical of that achieved in the partner countries. Similar patterns of results emerged for grade 9 students at the end of lower secondary level.

Jürgen Baumert: Publications 2017–2019/20

(last update: April 2020)

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# Emeritus Research Group of Gerd Gigerenzer

The ABC Research Group was established at the Max Planck Institute for Psychological Research in Munich in 1995, moved to the Max Planck Institute for Human Development in Berlin in 1997, and ended its local activities on September 30, 2017. Gerd Gigerenzer has continued as Director of the Harding Center for Risk Literacy at the Institute. This part of his research is discussed in the separate entry on the Harding Center in this report (pp. 167 ff.).

The following five topics are a selection reflecting new directions and extensions of earlier work. For Gerd Gigerenzer's continuing publications on bounded rationality and ecological rationality, see the literature section.

Classification: Simple Heuristics and Machine Learning

Classification, that is, the assignment of individuals to classes based on cues using a classification rule, is a topic of both psychology and machine learning. In our forthcoming book *Classification in the Wild,* K. Katsikopoulos, Ö. Şimşek, M. Buckmann, and G. Gigerenzer investigate the relationship between state-of-the-art machine learning algorithms and fast-and-frugal heuristics in real-world situations. The key proposition is that simple rules do well "in the wild," that is, in situations of uncertainty outside the lab as opposed to in situations of risk, which are typically studied in the lab. Katsikopoulos et al. focus on two classes of heuristics that exploit two core abilities of human intelligence, counting and ordering. The family of *tallying heuristics* simply counts reasons for assigning an individual to a class. The family of *fast-and-frugal trees* simply orders reasons and allows for quick classification decisions based on just one or a few reasons. These heuristics have been used for decades in emergency treatment, HIV testing, heart attack diagnosis, election predictions, and other applied situations, but have been largely ignored by both psychological and machine-learning research on classification. For situations of uncertainty, the authors show that these heuristics can approximate, match, or surpass the predictive performance of the most complex machine learning algorithms such as random forests. One reason is that heuristics tend to be robust under uncertainty and avoid overfitting.

A second advantage of simple heuristics that is largely ignored in both psychological research and machine learning is transparency. *A rule is transparent to a group of users if they can understand, memorize, teach, and execute it.* Transparency is central to and can increase safety in many real-world applications, be it in military operations or banking regulation. Transparency is also of legal and ethical value. Increasingly, highly complex or secret algorithms are used to evaluate whether, for instance, a defendant will commit another crime, an applicant should be considered for a job, or a loan seeker is creditworthy. Given the nontransparent nature of these algorithms, people cannot find out why they were denied bail, a job interview, or a loan. The machine learning community, including the U.S. Defensive Advance Research Projects Agency (DARPA) has recognized the problem and created a movement for "explainable AI." Yet DARPA makes the (wrong) assumption that complex algorithms are always better than simpler and more readily understandable ones. Therefore, complexity is retained and attempts are made to somehow explain its logic by using principles that, however, may have little in common with the complex models being explained. Instead of making this questionable detour, we show that in many situations the assumed trade-off between accuracy and simplicity does not exist and there is a more direct solution to the problems created by nontransparent algorithms. The solution is to investigate whether fast-and-frugal heuristics exist that are equally accurate but fully transparent. The book also discusses the relationship between fast-and-frugal classifiers and standard cognitive theories of classification such as exemplar models and random walk models, as well as more transparent machine learning tools such as classification-and-regression decision trees.
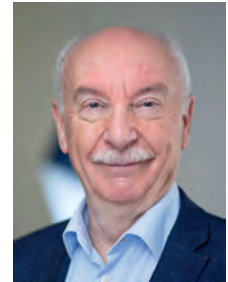
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Table 1. A simple heuristic leads to less error in predicting flu-related doctor visits than does Google's big data analytics. Shown is the performance of the second Google Flu Trends model, updated after the failure of the first to predict the swine flu in the summer of 2009. The weekly predictions are from September 2009 to September 2013. Predictive accuracy is measured as the mean absolute difference between predictions and observations (Katsikopoulos et al., in press).

Prediction Rule	Information Used	Mean Absolute Error in Prediction (Percentage Points)
Google Flu Trends in the revised version of 2009	160 cues selected from 50 million search terms	0.49
Recency heuristic (zero free parameters)	One data point	0.33

Whereas machine learning is largely atheoretical and driven by what works, classification in the wild derives classification rules from cognitive psychology. For instance, a long line of memory research dating back to Thomas Brown's (1838) *Law of Recency* demonstrated that in dynamic and changing situations, memories of recent experiences come to mind more easily than those of the distant past and are often the sole information that guides human decisions. We applied this principle to predicting the spread of the flu, the same problem Google tried to solve via its Google Flu Trends, a secret algorithm with 160 variables based on an analysis of 50 million search terms. In our case we came up with a simple rule.

> *Recency Heuristic:* Predict that this week's flu-related doctor visits will equal those of the most recent data available (2 weeks ago).

The recency heuristic does what humans do, that is, relies solely on the most recent data point available (the number of flu-related doctor visits 2 weeks ago); at the same time it is fully transparent, uses only one data point (the most recent data point), and does not require complex analysis. For the entire window of 4 years of weekly predictions by Google Flu Trends, we show that the simple heuristic is superior to the secret big data algorithm in predicting the spread of influenza. These and similar results open up a new principle for developing explainable AI: Always test complex algorithms against simple ones, and use the latter to foster transparency.

Digital Risk Literacy

Digital literacy encompasses the skills for using digital technology. *Digital risk literacy* has a different quality. It is the ability to understand a technology's potentials and risks. To use an analogy, medical professionals learn the skills to use computed tomography (CT) technology. Yet few are trained to use it sparsely and understand its risks: With a single full body CT, a person namely gets about half the radiation dose to which the average Hiroshima and Nagasaki survivor was exposed. But where is the risk with algorithms, one might ask? As in the case of CTs, it is not in the algorithm per se, but in people and companies who have conflicting interests, want to persuade or sell, and prefer not to know about the risks.

For instance, the majority of Germans now buy "smart" rather than regular TV sets. Yet in a representative survey of 3,200 people Gigerenzer conducted together with ERGO insurers, 77% were unaware that a smart TV with voice recognition can record all their personal conversation in front of the screen and send it to third parties.

One important area of digitalization is consumer scoring, that is, the assignment of scores to people that reflect their "value" in areas such as financial creditworthiness, health behavior, or driving behavior. In their capacity as members of the Advisory Council for Consumer Affairs to the German Ministry of Law and Consumer Protection, Gert G. Wagner and Gigerenzer conducted surveys and interviews with both the general public and the companies who offer these services, such as Schufa, Avarto, SparkasseDirekt and health insurers. The report of the advisory

council was presented to the Minister of Law and Consumer Protection in November 2018 (SVRV, 2018c). Here, a few findings and recommendations are summarized.

Transparency of Scoring
There is a divide between the largely secret algorithms used to assess credit scorers and job applicant scorers and the transparent algorithms used for health insurers' and telematic car insurers' bonus programs. Lack of transparency means that people who are denied a loan, a job interview, or bail cannot know or understand why. Gigerenzer and Wagner advised the Ministry to introduce legislation that prioritizes people's right to understand such sensitive decisions over the rights of businesses, that is, to legislate that all variables and their weights need to be revealed to the public, not only to data protection agencies. This would be not difficult because virtually all of scoring algorithms in these fields are linear equations.

Quality of Scoring and Supervisory Authorities
One would expect there to be efficient quality control in consumer scoring. Yet that is largely not the case. For instance, Schufa, Germany's largest credit scoring company, is required to reveal its algorithms to the data protection authority in the state of Hessen for a quality assessment—including potential for discrimination. But the staff at data protection authorities, who rarely have the necessary competencies in IT or statistics, are in no position to perform this task. Therefore, they rely on external reviewers. In the case of Schufa, it turned out that the company had proposed and paid for the reviewers.
For health insurers' bonus programs, one might assume that behavior shown by medical studies to strongly improve health is awarded the most points and other behavior fewer or no points. When 45 bonus programs were analyzed, however, it was found that many of these appear to disregard the scientific evidence. For instance, only 8 out of 45 programs awarded points for not smoking, and all awarded points for participating in cancer screening programs that have no proven benefit (no lives saved) but instead proven

harms such as overdiagnosis. In interviews with executives of the health insurance companies, it became clear that most did not even know the scientific evidence and appeared to pursue other goals than that of improving patients' health, including customer retention and solicitation. These conflicting goals explain why bonus programs and health apps are to a surprising degree evidence-free.

Privacy Is Worth Less Than a Euro
As data trading grows in significance, efforts intensify to bring together data from the most diverse areas of people's lives. Data brokers collect thousands of data points for each citizen, which can be brought together into a single citizen score by a single company. Entire countries—with China at the forefront—are developing social credit systems, where the data vector for each citizen is combined into a single score. Those with high scores are awarded exclusive access to the best private schools or express trains and similar bonuses. Surveys indicate that some 80% of Chinese are in favor of the digital surveillance state for security and moral reasons. Germans, by contrast, are renowned for being deeply worried about loss of privacy. In a 2019 survey, Gigerenzer together with ERGO asked a representative sample of 3,029 people in Germany:
How much would you be maximally willing to pay for using all social media if these would no longer record and sell your personal data?

75%	nothing
18%	up to 5 euros per month
5%	6 to 10 euros per month
2%	more than 10 euros per month

In other words, 75% were not willing to pay a single euro for their privacy. The willingness to pay was largest among the 18 to 30 year olds, but even among them, 62% were not willing to pay. At the same time, 51% said the greatest danger of digitalization is loss of data protection because their personal data are made available to companies and governments. When informed about the Chinese social credit system and asked whether it would be a good idea to introduce it in Germany, 20% said they would like such a system, up

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from 10% in the 2018 survey of the Advisory Council for Consumer Affairs. These developments indicate that privacy is worth little in terms of hard money and that the willingness to accept Chinese-style governmental surveillance and behavior control is increasing.

Deliberate Ignorance

Ignorance is generally considered an unwanted state of mind, and the act of willful ignorance may raise eyebrows. Yet people do not always want to know, demonstrating a lack of curiosity at odds with theories postulating a general need for certainty, ambiguity aversion, or the Bayesian principle of total evidence. Gigerenzer and Garcia-Retamero (2017) proposed a regret theory of deliberate ignorance that covers both the negative feelings that may arise from foreknowledge of negative events such as death and divorce and the positive feelings of surprise and suspense that may arise from foreknowledge of positive events, such as knowing the sex of an unborn child. The authors also conducted the first representative nationwide studies to estimate the prevalence and predictability of deliberate ignorance in the general population for a sample of ten events. Its prevalence is surprisingly high: Between 85% and 90% of people would not want to know about upcoming negative events, and 40% to 70% prefer to remain ignorant of upcoming positive events (see Figure 1). Only 1% of participants consistently wanted to know what was in store. Several predictions from regret theory were also deduced and tested: Individuals who prefer to remain ignorant are more risk averse and more frequently buy life and legal insurance. The theory also implies the counterintuitive time-to-event hypothesis, which states that if regret is at issue, deliberate ignorance is more likely the nearer the event approaches. These findings were cross-validated using two representative national quota samples in two European countries. In sum, it was shown that deliberate ignorance exists and can be explained as avoiding anticipatory regret. Individual differences exist: Those who choose not to know are more risk averse, buy more insurance, are older, and do not attend religious services.
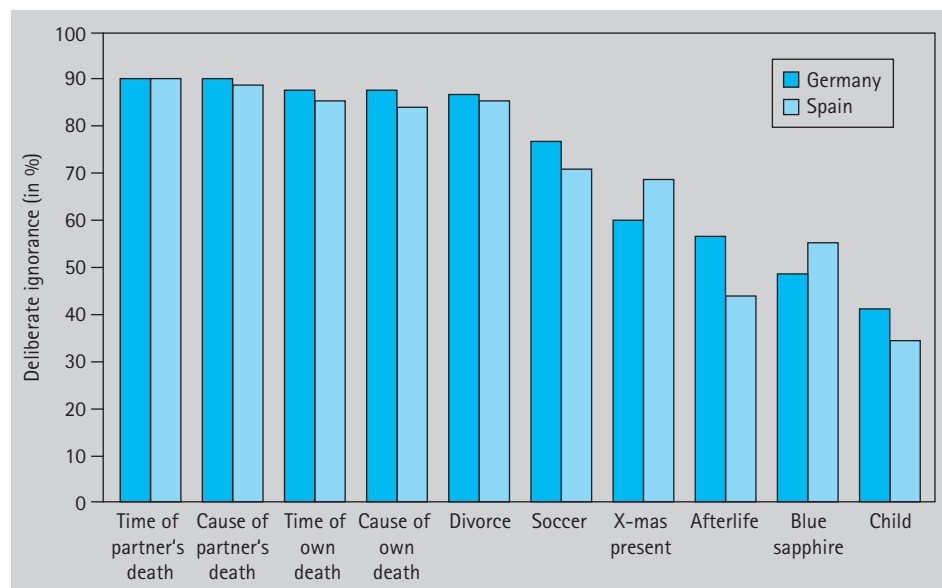
Figure 1. Prevalence of deliberate ignorance in two national quota samples in Germany (*n* = 1,016) and Spain (*n* = 1,002). For instance, about 90% of Germans and Spaniards would not want to know when their partner will die or from what cause. Almost as many would not want to know when and from what cause they themselves will die, or whether their marriage will end in divorce. Soccer = wanting to know who won before watching a replay of a soccer game; X-mas present = wanting to know what you get for Christmas; afterlife = wanting to know whether there will be an afterlife; blue sapphire = wanting to find out whether a sapphire is genuine after buying it; child = wanting to know the sex of one's child before it is born (adapted from Gigerenzer & Garcia-Retamero, 2017).

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The Bias Bias

Behavioral economics began with the promise to fill the psychological blind spot in neoclassical theory and largely ended up portraying psychology as the source of irrationality. According to this view, people have systematic cognitive biases that not only generate substantial costs but—like visual illusions—are persistent and hardly educable, meaning that governments need to step in and steer behavior with the help of "nudges." By contrast, Gigerenzer (2018a) shows that this view of human nature is tainted by a "bias bias."

> *Bias Bias:* The tendency among researchers to see systematic biases in behavior even if there is only unsystematic error or no verifiable error at all.

Note that the term *bias bias* refers to the reasoning of researchers, not to that of their subjects. Three categories of bias bias are identified:

(1) *Biased sample estimators are mistaken for people's biases.* The statistics of small samples can systematically differ from the population parameters. If researchers do not pay attention to this difference, they mistake correct judgments about samples for systematic biases.

(2) *Unsystematic errors are mistaken for systematic biases.* A bias is a systematic error, not an unsystematic one. Mistaking regression to the mean as a systematic error is a key example.

(3) *Logically equivalent frames are mistaken as informationally equivalent.* The alleged normative principle of "description invariance" serves as a key example.

The first category is illustrated by the so-called law of small numbers and the hot-hand fallacy, where in both cases researchers did not notice that the sample statistics (which respondents were asked to judge) systematically deviate from the population statistics. For instance, when a fair coin is thrown four times, most people's intuition is that a sequence of Heads-Heads-Tails is more likely than Heads-Heads-Heads. Researchers have insisted that this is an error because the population probabilities are the same, not noticing that people's intuition about samples is correct. The second category is illustrated by the phenomena known as overconfidence, miscalibration, and overestimation of low risks, which are in fact largely consequences of unsystematic error due to regression to the mean, not systematic errors of ordinary people. The third category is illustrated by many so-called framing biases, which mistake context-sensitive intelligence for logical errors. In all three categories, uncertainty is not taken seriously in the analysis of rationality. Getting rid of the bias bias is a precondition for a positive role of psychology in behavioral economics. This requires discarding the fascination with pointing out that people are systematically and perpetually irrational, and hence in need of governmental paternalism.

Theory Integration

Psychology's most vital challenge is to strengthen its theoretical fundament. Popper's program of competitive testing and the development of unified theories are two common routes toward this end. Gigerenzer (2017g) proposes a third and complementary route: the integration of already existing theories. To provide a systematic framework, Gigerenzer proposes a two-step theory integration program. The first step is integration of phenomena, that is, the study of how apparently disparate robust observations are theoretically connected, not just empirically correlated. The second step is integration of theoretical concepts, that is, the study of how apparently different explanatory concepts are linked. Links between phenomena or concepts include identity, nesting, and functional equivalence. Functional equivalence means that two or more psychologically distinct theoretical concepts can be shown to imply the same behavioral pattern by vicarious functioning. The two-step program requires formalization and close attention to operational and conceptual definitions. It should not be seen as an algorithm that can be applied automatically, but as a heuristic method requiring creativity for building a network between theories.

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Max–Planck–Institut für Bildungsforschung
Max Planck Institute for Human Development

Managing Director
Prof. Dr. Dr. h. c. Ute Frevert

To all colleagues

Berlin, 3rd of March 2020

We Mourn the Loss of Wolfgang Edelstein

A celebrated education reformer, theorist of child development, and passionate democrat

Wolfgang Edelstein, director emeritus of the Max Planck Institute for Human Development, died over the weekend at the age of 90. "We bid farewell to a renowned scientist, esteemed colleague, and amiable person whose ideas contributed to the establishment of our institute and defined its development over decades. I speak for our entire team in expressing our deepest sympathies with his family," said managing director Ute Frevert.

Wolfgang Edelstein was born in 1929 in Freiburg. In 1938, he and his family fled Nazi Germany to Iceland, an experience that greatly impacted his life. After completing his A-levels in Reykjavik, Wolfgang Edelstein studied linguistics, philosophy, ancient and modern languages, and education science in France and Germany. In 1962, he completed his doctorate in medieval Latin philology at the University of Heidelberg. He began teaching at the Odenwaldschule private boarding school in 1954. There he met Hellmut Becker, with whom he shared an interest in processes and contents of education in modern democratic societies. Together with Jürgen Habermas and Alexander Kluge, he wrote the memorandum that played a key role in Becker's negotiations with the Max Planck Society to found a new Institute for Human Development.

Edelstein followed Becker to Berlin in 1963. Ten years later, he became a Scientific Member of the Max Planck Society, and eight years after that, he became Director of the Research Center for Development and Socialization. His scholarship focused on intercultural analyses of the mutual relation between social inequality and cognitive as well as social-moral personality formation from childhood to adulthood. He was bestowed with an honorary doctorate in social sciences by the University of Iceland and was named honorary professor of education at the Freie Universität Berlin and the University of Potsdam, an institution that he helped establish.

After retiring in 1997, he continued promoting the education of democratic values in schools and spearheading projects that furthered democracy, such as in his capacity as the founder and longtime leader of the German Society for Democracy Education. He penned numerous texts on right-wing extremism and, in particular, right-wing extremist youth culture. He actively participated in events at the institute up until his death.

For his work and extraordinary social engagement, he was awarded the Federal Cross of Merit (First Class), the Hildegard-Hamm-Brücher Prize for Learning and Living Democracy, and the Theodor Heuss Prize.

Kind regards

Ute Frevert

Directors:
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Karl Ulrich Mayer: Publications 2017–2019/20

(last update: April 2020)

Becker, R., & **Mayer, K. U.** (2019). Societal change and educational trajectories of women and men born between 1919 and 1986 in (West) Germany. *European Sociological Review, 35*(2), 147–168. https://doi.org/10.1093/esr/jcy052

Fasang, A., & **Mayer, K. U.** (in press). Life courses and social inequality. In J. Falkingham, M. Evandrou, & A. Vlachantoni (Eds.), *Handbook on demographic change and the lifecourse.* Edward Elgar.

Mayer, K. U. (2019). On heuristics, theoretical foundations, accounting schemes and theories [Commentary on the articles in the special issue "Theoretical and Methodological Frontiers in Life Course Research"]. *Advances in Life Course Research, 41,* Article 100277. https://doi.org/10.1016/j.alcr.2019.04.007

Mayer, K. U. (2018a). Gutes Leben oder gute Gesellschaft? Dimensionen, Messung und politische Gestaltung von Lebensqualität. In K. U. Mayer (Ed.), *Gutes Leben oder gute Gesellschaft? Symposium der Deutschen Akademie der Naturforscher Leopoldina—Nationale Akademie der Wissenschaften und der VolkswagenStiftung am 17. und 18. Juni 2016 in Hannover* (pp. 7–19). Deutsche Akademie der Naturforscher Leopoldina, Nationale Akademie der Wissenschaften.

Mayer, K. U. (Ed.). (2018b). *Gutes Leben oder gute Gesellschaft? Symposium der Deutschen Akademie der Naturforscher Leopoldina—Nationale Akademie der Wissenschaften und der VolkswagenStiftung am 17. und 18. Juni 2016 in Hannover.* Deutsche Akademie der Naturforscher Leopoldina, Nationale Akademie der Wissenschaften.

Mayer, K. U. (2018c). Nachruf auf Wolfgang Zapf (25. April 1937–26. April 2018). *Kölner Zeitschrift für Soziologie und Sozialpsychologie, 70*(2), 343–347.

Mayer, K. U. (2018d). Wissenschaft: Weder Beruf, noch Berufung? *Denkströme: Journal der Sächsischen Akademie für Wissenschaften, 19,* 115–123.

Mayer, K. U., & Staudinger, U. M. (2017). *Gutes Leben oder gute Gesellschaft?* Deutsche Akademie der Naturforscher Leopoldina, Nationale Akademie der Wissenschaften.

Staudinger, U. M., Kempermann, G., Patzwald, K., Ehmer, J., Fürnkranz-Prskawetz, A., **Mayer, K. U.,** Sieber, C., & Siegrist, J. (in press). *Zukunftsreport Wissenschaft: Forschung für die gewonnenen Jahre.* Deutsche Akademie der Naturforscher Leopoldina, Nationale Akademie der Wissenschaften.

International Max Planck Research Schools (IMPRS) & Networks

International Max Planck Research School on the Life Course (LIFE)

Studying the development of human behavior from infancy to old age is at the heart of the LIFE graduate program. LIFE takes an integrative and interdisciplinary approach to identifying, understanding, and improving the mechanisms and conditions that shape the human life course. It actively promotes international networking and communication as an integral part of graduate training. The Berlin-based fellows are recruited from all over the world (e.g., Greece, Iran, Italy, Sweden, etc.). In addition, four LIFE sites in three countries (Germany, the United States, Switzerland) located on either side of the Atlantic guarantee a graduate education with a strong emphasis on international exchange and collaboration.

LIFE is all about the development of human behavior from infancy to old age. LIFE is a joint international PhD program of the Max Planck Institute for Human Development, the Freie Universität Berlin, the Humboldt-Universität zu Berlin, the University of Michigan, the University of Virginia, and the University of Zurich. LIFE was established in 2002 and reached the nominal maximum period of 18 years of funding by the Max Planck Society in 2019. In the course of these 18 years, 233 doctoral students successfully completed their graduate training with dissertations and went on to form a wide-ranging international network of LIFE alumni. The proposal to renew the IMPRS LIFE by another 6-year funding period was evaluated very positively by the Max Planck Society. The new funding period started in 2020, with continued involvement of all four sites.

LIFE takes an integrative and interdisciplinary approach to identifying, understanding, and possibly ameliorating the mechanisms and conditions that shape the human life course. LIFE unifies a wide range of disciplines from the behavioral, computational, social, and neurosciences. The research of individual fellows is anchored within specific disciplines and their training is enriched by exposure to an international and interdisciplinary context that actively promotes the lifespan perspective.

The target groups of LIFE are graduate students who have completed their M.A. or a comparable degree, share an interest in the human life course, and intend to pursue a doctorate in one of the disciplines represented in LIFE (biology, computer science, economics, educational science, neuroscience, psychology, and sociology). As a collabora-

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MPI for Human
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German Centre of
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Associate Co-Speaker
Toni C. Antonucci,
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Jacqui Smith,
University of Michigan,
Associate Co-Speaker
Steven M. Boker,
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Nancy Oeffner,
University of Michigan
Karen Johnson,
University of Virginia

Newsletter Editor
Julia A. M. Delius,
MPI for Human
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Figure 1. Participants from all four LIFE sites during the LIFE Fall Academy 2019 in Zurich.

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Table 1. LIFE Academies 2017–2019

Spring Academy 2017, 21.05.–24.05 2017	University of Michigan
Fall Academy 2017, 15.10.–19.10.2017	University of Zurich
Spring Academy 2018, 31.05.–04.06.2018	MPI for Human Development
Fall Academy 2018, 12.10.–15.10.2018	University of Virginia
Spring Academy 2019, 28.05.–31.05.2019	University of Michigan
Fall Academy 2019, 11.10.–15.10.2018	University of Zurich

Table 2. International LIFE Community (as of 02/2020)

	Berlin	Michigan	Virginia	Zurich
Faculty	34	31	25	16
Fellows	25	10	15	14
Alumni	103	56	38	36

tive research school, LIFE offers students a unique educational experience: academic training in their area of specialization that is enriched by interdisciplinary and international perspectives.

Collaboration among the participating institutions has been close and extensive from the program's inception. The semiannual academies, in which fellows and faculty from the four LIFE sites participate, are the beating heart of the international LIFE program. At the academies, typically about 40 fellows attend, and most of them present their dissertation research either as a poster or in a talk, with ample time for discussion with faculty and co-fellows. In addition, roughly 35 faculty members from all sites and a few local alumni participate in each academy as well as one or two guest speakers from other institutions. Each time, the graduating alumni also join the group to celebrate their LIFE Commencement. Each fellow participates in four academies.

Table 3. LIFE Seminars and Workshops 2017–2019, Berlin

Semester	Topic	Instructor(s)
Winter 2016/17	Developmental Theory and Methodology of the Lifespan	Ulman Lindenberger (MPIB) and guests
Summer 2017	Introductory Workshop "Foundations of Lifespan Research" Learning, Memory, and Forgetting From a Lifespan Perspective	Berlin LIFE faculty and guests Markus Werkle-Bergner (MPIB) and guests
Winter 2017/18	Evolutionary Approaches to Human Development Multilevel Modeling; Analysis of Incomplete Data Sets	Annie E. Wertz (MPIB) and guests Tenko Raykov (MSU)
Summer 2018	Introductory Workshop "Foundations of Lifespan Research" Rhythms of the Brain Academic Presentation Training	Berlin LIFE faculty and guests Markus Werkle-Bergner (MPIB) and guests Steve Weir (FU)
Winter 2018/19	Fellows' Project Presentations Academic Writing	Chaired by Berlin LIFE alumni Ulman Lindenberger (MPIB)
Summer 2019	Introductory Workshop "Foundations of Lifespan Research" Methods in Research on Human Development	Berlin LIFE faculty and guests Ulman Lindenberger (MPIB) and guests
Winter 2019/20	Practical Seminar on Bayesian Statistics Symposium on Good Scientific Practice and Open Science "Doing Good—Scientific Practice under Review" Academic Presentation Training	Timo von Oertzen (Universität der Bundeswehr München & MPIB) and guests MPI CBS Steve Weir (FU)

Freie Universität Berlin (FU), MPI for Human Development (MPIB), MPI for Human Cognitive and Brain Sciences (MPI CBS), Michigan State University (MSU).

The LIFE exchanges, or research stays abroad, are the other core element of international collaboration. Over the years, these exchanges have triggered an impressive number of collaborative research projects among fellows as well as fellows and faculty members from different sites and institutions. In the reporting period, 18 fellows from all four sites made use of this international research option.

LIFE fellows in Berlin participate in a special program of weekly seminars each semester. On a rotational basis, the topics are designed to give a broad coverage of research and theory in the biology, psychology, sociology, and education of the life course. The seminars are usually held at the MPI for Human Development, taught throughout the academic year by a varying team of faculty from the three Berlin institutions, and also include invited lectures by external faculty.

Table 4. Berlin LIFE Fellows' Dissertation Projects (as of 02/2020)

Name	Institution	Dissertation Project
Rasmus Bruckner	FU	Age differences in adaptive learning: A neuro-computational approach
Tiago Cabaço	HU	Within- and between-subject dynamics of cognitive processes
Andrea Hasl	Universität Potsdam	The interplay between cognitive and noncognitive factors in education
Stefan Heß	MPIB	The role of cognitive processing units in writing and their emergence during primary school
Ann-Kathrin Jöchner	MPIB	Spotlight on the sleeping brain! The development of sleep spindles, slow oscillations, and their role in memory consolidation across childhood
Angela Jones	MPIB	Development of active learning strategies across the lifespan
Anna Karlsson	MPIB	Age differences in the use and reinstatement of contextual information in episodic memory
Lena Keller	FU	Profiles in students' achievement and achievement motivation: Gender differences, top performers, and life outcomes
Neda Khosravani	MPIB	Practice-related plasticity in task-switching during childhood: An individual differences perspective
Christoph Koch	MPIB	How age affects neural differentiation in the medial temporal lobe: Decoding neural tuning functions of spatial orientation
Mario Lawes	FU	Job loss and well-being
Felix Molter	FU	The role of visual attention in multi-alternative and multi-attribute choice
Toni Muffel	HU	Modulating and assessing plasticity after stroke and across the lifespan
Jannik Orzek	HU	Statistical learning in psychological research: Methods and applications
Eleftheria Papadaki	MPIB	Neuronal changes in auditory cortex due to musical training
Sarah Polk	MPIB	Effects of long-term exercise on brain and cognition
Sophie Potter	HU	Well-being and health in adulthood and old age: Their interplay among individuals and dyads across multiple time scales
Lisa Reiber	MPIB	Risk preferences and behavior across the lifespan: The role of life events on individual risk trajectories
Connair J. S. Russell	MPIB	Error management in learning and generalization
Karola Schlegelmilch	MPIB	"Grass or gravel": Influences on the categorization of naturalistic structures in infancy and childhood
Alexander Skowron	MPIB	Neural computations supporting reinforcement learning under naturalistic conditions and their age-related changes
Verena R. Sommer	MPIB	Representational similarity of memory encoding and retrieval across the adult lifespan
Sophie Stallasch	Universität Potsdam	Multilevel design parameters and effect size benchmarks for students' competencies
Anna Thoma	MPIB	Ecological rationality of repeated choice under uncertainty: A developmental perspective
Mareike Trauernicht	FU	Preschool teachers' burnout: The role of working conditions and its consequences for the encouragement of social-emotional competencies

Freie Universität Berlin (FU), Humboldt-Universität zu Berlin (HU), MPI for Human Development (MPIB).

Name	Center/Research Group	Position
Annette Brose	Lifespan Psychology	Associate Research Scientist
Douglas D. Garrett	Lifespan Neural Dynamics Group & Lifespan Psychology	Senior Researcher
Ralph Hertwig	Adaptive Rationality	Director
Simone Kühn	Lise Meitner Group for Environmental Neuroscience	Group Leader
Ulman Lindenberger	Lifespan Psychology	Director
Thorsten Pachur	Adaptive Rationality	Senior Researcher
Naftali Raz	Lifespan Psychology	Research Scientist
Azzurra Ruggeri	Max Planck Research Group iSearch	Group Leader
Myriam C. Sander	Minerva Group, Lifespan Psychology	Group Leader
Sascha Schroeder	Lifespan Psychology	Associate Research Scientist
Nicolas W. Schuck	Max Planck Research Group NeuroCode	Group Leader
Timo von Oertzen	Lifespan Psychology	Associate Research Scientist
Gert G. Wagner		Max Planck Fellow
Markus Werkle-Bergner	Lifespan Psychology	Senior Researcher
Annie E. Wertz	MPRG Naturalistic Social Cognition	Group Leader

Note that Annette Brose, Thorsten Pachur, Nicolas W. Schuck, and Markus Werkle-Bergner are LIFE alumni, that is, they completed their graduate training within LIFE.

Examples of covers of the LIFE Newsletter, which is distributed among LIFE fellows, faculty, and alumni three times a year.

International Max Planck Research School for Moral Economies of Modern Societies (IMPRS MEMS)

The IMPRS MEMS is a PhD program in Modern History and a collaboration of the MPI for Human Development with Freie Universität Berlin, Humboldt-Universität zu Berlin, and Technische Universität Berlin. From 2013, when the first of four cohorts started, to 2020, when the last cohort will file their dissertations, the graduate school offered 22 international doctoral students in four cohorts a fully funded 4-year training. The PhD candidates came from seven different countries of origin (Austria, Germany, Israel, Romania, Switzerland, Turkey, and from the United States) to pursue their doctoral degree within the IMPRS MEMS. They are supervised by teams of two to three faculty members from the MPI of Human Development and the three Berlin universities. A scientific coordinator at the MPI for Human Development, where all doctoral students have an office space, serves as their local interlocutor and helps in guiding them through the program.

Concept and Classes

The dissertations written in this program analyze values, emotions, and habits that informed social and economic changes in Europe, North and South America, China, and South Asia from the 18th to the 20th century.

The program's curriculum offered discipline-based training through specialized courses on historical theories and methodologies as well as tailor-made seminars on moral economies. In semesters 1–3, the doctoral students took courses in historical theory and methodology and on the concept of moral economies. In semesters 4–5, the students went on archival research trips to collect source material necessary for their respective projects. These included archives in China, Cuba, France, Great Britain, India, Italy, Paraguay, Romania, Spain, Switzerland, Turkey, the United States, and in various German cities. Finally, in semesters 6–8, the students write and submit their theses.

The small size of the graduate school enables close relationships and exchange among the graduate students, with the researchers at the MPI for Human Development and at the universities. The special issue *Moral Economies* of the peer-reviewed journal *Geschichte und Gesellschaft* published in the fall of 2019 is only the most visible outcome of this

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Springorum,
Center for Research
on Antisemitism,
Technische Universität Berlin

Research Coordinator
Julia Wambach,
Monika Freier
(until 12/2017)
MPI for Human
Development

Figure 1. IMPRS MEMS in December 2019.

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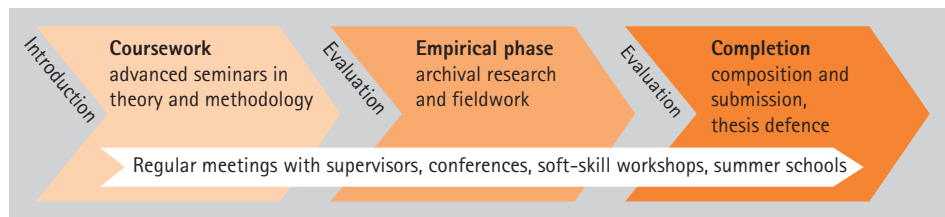
Figure 2. IMPRS MEMS program of study.

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close collaboration (see Box 1). The graduate students also actively participate in various informal working groups of the Center for the History of Emotions.

Academic and Professional Development
During the yearly 2- to 3-day summer retreats, the doctoral students present their dissertation progress and meet with their group of advisers for in-depth conversations about their work in a quiet space. The last retreat in 2019 also featured a workshop on careers inside and outside of academia. Another professional development workshop included the development of communication and presentation skills for conferences, the thesis defense, and conference small talks (elevator pitch). In December 2018, the students further developed their writing and time management skills during an intensive writing seminar. Inspired by the seminar, the graduate students began to organize a writing group at the Institute, which meets once a week and helps the students to stay focused in their writing process. Furthermore, there are regular meetings to discuss chapters written by the students or prepare their thesis defense.

Internationalization
The exchange agreements with the University of Chicago and the University of California, Berkeley (UCB), have enabled sixteen students of the IMPRS to spend a semester either here or there. During their time abroad, the doctoral students built professional networks with researchers and graduate students at their host universities, attended lectures, workshops, and presented their work in research groups.
The close collaboration with Berkeley's German history working group "Der Kreis," led to the idea of a joint graduate student workshop

on "Moral Economies," which took place on 19–20 June 2018 in Berlin. Ute Frevert, Stefan-Ludwig Hoffmann (UC Berkeley), Lisa Herzog (Hochschule für Politik München), and Vanessa Ogle (UC Berkeley) led two seminar discussions on the concept of "Moral Economies" and 19 graduate students from Berkeley and the IMPRS presented and commented on each other's papers. Vanessa Ogle gave the keynote on 19 June 2018 titled Immoral Economies: Tax Havens and Tax Avoidance, 1920s–1980s.

Dr. Julia Wambach, a former PhD student at Berkeley, took over the position as coordinator of the IMPRS MEMS from Monika Freier in June 2018 and further strengthened the ties between the Moral Economies group and Berkeley.

Figure 3. Retreat at Schloss Blankensee 2019.

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Figure 4. Weekly writing group.

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Moral Economies Volume

During the Occupy movement in 2011, a graffito appeared on a New York wall: "Love is Greater Than Money." This graffito was chosen as the cover for the volume titled *Moral Economies,* a special issue of one of Germany's most important peer-reviewed history journals, *Geschichte und Gesellschaft* (History and Society). Demands for a more moral economy have long been a rallying cry for a wide range of political movements and actors. Proponents include not only the Occupy movement, but also Bernie Sanders and Pope Francis, NGOs like Attac, and supporters of initiatives like "Buy Moral," which pushes consumers to purchase goods "ethically" from "moral vendors." These initiatives, however, have a history.

The volume combines two of editor Ute Frevert's longstanding research interests: capitalism and the moral economies of modern societies (cf. pp. 76 f.). In 2017, Frevert, principal investigator and spokesperson for the IMPRS MEMS, convened a 2-day workshop that brought together seven students from the IMPRS and seven external senior researchers to discuss the history of the concept while fostering exchanges between junior and senior researchers. The outcome of this fruitful discussion was the idea of a book project that would illustrate how, in the last 200 years, moral judgments have informed economic decisions and actions. In her article "Moral Economies, Present and Past: Social Practices and Intellectual Controversies," Ute Frevert analyzes the long, varied history of the concept of "moral economy" as a means of criticizing capitalism.

Four graduate students of the program (Anna Danilina, Björn Blaß, Thomas Rohringer, and Till Großmann) passed the strict double-blind peer review procedure and contributed with an article to this volume, thereby advancing their publication skills and record:

Anna Danilina wrote a conceptual history of the notion of just and moral economies in the "inner colonies" of the German settlement movement (1893–1926) by focusing on deliberations about land, community, nutrition, and the body.

By looking at New York's Progressive-Era municipal housekeeping movement and its impact on the city's waste regime, Björn Blaß identified in his article a unique moral economy shaped by political activism, moral imperatives, and economic concerns.

Thomas Rohringer investigated the economic, sociological, and moral discourses related to the rehabilitation of disabled veterans in Austria-Hungary and the role of work in the measures taken to help them. He identified joy and self-confidence as key components of the "moral economy" of the veterans' social reintegration.

By analyzing GDR citizens' conceptions of marriage, gender roles, and work in advice correspondence, Till Großmann mapped out their search for insights into their own lives. He shows how marriage counselling in the GDR shaped values, emotions, and knowledge perceived as socialist, while simultaneously rejecting the constrictions of proletarian identity.

Box 1.
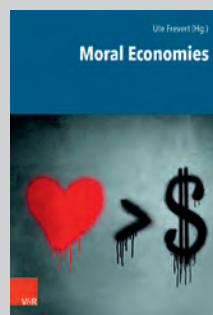
Key References

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Danilina, A. (2019). Die moralische Ökonomie der "inneren Kolonie": Genossenschaft, Reform und Rasse in der deutschen Siedlungsbewegung (1893–1926). In U. Frevert (Ed.), *Moral economies* (pp. 103–132). Vandenhoeck & Ruprecht.

Großmann, T. (2019). Moral economies of love and labor in the GDR: Family values and work ethics in advice correspondence, circa 1960. In U. Frevert (Ed.), *Moral economies* (pp. 213–237). Vandenhoeck & Ruprecht.

Rohringer, T. (2019). Arbeitsfreude und Selbstvertrauen: Die moralische Ökonomie der Re-Integration Kriegsbeschädigter in Cisleithanien (1914–1918). In U. Frevert (Ed.), *Moral economies* (pp. 163–186). Vandenhoeck & Ruprecht.

Moral Economies Alumni

With the last cohort reaching the finishing line and filing their dissertations at the end of September 2020, the Moral Economies graduate school can look back on eight successfully submitted dissertations.

The IMPRS MEMS has well prepared its doctoral students for careers in academia and beyond. Many have taken up positions as lecturers at German universities, others became teachers, or postdocs at research centers or other MPIs.

Figure 5. Berkeley Exchange 2020.

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Figure 6. IMPRS MEMS–Berkeley Workshop 2018.

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Table 1.	Academic Events at the IMPRS MEMS
Year	Topic
2017	Moral Economies Academic Writing Seminar (weekly sessions) (May–June 2017) Workshop Conflict Management for IMPRS Coordinators (19.06.–20.06.2017) (MPG professional development workshop) Retreat Schloss Blankensee IMPRS MEMS Workshop (05.07.–07.07.2017) Geschichte und Gesellschaft Special Issue Workshop "Moral Economies" (14.09.–15.09.2017)
2018	IMPRS MEMS–Berkeley Workshop "Moral Economy" (19.06.–20.06.2018) in cooperation with the working group "Der Kreis" (University of California, Berkeley) Retreat Schloss Blankensee IMPRS MEMS Workshop (04.07.–06.07.2018) Writing Sweatshop Workshop (04.12.–06.12.2018)
2019	Presentation and Communication Workshop (06.06.–07.06.2019) Retreat Schloss Blankensee IMPRS MEMS (03.07.–05.07.2019) Career Strategies Workshop (03.07.2019)

Table 2.	Students of the IMPRS MEMS	
Name	Funded by (enrolled at)	Project Title
Cohort I (2013–2017)		
Benger Alaluf, Yaara	MPIB (FU)	The Emotional Economy of British Seaside Holidaymaking 1870–1918
Bernet, Tobias	FU	Moral Economies of Urban Dwelling: Nonprofit Housing in Germany, Austria, and Switzerland (20th/21st Century)
de Groot, Timon	HU	Shame and the Search for Rehabilitation: Pardoning Practices in Germany, 1870–1933
Rohringer, Thomas	TU	Spaces and Emotional Styles: War Victims in the Interwar Period (1920s–1930s)
Schubenz, Marie	MPG (HU)	Contested Solidarity: Moral Economies in the Trade Union Movement of the 1970s and 1980s
Steininger, Fabian	MPG (FU)	Morality, Emotions and Political Community in the Late Ottoman Empire (1880–1905)
Cohort II (2014–2018)		
Blaß, Björn	FU	Environments of Disposal: Moralities, Practices, and Localities of Waste (1880–1930)
Danilina, Anna	MPG (TU)	Ethics of Essence: On the Emotional Production of "Aryan" Subjectivity in Völkisch Settlements, 1890–1925
Franke, Paul	HU	The Production of "Monaco" and "Las Vegas" as Sites of (Un)Moral Economies
Großmann, Till	MPG (FU)	Planned Love? Advice Communication on Marriage and Partnership in the GDR
İlengiz, Çiçek	MPIB (TU)	When History Goes Mad: Rewriting the History of State Violence in Dersim
Szedlacsek, Petru	TU	Political Workings of the Ideology of Remoteness: Imagining the Szeklerland as a Moral Site of Cultural Resistance in the 20th Century
Cohort III (2015–2019)		
Bähr (Menniken), Marvin	MPIB (FU)	Grassroots Veterans: The American Legion and Conservative Change in California, 1945–2000
Brandes, Sören	FU	The Market's People: Mass Media and the Making of Neoliberal Populism in the US and UK, 1940–1990
Lindner, Thomas	TU	Transnational Networks of Anti-Imperialism: Mexico in the Long 1920s
Cohort IV (2016–2020)		
Borrero, Anna	TU	Heroization Through Socialization: Soldiers, War, and the U.S. Military in American History Textbooks (1965–1999)
Lieth, Julia	MPIB (FU)	Love as a Life Project: The Pastor, Feeling, and Morality in Lutheran Pietism of the 19th Century
Oesterheld, Marius	MPG (FU)	Idleness, Industry, and Self-Fulfillment: The Ethics and Psychology of Work in Late Imperial and Early Republican China
Pösche, Helge	HU	Benefits or Basic Social Rights? German Court Disputes on the Morality of the Welfare State in the 20th Century
Rudeck (Eggers), Lena	FU	Between Pleasure and Immorality: Western Allies' Soldiers' Clubs in Germany as Sites of Encounters Between Occupiers and the Occupied in the 1940s and 1950s
Schlünz, Britt	HU	Pastoral Care as Political Counseling? Religion, Power, and Morality in Spain During the 19th Century
Schröer, Frederik	MPG (FU)	Religious Tradition—Secular Ethics? Transformations of Tibetan Buddhist Ethics in 20th-Century South Asia

International Max Planck Research School on Computational Methods in Psychiatry and Ageing Research (COMP2PSYCH)

The International Max Planck Research School (IMPRS) COMP2PSYCH serves as the graduate program of the Max Planck UCL Centre for Computational Psychiatry and Ageing Research (see pp. 177 ff.). In London, the students are based at University College London (UCL); in Berlin, they are based at the MPI for Human Development and at Humboldt-Universität zu Berlin (see Box 1).

COMP2PSYCH teaches and trains concepts and methods from computer science and statistics in relation to substantive research questions in psychiatry and lifespan psychology. It was established by the Max Planck UCL Centre for Computational Psychiatry and Ageing Research in early 2016 and gives predoctoral students the opportunity to learn, apply, and develop computational and statistical methods that foster our understanding of individual development from childhood to old age, with an emphasis on mental illness and healthy cognitive aging.

COMP2PSYCH combines and integrates training in computer science, applied mathematics and statistics, psychology, and psychiatry with the goal to enable the students to adapt and develop computational and statistical tools according to their data-analytic and scientific needs in the fields of psychiatry and lifespan psychology. Teaching fundamental concepts in cognitive science, lifespan psychology, and psychiatry in relation to computational and statistical theories and methods creates a superior degree of synergy between fields. In addition, the students benefit from the excellent research opportunities offered at both the Berlin and London sites.

Predoctoral students have been recruited yearly since 2016. Successful applicants have completed an M.A., or equivalent, in a discipline relevant to the school's program, for example, cognitive neuroscience, psychology, psychiatry, health science, or statistics. Eight COMP2PSYCH students are currently active in Berlin (see Table 1). Seven are working at the MPI for Human Development: three in the Lifespan Neural Dynamics Group (LNDG), two at the Center for Adaptive Rationality (ARC), and two at the Max Planck Research Group NeuroCode (Neural and Computational Basis of Learning, Memory and

Speakers

Ulman Lindenberger,
MPI for Human Development
Raymond J. Dolan,
University College London

Coordinators

Silke Schäfer,
MPI for Human Development
Susan Fischer,
University College London

Table 1. Berlin COMP2PSYCH Students' Affiliations and Dissertation Projects (as of 05/2020)

Manuel Arnold (Humboldt-Universität zu Berlin)	Detecting heterogeneity in psychological models
Simon Ciranka (ARC; see pp. 15 ff.)	Social influence in adolescent risky choice
Verena Clarmann von Clarenau (ARC; see pp. 15 ff.)	Psychophysical foundations of experienced-based decisions
Julian Q. Kosciessa (LNDG; see pp. 195 ff.)	Age differences in thalamo-cortical neural dynamics
Anika Löwe (MPRG NeuroCode; see pp. 227 ff.)	Investigating the computational role of hippocampal replay in planning and value computation
Liliana Polyanska (LNDG; see pp. 195 ff.)	The association between brain signal variability and the locus coeruleus–norepinephrine system across the lifespan
Alexander Skowron (LNDG; see pp. 195 ff.)	Neural computations supporting reinforcement learning under naturalistic conditions and their age-related changes
Lennart Wittkuhn (MPRG NeuroCode; see pp. 227 ff.)	Tracking hippocampal replay in humans using functional magnetic resonance imaging (fMRI)

Decision Making). In addition, one student is working at the Department of Psychology, Humboldt-Universität zu Berlin.

The 3-year training program involves seminars, workshops, participation in summer schools, and collaborative supervision of research training. The focus of the Berlin site is on computational and statistical advances in studying individual differences in development from childhood to old age. Methods include structural and functional neuroimaging, computational modeling, and statistical methods for the multivariate analysis of longitudinal changes in brain and behavior. Table 2 shows the seminars and workshops offered in Berlin during the reporting period. Designated workshops allow students to present their dissertation proposals and obtain collective faculty feedback. Two such workshops have taken place at the MPI for Human Development in November 2017 and in November 2019. COMP2PSYCH students also take part in the Max Planck UCL Centre's biannual Symposium and Advanced Course on Computational Psychiatry and Ageing Research, which was last held in September 2018 at Ringberg Castle.

Table 2. COMP2PSYCH Seminars and Workshops 2017–2019/20, Berlin

Semester	Topic	Instructor(s)
Winter 2017/18	Aspects of Theoretical Computer Science	Timo von Oertzen, Universität der Bundeswehr München & MPI for Human Development
	Reinforcement Learning Lectures at the Gatsby Computational Neuroscience Unit, London	Peter Latham & Marcus Stephenson-Jones, Sainsbury Wellcome Centre
	COMP2PSYCH Dissertation Workshop	Ulman Lindenberger, MPI for Human Development, Raymond J. Dolan, UCL, & COMP2PSYCH Faculty
Summer 2018	Rhythms of the Brain	Douglas D. Garrett, Nicolas W. Schuck, & Markus Werkle-Bergner, MPI for Human Development
	Foundations of Computer Science—Algorithms and Data Structures	Andreas Brandmaier, MPI for Human Development
Winter 2018/19	Structural Equation Modeling	Andreas M. Brandmaier, MPI for Human Development
Summer 2019	Sainsbury Workshop	Organizer: Raymond J. Dolan, UCL
	The Cortical Dynamics of Integrative Decision-Making	Peter Dayan, UCL
Winter 2019/20	Practical Seminar on Bayesian Statistics	Timo von Oertzen, Universität der Bundeswehr München & MPI for Human Development
	COMP2PSYCH Dissertation Workshop	Ulman Lindenberger, MPI for Human Development, Raymond J. Dolan, UCL, & COMP2PSYCH Faculty
	Symposium on Good Scientific Practice and Open Science "Doing Good—Scientific Practice under Review"	MPI for Cognitive and Brain Sciences, Leipzig
	A Reproducible Data Analysis Workflow with R Markdown, Git, Make, and Docker	Andreas M. Brandmaier, MPI for Human Development
	Presentation Training	Steven Weir, Freie Universität Berlin

Note. The Berlin students were able to participate in the reinforcement learning lectures at UCL via video-conferencing; some also attended the Sainsbury Workshop. Peter Dayan's talk was held at the MPI for Human Development. The Berlin students were also invited to participate in LIFE activities (see pp. 279 ff.).

COMP2PSYCH Students
Manuel Arnold, Humboldt–Universität zu Berlin
Rachel Bedder, University College London
Simon Ciranka, MPI for Human Development
Verena Clarmann von Clarenau, MPI for Human Development
Magda Dubois, University College London
Alexandra Hopkins, University College London
Julian Q. Kosciessa, MPI for Human Development
Yunzhe Liu, University College London
Alisa Loosen, University College London
Anika Löwe, MPI for Human Development
Jolanda Malamud, University College London
Matthew Nour, University College London
Liliana Polyanska, MPI for Human Development
Max Rollwage, University College London
Yuki Shimura, University College London
Alexander Skowron, MPI for Human Development
Lennart Wittkuhn, MPI for Human Development

COMP2PSYCH Alumni
Benjamin Chew, University College London
Samuel Ereira, University College London

COMP2PSYCH Faculty
Dominik Bach, University College London
Andreas M. Brandmaier, MPI for Human Development
Christian Doeller, MPI for Human Cognitive and Brain Sciences, Leipzig
Raymond J. Dolan, University College London
Stephen Fleming, University College London
Douglas D. Garrett, MPI for Human Development
Mona M. Garvert, MPI for Human Cognitive and Brain Sciences
Tobias Hauser, University College London
Hauke Heekeren, Freie Universität Berlin
Ralph Hertwig, MPI for Human Development
Quentin Huys, University College London
Ylva Köhncke, MPI for Human Development
Ulman Lindenberger, MPI for Human Development
Janaina Mourao-Miranda, University College London
Thorsten Pachur, MPI for Human Development
Robb Rutledge, University College London
Nicolas W. Schuck, MPI for Human Development
Bernhard Spitzer, MPI for Human Development
Wouter van den Bos, University of Amsterdam
Timo von Oertzen, Universität der Bundeswehr München & MPI for Human Development
Arno Villringer, MPI for Human Cognitive and Brain Sciences
Manuel C. Völkle, Humboldt–Universität zu Berlin

Box 1.

Figure 1. COMP2PSYCH students at the Max Planck UCL Centre Symposium and Advanced Course on Computational Psychiatry and Ageing Research 2018, Ringberg Castle.

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MaxNetAging Research School (concluded)

The Max Planck International Research Network on Aging (MaxNetAging) was founded in 2004 by the late Paul B. Baltes. The MaxNetAging Research School (MNARS) was launched by MaxNetAging in October 2007 (Director: James W. Vaupel) and ended in 2019. The program provided funding for doctoral and postdoctoral researchers. The MPI for Human Development was involved in this training program along with more than 20 Max Planck Institutes as well as many other international research institutions. The represented disciplines ranged from art history to cognitive neuroscience.

At the beginning of their term, the MNARS students and postdocs were located at the MPI for Demographic Research in Rostock for 6 months. During this time, they spent approximately 6 to 8 hours each week in a course program designed to introduce them to various aspects of aging research. The interdisciplinarity of the participants was a particular asset of the research school.

Thereafter, the PhD students and postdocs continued their PhD education and research projects at the Max Planck Institutes they were affiliated with. During this period, they were invited to multifaceted MaxNetAging workshops representing many disciplines and institutions. In June 2017, the MNARS Graduate Workshop took place at the MPI for Human Development in Berlin.

Table 1. MNARS Fellows at the MPI for Human Development (2007–2019)

Name	Dissertation Title	MPIB Supervisor(s)	Period	Center
Predoctoral Fellows				
Elisabeth S. Blanke	Recognizing others' thoughts and feelings: Empathic skills and their social implications in younger and older adults	Michaela Riediger	2012–2015	MPRG Affect
Hanna Bettine Fechner	Cognitive foundations of decision-making: Grounding behavioral and neural signatures of decisions within cognitive architecture	Lael Schooler	2012–2015	ABC
Christina Leuker	Risks, rewards, and rationality: How knowing that you probably won't hit the jackpot affects your judgments and decisions	Ralph Hertwig	2015–2018	ARC
Beate E. Mühlroth	Sleep-associated consolidation of episodic memories in old age: The challenge of studying cognitive and cerebral aging	Markus Werkle-Bergner & Ulman Lindenberger	2016–2019	LIP
Susanne Passow	Attentional control of auditory perception: Age-related differences and genetic modulation	Ulman Lindenberger	2007–2010	LIP
Julia K. Wolff	Social support and subjective health as within-person processes: Adult age differences in intraindividual variability and in associations between social support and physical and emotional well-being	Ulman Lindenberger & Florian Schmiedek	2008–2011	LIP
John Wong	The aging decision-maker: A systematic description of the fast and frugal heuristic adaptive toolbox in sequential decision-making paradigms	Lael Schooler & Jonathan Nelson	2011–2014	ABC
Veronika Zilker	Measuring and modeling the construction of preferences in decision-making under risk	Ralph Hertwig & Thorsten Pachur	2016–2019	ARC

Name	Project Title		Period	Center
Postdoctoral Fellows				
Anna Sofia Morais	How cognitive aging impacts decision-making in real-world environments		2012–2014	LIP
Job J. Schepens	The development of experience-based decision-making during conversations		2015–2016	ARC
Gian Marco Vidor	"This sweet flower cut down in its prime": Emotions in the 19th and 20th century Italian cemeteries. The case of children's graves		2010–2012	HoE

Services at the Institute

Library and Research Information Unit

The Library and Research Information is a central service unit for supporting research. It is responsible for the supply of analog and digital information resources to researchers, for whom it also provides numerous services such as information research, scientific publishing support, impact optimization, and impact analyses. In this way, the Library and Research Information offers custom-tailored information-based services for all stages of the research process.

In order to continuously adapt its service portfolio to constantly changing needs and requirements, which are due both to the digital transformation of research in general and to the changing research profile of the Institute, the team developed an ambitious strategic working program in 2019. This program will be implemented successively until 2023. It also takes into consideration the results of an extensive user survey which was conducted in close cooperation with the Berlin School of Library and Information Science at Humboldt-Universität zu Berlin in 2018.

In this survey, it became already clear that users were very interested in a more attractive library space suited both for undisturbed individual work and for collaborative scenarios. In order to obtain deeper insights into such space-related user needs, a design-thinking project was realized together with the School of Design Thinking of the Hasso Plattner Institute in Potsdam. Its results lead to the development of a new functional and spatial concept for the library which is to be realized as soon as possible.

An important service focus was and will be on research data management (cf. pp. 294 f.). An exemplary step in this direction was the complete relaunch of FACES, a platform providing face-based stimuli which can be used in many different research contexts. The responsibility for granting access to FACES was transferred to the Library and Research Information. The team was also very actively involved in the activities of the newly established research data management working group which is lead by the Head of the Library and Research Information. Also, the Institute hosted a workshop on the strategic development of research data management services for information professionals in November 2018.

The media collection includes printed and electronic media from all relevant research fields of the Institute. Collection development has also been adapted to changing research fields in order to take into account the establishment of new research areas and groups (Environmental Neuroscience, Humans and Machines, NeuroCode). The collection currently comprises about 230,000 volumes and printed journals as well as many thousands of electronic journals, newspapers, and numerous databases. Based on the results of a user survey from 2016, criteria—for example, a focus on online reference works such as handbooks or encyclopedias—for systematically expanding the local e-books collection were developed. External access to licensed resources for Institute members has again become easier due to a dedicated EZproxy add-on for the Chrome and Firefox browsers, which was developed in-house. This add-on helps users to very easily obtain access to licensed resources via the EZproxy service, introduced in 2015, from home or on travel on all kinds of devices by simply using a browser. In 2018, an internal weblog was launched which provides Institute members with infor-

Design concept for the library.

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Head
Ursula Flitner
(until 04/2017)
Sebastian Nix
(as of 10/2017)

Academic Librarian
Nicole Engelhardt
(interim Head
05–09/2017)

mation about new or recommended resources and library services and thus complements the extensive, but more static, intranet site. Also, with the relaunch of the Institute's website, new web pages on research data and Open Access were created. The team also organized training events about research-related copyright issues, bibliometric tools and methods for the humanities, and newly licensed tools such as SciFlow (a tool for collaborative scientific writing) or SAGE Research Methods (an online platform offering information about all kinds of research methods from a great variety of disciplines).

Other important projects during the reporting period were in relation with the Institute's publication output. Together with the relaunch of the website, thousands of bibliographic data sets pertaining to the Institute's publications were migrated from an internal database to MPG.PuRe, the Max Planck Society's publication repository. In this context, data from *Unpaywall,* an open database of millions of free scholarly publications, were used in order to automatically identify Open Access publications prior to 2010. Thus, these freely accessible publications are now visible via the new website. The newly established team "Open Access" (cf. p. 296 for more information about Open Access) also gained initial experiences with the secondary publication of originally not freely accessible scientific articles in Open Access. Furthermore, the team was and is actively involved in the relaunch of *Digital Libraries Connected* (DLC), an Open Access platform that helps researchers to manage digitized resources and to present these publicly in a way that meets scientific requirements. The relaunch of DLC, which now holds approximately 5,000 publicly available digitized objects, is centrally funded by the Max Planck Society. The aim of the relaunch is to modernize both the back- and front end of DLC by using completely new software components and thus to significantly enhance the user friendliness and the functional scope of the platform.

Research Data Management at the MPI for Human Development

Beside conceptual and methodological advancements, the foundation of scientific progress at the MPI for Human Development is based on the collection and analysis of empirical data. One particular challenge of managing research data at the Institute is the multidisciplinarity of research areas that requires handling highly diverse data from a range of study designs and instruments, including longitudinal studies of cognitive aging, human brain imaging studies, or online survey designs. Funding agencies, journals, and scientists themselves have lately dramatically increased the incentives for data sharing and comprehensive curation of digital objects (such as requirements to publish raw data or computer codes) and, thus, increased the need for a systematic management of research data. Research data management (RDM) purports to the way research data are managed throughout their entire life cycle, from study planning, to data collection, to their publication (either in manuscript form or as open data) and possibly their long-term preservation. In all phases of research, RDM implicitly is part of the "Rules of Good Scientific Practice" of the Max Planck Society.

This is why the Board of Directors established a RDM working group in July 2018 with the goal of developing a cross-departmental, sustainable RDM strategy for the MPI for Human Development. The working group members are recruited from different units across the Institute (IT, Library and Research Information, research management, scientific research) to realistically reflect the various requirements for RDM. In order to guarantee long-term availability of research data in-house, the working group has identified the urgent need for the development of an organizational and technical research data infrastructure as one primary goal. Further emphasis is placed on developing institute-wide strategies to support practices related to "Open Science" (cf. pp. 295 f.).

During the reporting period, the working group elaborated a comprehensive and detailed concept for a cross-departmental RDM infrastructure. This infrastructure will be realized

over the course of the next reporting period. The working group identified the need for the establishment of RDM as a central service unit at the Institute with a staff requirement of two new positions, which should be created particularly for this purpose. The group's concept includes the position of a research data coordinator who would be the main driver of strategic developments of RDM and the position of a technician who would support the coordinator and researchers in implementing new and adapting existing RDM infrastructure. The new unit would be responsible for centralizing and strategically developing ongoing RDM-related activities.

Such activities during the reporting period included the institutionalized provision of access to data sets from various research projects, for example, the Berlin Aging Studies (BASE & BASE-II), the COGITO Study (cf. p. 154), or the Day2day study (Filevich et al., 2017). Furthermore, in 2018, the FACES plat-form, which provides access to visual stimulus objects (faces of 171 women and men with different facial expressions), was relaunched in close cooperation with the Max Planck Digital Library, and supplementary stimuli were added. The platform is used worldwide at more than 180 research institutions in about 40 countries in various of disciplinary contexts ranging from developmental psychology to computer science.

As participant management and recruitment is an essential part in RDM of human sciences, the Institute plays an active role in the development of *Castellum* (see below). Moreover, within the research center Adaptive Rationality, a software tool was developed, which supports researchers in systematically collecting meta-information on studies and helps to more easily realize such studies, for example, by automatically installing codes for experimental studies on computer workplaces or by helping to apply for ethical approval.

Castellum

Castellum is a joint open source software development project centrally funded by the Max Planck Society on a 3-year perspective starting in February 2018. In coordination with stakeholders of three Max Planck institutes, the Max Planck Computing & Data Facility and the MPS Data Protection Officer, the project members aim at developing a participant database meeting the European General Data Protection Regulation (GDPR).

As a technological basis, it provides a strict separation of contact data, recruitment information, and scientific data. *Castellum* facilitates setting up global and study-specific access permissions to study and for participant data via assigned roles. Furthermore, it applies confidentiality levels for potential participants and their attributes (regular, elevated, high) in analogy to the Max Planck Society's protection levels. A pseudonym service for the allocation of study- or context-specific pseudonyms (central identity management) is another core feature.

Castellum is designed to support organizational processes according to the GDPR in various ways. It ensures that name-linked search for participants is only open to a limited number of people. It allows to fulfill user rights according to the GDPR (data withdrawal, information, and deletion). *Castellum* guarantees that the application of study-related selection criteria (inclusion/exclusion) precludes the viewing of personal data, whereas recruitment lists of potential participants do not provide recruiters with any insights into the selection criteria determined by the study. Centrally generated pseudonym lists for studies allow for automatically implemented deletion times (as defined at study inception).

Open Science at the MPI for Human Development

In the reporting period, there were significant activities at several levels in order to implement the fundamental principles of Open Science—transparency, reproducibility, reusability, open communication—in various ways and thus to increase transparency, openness, comprehensibility, and reusability of scientific workflows and results.

Open Science is not only about removing publishers' paywalls, but also about sharing materials and methods to foster scientific communication and accelerate innovation.

Scientists at the Institute increasingly use open platforms to share both materials (e.g., data or software) and methods over and above their scientific results. For

Key References

Arslan, R. C. (2019). How to automatically document data with the codebook package to facilitate data reuse. *Advances in Methods and Practices in Psychological Science, 2*(2), 169–187. https://doi.org/10.1177/2515245919838783

Brandmaier, A. M., Ghisletta, P., & von Oertzen, T. (2020). Optimal planned missing data design for linear latent growth curve models. *Behavior Research Methods.* Advance online publication. https://doi.org/10.3758/s13428-019-01325-y

Muehlroth, B. E., Sander, M. C., Fandakova, Y., Grandy, T. H., Rasch, B., Shing, Y. L., & Werkle-Bergner, M. (2019). Precise slow oscillation-spindle coupling promotes memory consolidation in younger and older adults. *Scientific Reports, 9,* Article 1940. https://doi.org/10.1038/s41598-018-36557-z

Peikert, A., & Brandmaier, A. M. (2019, November 11). A reproducible data analysis workflow with R Markdown, Git, Make, and Docker. *PsyArXiv.* https://doi.org/10.31234/osf.io/8xzqy

Schuck, N. W., & Niv, Y. (2019). Sequential replay of nonspatial task states in the human hippocampus. *Science, 364*(6447), Article eaaw5181. https://doi.org/10.1126/science.aaw5181

Włodarczyk, A., Elsner, C., Schmitterer, A., & Wertz, A. E. (2018). Every rose has its thorn: Infants' responses to pointed shapes in naturalistic contexts. *Evolution and Human Behavior, 39*(6), 583–593. https://doi.org/10.1016/j.evolhumbehav.2018.06.001

example, researchers use free platforms to share methods (e.g., Brandmaier et al., 2020; Muehlroth et al., 2019), preregister their hypotheses (e.g., https://osf.io/9bja6/), share data together with publications (e.g., Schuck & Niv, 2019; Włodarczyk et al., 2018), and also publish their research results as preprints or postprints. This trend is complemented by the development of general tools and best practices to support researchers in Open-Science-related activities, for example, tools to automatically document research data with the codebook package in R (Arslan, 2019) or best practices for reproducible research (Peikert & Brandmaier, 2019). A further example of substantial open research is the bilingual online portal *History of Emotions— Insights into Research.* Intended for historians, scholars from other fields, and nonspecialist laypersons alike, the platform features short essays that delve into one exemplary source to illustrate the manifold perspectives and methods that inform research on the history of emotions (cf. p. 66). Another contribution to Open Science is the Institute's active participation in the founding of a new, international Open Access Journal, *Quantitative and Computational Methods in Behavioral Sciences* (cf. https://qcmb.psychopen.eu/index.php/qcmb).

These activities at the level of the research units were accompanied and supported by house-wide offers. Throughout 2019, the

research data management working group (cf. pp. 294 f.) hosted six talks by external experts on various aspects of Open Science, including data sharing, software licensing, and issues related to data protection. In addition, the group regularly hosts an "Open Science Lunch" meeting offering a low-barrier opportunity for informal exchange on all topics related to Open Science. It also started the process of elaborating an Open Science policy for the Institute in order to openly communicate the Institute's attitude toward Open Science and to implement measures for achieving the institutionally desired level of "openness." To this end, various policy documents from research institutions in Germany and from abroad were analyzed, and these data were complemented with qualitative interviews with eight researchers from the Institute on their perspectives on Open Science. The resulting draft structure for an Open Science policy will be discussed with the Board of Directors and the scientific members of the Institute. Moreover, Open Access (OA) publication is encouraged and actively supported because it accelerates scientific innovation and improves the visibility of research output. In the reporting period, the share of OA journal articles in particular increased continuously, as the following chart illustrates (the OA publications published during the reporting period are also marked with a symbol in the publications lists of this report). A systematic workflow was developed and will be implemented over the course of the next reporting period, which will also contribute to making such scientific publications freely accessible that were not originally published in a genuine OA medium. Moreover, the Institute has implemented a streamlined process for handling OA charges, both for articles and books, that are not covered centrally by the Max Planck Digital Library. As part of the relaunch of the Institute's website, a separate information page on OA at the Institute was also set up. Finally, a project carried out by the Library and Research Information at the end of 2019 helped to identify and make visible, via the Institute's website, numerous OA versions of older Institute publications, that is, texts published before 2010 by using data from the *Unpaywall* service.

OA journal articles 2017–2019 (in %)

Year	Closed access	Open Access
2017	69,51	30,49
2018	62,39	37,61
2019	57,09	42,91
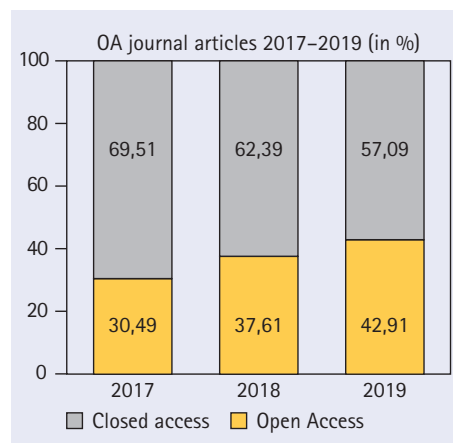
Evolution of the share of Open Access journal articles by MPIB authors between 2017 and 2019.

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Central IT Unit

The Central IT Unit supports the individual research centers and other service units at the Institute. This includes the central client and server infrastructure and the associated services, user support, and operation of the Institute's data center.

In 2018, the data center was completely overhauled to meet the current and anticipated research requirements. Three focal points (air conditioning, power supply, and heavy load/space) were completely redesigned. The result not only reflects the current state of the art but also provides the necessary redundancy, stability, monitoring, and sustainability of a modern data center and thus the foundation for the technical growth of the Institute and the associated research.

For various services, such as internet/intranet, printing, software, storage, and email, central servers with MS Windows and Linux operating systems are installed at the Institute. Several powerful servers build a Citrix server farm. They allow the users to run programs (MATLAB, SPSS, R, etc.) on the server CPUs from their own workstations (Windows, Linux, or Mac OS) or tablet computers from any location worldwide at any time. "Server-based computing" helps to overcome the different workstation constraints, such as CPU power and local storage.

More and more servers and desktops are being virtualized to implement a consolidation concept that will save resources and simplify deployment. Today we run more than 200 virtual systems on four physical systems. In the storage area network (SAN), more than 1 PByte storage capacity will be available from 2020. A central backup service is provided for all persistent data.

The decentralized computing capacity comprises more than 600 personal computers. Apple computers run with Mac OSX, and PCs with Microsoft Windows or a Linux distribution. For these heterogeneous desktop systems a wide range of software is available, which is distributed to a large extent automatically.

To provide the necessary security, a Check-Point firewall system is installed. The central anti-virus software Sophos—continuously updated via the internet—monitors all servers and personal workstations to avoid data loss caused by viruses and malware.

The integration of all desktop computers in the local area network (LAN) provides access to central resources and cluster capacity. Desktop systems are directly connected with a maximum speed of 1 Gbit/s, and between 10 and 100 Gbit/s are used in the network backbone. Since 2020, the Institute is redundantly connected to the internet.

A wireless LAN is available for users with mobile devices throughout the entire Institute.

Head
Sebastian Lau
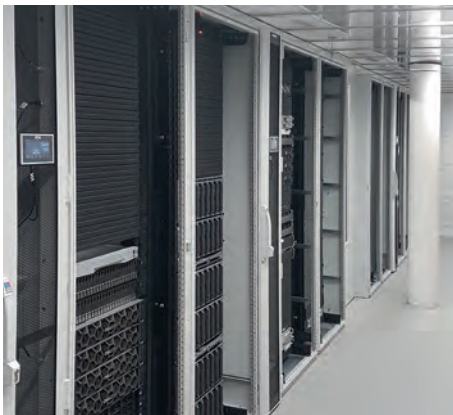
Server room.

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The IT Center's services include
- operation, optimization, and development of the following core areas:
  - central infrastructure (data center, server, network, etc.);
  - services (email, Citrix Terminal services, printing capacity, etc.);
  - clients (installation, license, patch management, etc.);
- data storage and backup strategies;
- preventive security measures;
- daily user support and troubleshooting;
- making national and international connections (wide area network) available;
- management of the central telephone system, including the voice-mail server.

The Magnetic Resonance Imaging Laboratory

Gerd Angermann
(Technician)
Sonali Beckmann
(Head of the MRI
Measurement
Facility)
Nils C. Bodammer
(Physicist)
Thomas Feg
(Technician)
Davide Santoro
(Physicist)
Sebastian Schröder
(Technician)
Nadine Taube
(Technical Assistant)

How do human brains differ structurally and functionally by age? How do people differ in the ways their brains change over time, and how are brain changes related to concomitant changes in behavior? What are the brain signatures of superior memory performance in old age? How plastic is the human brain, and how does plasticity unfold in the course of skill acquisition? Researchers at the MPI for Human Development are investigating these and many more questions using the Institute's magnetic resonance (MR) tomograph.

Magnetic resonance imaging (MRI) is a technique that obtains three-dimensional images of sections of the body by exploiting differences in the magnetic properties of various bodily tissues. Relevant differences may refer to levels of water and fat, the spatial density of cell membranes, or to iron content. MR imaging of the brain allows cognitive neuroscientists to obtain estimates of the brain's histological properties, metabolism, anatomical features, and functional activation.

Equipment
Currently, the Institute operates one Siemens TIM Trio tomograph with a field strength of 3 Tesla, which is exclusively used for research purposes. The MR system is equipped for proton (^{1}H) MR imaging and MR spectroscopy with 12-channel and 32-channel radio frequency head coils, and a circularly polarized birdcage headcoil. Instrumentation for phosphorus (^{31}P) MR imaging and spectroscopy, that is, a dual-tuned circularly polarized head coil, a dual-tuned surface coil, and an additional high-frequency amplifier working at the resonance frequency of phosphorus, is also available. Additional components include a transcranial magnetic stimulation (TMS) system with an MR-suited stimulation coil; an MR-suited EEG system; an audio/video stimulus presentation system using MR-compatible headphones and goggles; a visual presentation system based on video projection, mirrors, and a projection screen; ultra-slim MR-compatible active noise canceling headphones; an MR-compatible eye-tracking system; a physiological signal recording system suited also for skin resistance recordings; and a variety of hand-held response boxes for children and adults.
The laboratory also houses a mock scanner that looks and sounds just like the real one. It is used to familiarize research participants, in general, and children, in particular, with the scanning environment.

Structural Imaging
The tissue structures in the brain vary widely regarding their different histological properties. Therefore, they possess different magnetic properties when embedded in a strong external magnetic field. That means that, directly after electromagnetic waves are transmitted by a radio-frequency (RF) coil to excite the spins of the water protons, different tissues emit electromagnetic signals of varying amplitudes in the RF range. These emitted MR signals come from the protons, which are part of the water molecules, making up about 80% of the human brain. The MR tomograph can record these RF signals and convert them into anatomical images of the brain. This is called structural imaging.
Repeated acquisition of structural image data over longer periods of time permits researchers to identify even small local alterations in brain anatomy.

Functional Imaging
Beyond structural imaging, it is also possible to watch the brain "at work." When a certain brain region is active, it uses up oxygen. Blood coming from the lungs transports new oxygen to the active region. As oxygen-rich blood has other magnetic properties than oxygen-depleted blood, differences in the respective brain regions emerge depending on whether they are active or not. This means that brain activity during cognitive tasks can also be detected by the MR scanner. This is called functional brain imaging.
The *Brain Imaging Methods* project at the Center for Lifespan Psychology has tested and implemented some more advanced imaging techniques (cf. pp. 149 ff.).

Appendix

List of Abbreviations

ARC	Center for Adaptive Rationality
HoE	Center for the History of Emotions
CHM	Center for Humans and Machines
LIP	Center for Lifespan Psychology
Harding Center	Harding Center for Risk Literacy
Max Planck UCL Centre	Max Planck UCL Centre for Computational Psychiatry and Ageing Research
LMG EnvNeuro	Lise Meitner Group for Environmental Neuroscience
LNDG	Emmy Noether Group: Lifespan Neural Dynamics Group
MPRG iSearch	Max Planck Research Group iSearch—Information Search, Ecological and Active Learning Research with Children
MPRG Naturalistic	Max Planck Research Group Naturalistic Social Cognition
MPRG NeuroCode	Max Planck Research Group Neural and Computational Basis of Learning, Decision Making and Memory
MPRG REaD	Max Planck Research Group Reading Education and Development (REaD)
LIFE	International Max Planck Research School on the Life Course
MEMS	International Max Planck Research School for Moral Economies of Modern Societies
COMP2PSYCH	International Max Planck Research School on Computational Methods in Psychiatry and Ageing Research
MNARS	MaxNetAging Research School

Last update: April 2020

1. Honors and Awards 2017–2019/20

Arslan, Ruben C.   DPPD dissertation prize (Differential and Personality Psychology and Diagnostics Section of the German Psychological Society), German Psychological Society, 2019.

Artinger, Florian   Joachim Jungius Prize 2016, Joachim Jungius-Stiftung der Wissenschaft zu Hamburg, 2017.

Baumert, Jürgen   Special prize for his lifetime achievement, Society for Empirical Educational Research, 2019.

Brauer, Juliane   Wuppertaler Lehrlöwe 2018 (Teaching Award), University of Wuppertal, 2018.

Brod, Garvin   Otto Hahn Medal 2016, Max Planck Society, 2017.

Cebrian, Manuel   Nature Magazine's *The scientific events that shaped the decade* featuring Machine Behavior paper, Springer Nature, 2019; BeeMe Experiment Documentary selected for the 2020 Miami International Science Fiction Film Festival; *Cooperating with machines*—3rd most read article in the Physics category of Nature Communications, Springer Nature, 2018.

Cebrian, Manuel / Rahwan, Iyad   Project DeepAngel exhibited at Ars Electronica, 2019.

Dallacker, Mattea   Otto Hahn Medal 2017, Max Planck Society, 2018; Distinguished Student Award, Society of Behavioral Medicine, 2017; Meritorious Student Abstract Winner, Annual Meeting of the Society of Behavioral Medicine, San Diego, 2017.

Driver, Charles C.   Gustav A. Lienert Prize for dissertations, German Psychological Society, 2019.

El Zein, Marwa   Marie Skłodowska-Curie Individual Fellowship 2021–2023, European Commission, 2020.

Frevert, Ute   Honorary Doctorate, University of Tampere, Finland, 2018.

Freytag, Julia / Stroben, Fabian / **Kämmer, Juliane E.** / Hautz, Wolf E. / Eisenmann, Dorothea   RIME Award 2017: Best Research Protocol, German Association for Medical Education, 2017.

Garrett, Douglas D.   Poster Award, Alpine Brain Imaging Meeting, Champéry, Switzerland, 2019.

Gerlach, Philipp   Best Student Presentation Award, 16th International Conference on Social Dilemmas, Hong Kong, 2017.

Gigerenzer, Gerd   Allais Memorial Prize for Behavioral Sciences, Prague Conference on Behavioral Sciences & Fondation Maurice Allais, 2019; Appointment to the Scientific Council, European Research Council, 2019; Author's colloquium: Exploring future directions of Gerd Gigerenzer's scholarly contributions, Center for Interdisciplinary Research (ZiF), Bielefeld, 2017.

Keller, Niklas / Feufel, Markus A. / Kendel, Friederike / Spies, Claudia **/ Gigerenzer, Gerd**   Henry Walton Prize, Journal Medical Education, 2018.

Hertwig, Ralph   Fellow, Max Planck School of Cognition, 2019; Gottfried Wilhelm Leibniz Prize 2017, German Research Foundation, 2017.

Hertwig, Ralph / Hilbrand, Sonja / Coall, David A. / Gerstorf, Denis   January 2017 Elsevier Atlas Award 2017, Elsevier, 2017.

Hertwig, Ralph / Pachur, Thorsten   Announcement to the Cluster of Excellence "Science of Intelligence (SCIoI)," a joint Cluster of Excellence with the Technische Universität Berlin and Humboldt-Universität zu Berlin, German Research Council, 2018.

Hitzer, Bettina   Leipzig Book Fair Prize 2020 for the Best Non-fiction Book *Krebs fühlen: Eine Emotionsgeschichte des 20. Jahrhunderts (Feeling cancer: A 20th-century history of emotions),* Leipzig Book Fair, 2020.

Laukötter, Anja   Otto-Hintze-Prize 2019, Michael-und-Claudia-Borgolte-Stiftung, 2019.

Leuker, Christina   DeFinetti Award, European Association for Decision Making (EADM), 2019.

Lewandowsky, Stephan   Humboldt Research Award for research collaboration with the Center for Adaptive Rationality, Alexander von Humboldt Foundation, 2020.

Lindenberger, Ulman   Fellow, Max Planck School of Cognition, 2019; Appointment to the Nominations Committee for the Gottfried Wilhelm Leibniz Program 2017–2022, German Research Foundation (DFG), 2017.

Månsson, Kristoffer N. T.   Best Oral Presentation, Alpine Brain Imaging Meeting, Champéry, Switzerland, 2020.

Mayer, Karl Ulrich   John Bynner Award 2019, Society for Longitudinal and Life Course Studies, 2019; Honorary Doctorate, European University Institute, Florence, 2019.

Loizeau, Andrea / Theill, Nathan / Cohen, Simon M. / Eicher, Stefanie / Mitchell, Susan L. / Meier, Silvio / **McDowell, Michelle** / Martin, Mike / Riese, Florian   Vontobel Award for Research on Age(ing) 2018, Center for Gerontology of the University of Zurich & Vontobel Foundation, 2018.

Mather, Mara   Max Planck Sabbatical Award for research collaboration with the Center for Lifespan Psychology, Max Planck Society, 2018.

Moussaïd, Mehdi   Jane Beattie Scientific Recognition Award 2017, European Association for Decision Making, (EADM), 2017.

Mühlroth, Beate E.   "GNP-Prize" 2019 for Cognitive and Clinical Neuropsychology, German Society for Neuropsychology (GNP), 2019; Award for early career scientists, German Sleep Society (DGSM), 2018.

Mühlroth, Beate E. / Sander, Myriam C. / Fandakova, Yana / Grandy, Thomas H. / Rasch, Björn / **Shing, Yee Lee / Werkle-Bergner, Markus**   Best Poster Award, Salzburg Mind-Brain Annual Meeting, 2017.

Obradovich, Nick   Outstanding Reviewer for Environmental Research Letters, IOP Publishing, 2017.

Obradovich, Nick / Migliorini, Robyn / Paulus, Martin P. / **Rahwan, Iyad**   Best Environmental Epidemiology Paper (BEEP) 2018, International Society for Environmental Epidemiology (ISEE), 2019.

Pachur, Thorsten   Fellow, Association for Psychological Science (APS), APS, 2018.

Prestel, Joseph Ben   Best Book in Non-North American History Award, 2017–18, Urban History Association, 2019.

Raffington, Laurel   Otto Hahn Medal 2018, Max Planck Society, 2019.

Rahwan, Iyad   Best Poster Award, International Conference on Computational Social Science (IC2S2), 2018; Best Video, International Joint Conference on Artificial Intelligence (IJCAI), demo track, 2018.

Rajamani, Imke   Friedrich Meinecke Prize 2017, Freie Universität Berlin, 2017; Otto Hahn Medal 2016, Max Planck Society, 2017.

Schuck, Nicolas W.   ERC Starting Grant, European Research Council, 2019.

Schulze, Christin   Member Select-Speaker Award, 58th Annual Meeting of the Psychonomic Society, Vancouver, Canada, 2017.

Sommer, Verena R.   Poster Award, International Aging & Cognition Conference of the European Cognitive Aging Society (EUCAS), 2017.

Tucker-Drob, Elliot   Max Planck Humboldt Medal 2019 for research collaboration with the Center for Lifespan Psychology, Max Planck Society & Alexander von Humboldt Foundation, 2019.

Turner, Tamara   Elsevier Oustanding Thesis Prize, Elsevier, 2017.

van den Bos, Wouter   ERC Starting Grant, European Research Council, 2018.

Wagner, Gert G.   The Order of Merit of the Federal Republic of Germany 1st class, 2018; Senior Fellow, Max Planck Society, 2018; FAZ Economist Ranking, Frankfurter Allgemeine Zeitung, 2017/2018/2019; Honorary Doctorate, University of Cologne, 2017.

Werkle-Bergner, Markus   Jacobs Foundation Research Fellowship 2017–2019.

Wittkuhn, Lennart   ReproNim/INCF Training Fellowship Program 2020–2021, ReproNim & International Neuroinformatics Coordinating Facility (INCF).

Grants and Stipends

Abdel Rahman, Rasha / Ammon, Sabine / Brock, Oliver / Hafner, Verena / Haynes, John-Dylan / Hellwich, Olaf / **Hertwig, Ralph** / Krause, Jens / Kyselo, Miriam / Lazarides, Rebecca / Lewejohann, Lars / Maertens, Marianne / Obermayer, Klaus / **Pachur, Thorsten** / Pauen, Michael / Raisch, Jörg / Rolfs, Martin / Romanczuk, Pawel / Schulz-Schaeffer, Ingo / Sprekeler, Henning / Thöne-Reineke, Christa   Funding for the Cluster of Excellence "Science of Intelligence" (EXC 2002), a cooperation between Technische Universität Berlin, Humboldt-Universität zu Berlin, Charité Universitätsmedizin Berlin, Freie Universität Berlin, MPI for Human Development, and Universität Potsdam, German Research Foundation, 01/2019–12/2025.

Bahrami, Bahador   European Research Council Consolidator Grant for Project "Improving collective decisions by eliminating overconfidence: Mental, neural and social processes," Ludwig-Maximilians-Universität München, 09/2019–09/2024; Humboldt Senior Research Fellowship, Alexander von Humboldt Foundation, 10/2018–09/2019.

Bonah, Christian / **Laukötter, Anja** (Co-Director)   ERC Advanced Grant, "The healthy self as body capital. Individuals, market-based societies, body politics and visual media in twentieth century Europe," European Research Council, 10/2016–09/2021.

Brauer, Juliane / Röger, Maren / Stach, Sabine   Funding for Hermann Weber Conference on Historical Communism Research in cooperation with University of Augsburg & German Historical Institute Warsaw, Foundation for the Reappraisal of the SED Dictatorship, 12/2019.

Buchberger, Elisa S.   Expose-Stipend, Studienstiftung des Deutschen Volkes, 12/2019–05/2020.

Dahl, Martin J.   Stipend, Sonnenfeld Foundation, 01/2018–11/2018.

Deserno, Marie K.   Rubicon Fellowship, The Netherlands Organization for Scientific Research, 12/2019–07/2021.

Düzel, Sandra   Boost!-Programme, Max Planck Society, 11/2019–03/2022.

El Zein, Marwa   Sir Henry Wellcome Postdoctoral Fellowship, "An adaptive role of collective decisions: Shared responsibility in the human brain," University College London, 01/2017–04/2021.

Fandakova, Yana   Funding for Project "Plasticity of task switching in childhood: Mechanisms and sequential progression," German Research Foundation, 10/2018–09/2021.

Fandakova, Yana / Bunge, Silvia A.   Funding for Project "How do students learn new concepts? Identifying factors that promote students' understanding of physical science concepts," Jacobs Foundation, 06/2019–05/2021.

Fecher, Benedikt / Hornbostel, Stefan / Sokolovska, Nataliia / **Wagner, Gert G.**   Funding for Project "Indikatorik, Messung und Performanz der Qualitätssicherung: Third-Mission-Tätigkeiten in den Gesellschaftswissenschaften (IMPaQT), BMBF-Programm "Qualitätsentwicklungen in der Wissenschaft," Federal Ministry of Education and Research, 07/2019–06/2022.

Garrett, Douglas D.   Emmy Noether Programme, "Toward a structural and functional basis for changes in brain signal variability with age," German Research Foundation, 01/2017–12/2021.

Garrett, Douglas D. / Westlye, Lars   DAAD–Norway Research Foundation Collaborative Grant, "Clinical utility and genetics of neuronal intra-individual variability in severe mental illness: A Norwegian-German collaboration," German Academic Exchange Service, 01/2016–12/2021.

Gigerenzer, Gerd   Funding of the Harding Center, Winton Capital Management & Claudia and David Harding Foundation, 01/2007–12/2019; the Center will be continuously funded at the University of Potsdam from 2020–2024.

Gigerenzer, Gerd / Jenny, Mirjam A.   Funding for Project "Förderung der Gesundheitskompetenz," Helsana Health Insurance, 03/2016–03/2017.

Gigerenzer, Gerd / Rebitschek, Felix G. / Jenny, Mirjam A. Funding for Project "Webbasierter, evidenzbasierter Risikoatlas—Werkzeuge zur nachhaltigen Stärkung der Risikokompetenz (WebPRA)," Federal Ministry of Justice and Consumer Protection (BMJV), 07/2016–12/2019.

Grüneisen, Sebastian Marie Skłodowska-Curie Individual Global Fellowship, "The Psychological Origins of Trust-Based Cooperation (ORIGINSOFTRUST), in cooperation with University of Michigan, European Commission, 04/2018–03/2021.

Gumenik, Ksenija Stipend, Ernst Ludwig Ehrlich Studienwerk (ELES), 10/2019–09/2021.

Haux, Lou M. Stipend, Studienstiftung des Deutschen Volkes, 01/2019–01/2021.

Hechtlinger, Shahar Research Grants—Doctoral Programs in Germany, German Academic Exchange Service, 10/2019–09/2020.

Hertwig, Ralph External cooperation partner of the Cluster of Excellence "Centre for the Advanced Study of Collective Behaviour" (EXC 2117), a cooperation between University of Konstanz and Max Planck Institute of Animal Behavior, German Research Foundation, 01/2019–12/2025; Gottfried Wilhelm Leibniz Prize 2017, German Research Foundation, 01/2018–12/2024; Funding for Summer Institute for Bounded Rationality 2017–2019 and 2020–2022, Joachim Herz Foundation.

Hertwig, Ralph / Lewandowsky, Stephan / Eliassi-Rad, Tina / **Herzog, Stefan M.** / Rashid, Awais Planning Grant "Controlling the Jekyll and Hyde of artificial-intelligence assisted information architectures: Accepting customization while resisting micro-targeted manipulation," Volkswagen Foundation, 03/2019–05/2020.

Hertwig, Ralph / Pachur, Thorsten Funding for Project "How efficient are choice heuristics under varying degrees of uncertainty?" as part of the DFG Priority Program "New frameworks of rationality," German Research Foundation, 04/2015–03/2018.

Hertwig, Ralph / Wagner, Gert G. Funding for Project "Origins and determinants of malleable risk preferences", Max Planck Society, 04/2017–04/2022.

Hidalgo, César A. / **Rahwan, Iyad** Funding for Project "Knowledge production networks," The Center of Complex Engineering Systems (CCES) & King Abdulaziz City for Science & Technology (KACST), 01/2015–12/2017.

Jenny, Mirjam A. Funding for Project "Communicating the risk of sudden unexpected death in epilepsy," University Hospital Frankfurt, 06/2018–12/2019; Funding for Project "Effective risk communication in health care II and III," Helsana Health Insurance, 02/2018–12/2019; Membership in the Young Leaders in Science program, Ernst Schering Foundation, 05/2016–04/2017.

Jenny, Mirjam A. / Ellermann, Christin / McDowell, Michelle Funding for Project "VisRisk," Federal Institute for Risk Assessment, 08/2017–12/2019.

Jenny, Mirjam A. / Gigerenzer, Gerd Funding for Project "Risk barometer," Ergo Insurance, 10/2017–12/2019.

Jenny, Mirjam A. / Prinz, Roman Funding for Project "Science to goal," Deutscher Fußball-Bund, 12/2017–03/2018.

Jenny, Mirjam A. / Rebitschek, Felix / Lein, Ines Funding for Project "Comprehending drone risks," Federal Ministry of Transport and Digital Infrastructure, 10/2018–06/2019.

Kämmer, Juliane E. Marie Skłodowska-Curie Individual Fellowship, "TeamUp: Understanding and improving team decision-making in uncertain environments", in cooperation with University of Bern, European Commission, 04/2020–03/2022.

Kühn, Simone ERC Starting Grant, "Take control! Towards novel training regimes enhancing inhibition and impulse control in health and psychiatric disease," European Research Council, 08/2016–08/2021; Funding for Project "The Baltic game industry—Empowering a booster for regional development; Interreg Baltic Sea Region, European Union, 08/2017–09/2020; Heisenberg Professorship at University Medical Center Hamburg-Eppendorf, German Research Foundation, 02/2017–06/2019; Funding for Project "Neuroplasticity in HERA—Structural and functional changes in hippocampal plasticity after isolation and its behavioral significance for long duration space exploration missions," in cooperation with Charité Universitätsmedizin Berlin (Coordinator: Alex Stahn); German Aerospace Center (DLR), 07/2016–06/2019; Funding for Project "Metrology for modern hearing assessment and protecting public health from emerging noise sources (EMPIR)," in cooperation amongst others UCL Ear Institute, Carl von Ossietzky Universität Oldenburg (Coordinator: Christian Koch, Physikalisch-Technische Bundesanstalt), EU Horizon 2020, European Commission, 05/2016–05/2019; Jacobs Foundation Research Fellowship, Jacobs Foundation, 07/2016–07/2018.

Kurvers, Ralf H. J. M. DFG Fellowship, "The role of individual differences in collective behaviour," in cooperation with Leibniz-Institute of Freshwater Ecology and Inland Fisheries, German Research Foundation, 07/2016–10/2020.

Kurvers, Ralf H. J. M. / Trianni, Vito (ISTC-CNR) "CROME: Harnessing the wisdom of crowds in medical diagnostics", Nesta Collective Intelligence Grant, 04/2020–04/2021.

Lindenberger, Ulman 6th Annual Flux Congress 2018 in Berlin, German Research Foundation; Funding for Project "Probing and enhancing plasticity of auditory cortex in human adults: Investigating functional and structural changes following pitch discrimination training," Strategic Innovation Fund of the Max Planck Society, 04/2016–09/2018.

Lindenberger, Ulman / Dolan, Raymond J. Max Planck UCL Centre for Computational Psychiatry and Ageing Research in cooperation with University College London & Humboldt-Universität zu Berlin, Max Planck Society, 04/2014–03/2024.

Lindenberger, Ulman / Düzel, Emrah / Sendtner, Michael / Kreutz, Michael Collaborative Research Project "Energizing the hippocampus in aging individuals (EnergI)," in cooperation with the German Center for Neurodegenerative Diseases (DZNE), Universitätsklinikum Würzburg, & Leibniz Institute for Neurobiology, Federal Ministry of Education and Research (BMBF), 07/2015–06/2020.

Lindenberger, Ulman / Kühn, Simone / Brandmaier, Andreas M.   Funding for LIFEBRAIN Consortium Project "Healthy minds 0–100 years: Optimising the use of European brain imaging cohorts ("Lifebrain")," EU Horizon 2020, European Commission, 01/2017–12/2022.

Lindenberger, Ulman / Werkle-Bergner, Markus   Bremer Initiative to Foster Early Childhood Development (BRISE), Federal Ministry of Education and Research, 12/2016–11/2019.

Meder, Björn / Nelson, Jonathan D. / Martignon, Laura / Crupi, Vincenzo / Tentori, Katya   Funding for Project "Models of information search: A theoretical and empirical synthesis II," as part of the DFG Priority Program "New frameworks on rationality," German Research Foundation, 12/2014–08/2018.

Moneta, Nir   PhD Fellowship, Einstein Center for Neurosciences Berlin, 10/2019–09/2022.

Mousavi, Shabnam / Gigerenzer, Gerd / Sunder, Shyam   Think Forward Initiative Long-Term Research Grant, ING Bank, 05/2019–12/2020.

Oberländer, Alexandra / Bruisch, Katja   Funding for Conference "Vse idet po planu—Unwrapping the (Un)planned Soviet Economy" in cooperation with German Historical Institute Moscow, Fritz Thyssen Foundation, 05/2019.

Pachur, Thorsten / Scheibehenne, Benjamin   Funding for Project "Parameter intercorrelations in cognitive models—Prevalence, causes, and solutions," Swiss National Foundation, 06/2017–11/2019.

Pahl, Kerstin Maria   Boost!-Programme, Max Planck Society, 11/2019–04/2021.

Prinz, Roman / Gigerenzer Gerd   Funding for Project "VISUAL—Systematische Verwertung wirtschaftswissenschaftlicher Evidenz durch Visualisierung und Problemlösung," in cooperation with Fraunhofer Center for International Management and Knowledge Economy, German Aerospace Center (DLR), 04/2016–03/2018.

Raffington, Laurel   Graduate Fellowship, Berlin School of Mind and Brain & Humboldt-Universität zu Berlin, 10/2013–01/2018.

Rahwan, Iyad   Funding for Project "Transcription of the dictionary of occupational titles," MIT Task Force on Work of the Future, 03/2019–06/2020; Funding for Project "Engineering human-compatible automated moral reasoning," MIT-IBM Watson AI Lab, 01/2018–12/2019; Funding for Project "Kinetic autonomy & turing box," Ethics & Governance of Artificial Intelligence Fund by MIT Media Lab & Harvard Berkman-Klein Center for Internet and Society, 01/2018–12/2019; Funding for Project "The skillscape (part 2)," Siegel Family Endowment, 01/2018–12/2019; Funding for Project "The charity machine," Gift from Charles Bresler, 01/2017–12/2019; Funding for Project "Society in the loop," Ethics & Governance of Artificial Intelligence Fund by MIT Media Lab & Harvard Berkman-Klein Center for Internet and Society, 01/2017–12/2019; Funding for Project "Hybrid forecasting competitions," consortium with Harvard University, Northeastern University, University of Houston, Texas, The Intelligence Advanced Research Projects Activity (IARPA), 01/2017–12/2018; Funding for Project "Saudi skill space," The Center of Complex Engineering Systems (CCES) & King Abdulaziz City for Science & Technology (KACST), 01/2017–12/2018; Funding for Project "The skillscape," Siegel Family Endowment, 01/2017–12/2018.

Rahwan, Iyad / Frank, Morgan R.   Funding for Workshop "Innovation, cities, and the future of work," National Science Foundation, 11/2017.

Rioux, Camille   Postdoctoral Fellowship, Alexander von Humboldt Foundation, 02/2018–01/2020.

Ruggeri, Azzurra   Funding for Project "Center for Active Learning in Museums (CALM)," Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science, 01/2020–12/2020.

Ruggeri, Azzurra / Raab, Markus   Funding for Project "Kletternd zum Selbst: Eine Embodied Cognition Perspektive der Entwicklung zum Zusammenhang zwischen dem Minimalen Selbst und sensomotorischen sowie kognitiven Fertigkeiten," German Research Foundation, 01/2019–12/2021.

Rust, Henning / Ulbrich, Uwe **/ Hertwig, Ralph / Fleischhut, Nadine** / Kox, Thomas / Gerhold, Lars / Schiller, Jochen / Voss, Martin / Raupp, Juliana   Funding for Project "WEXICOM—Weather warnings: from EXtreme event Information to COMunication and action," in cooperation with Freie Universität Berlin, Hans Ertle Center for Weather Research, Germany, funded by Deutscher Wetterdienst (DWD), 01/2019–12/2022.

Sander, Myriam C. / Werkle-Bergner, Markus   Funding for Project "Adult age-differences in auditory selective attention: The interplay of norepinephrine and rhythmic neural activity," German Research Foundation, 01/2018–12/2019.

Schnädelbach, Sandra   Teaching Stipend, bologna.lab by Humboldt-Universität zu Berlin, 10/2018–02/2019.

Schroeder, Sascha   Funding for Project "Transfereffekte musikalischer Frühförderung auf Kognition und Leseentwicklung (MusiCo)," Rat für Kulturelle Bildung, 01/2014–12/2017.

Schroeder, Sascha / Grainger, Jonathan   Funding for Project "The role of morphemes during reading development," German Research Foundation & ANR—The French National Research Agency, 03/2016–09/2020.

Schroeder, Sascha / Richter, Dirk / Böhme, Katrin   Funding for Project "Effects of reading instruction on cognitive processing (ERIC)," Federal Ministry for Education and Research (BMBF), 07/2015–06/2017.

Schuck, Nicolas W.   ERC Starting Grant, "The function of hippocampal and cortical memory replay in humans," European Research Council, 04/2020-03/2025.

Schulte-Mecklenbeck, Michael / DeBellis, Emanuel / Stöckli, Sabrina / Baumann, Daniel **/ Hertwig, Ralph**   Funding for Project "Der Einfluss energieeffizienter Strassenbeleuchtung auf die Fahrgeschwindigkeit," Bundesamt für Strassen ASTRA (Switzerland), 01/2019–12/2020.

Schulze, Christin   Boost!-Programme, Max Planck Society, 11/2019–10/2025.

Stille, Max / Gerharz, Eva   Funding for Project "(Un)typical utopias: Imaginations of the future by youths in Islamic educational institutions in Bangladesh and Great Britain," Gerda Henkel Foundation, 11/2018–08/2020.

Professorship Offers

(labeled in accordance with American system)

Artinger, Florian   Full Professor of Digital Business, Berlin International University of Applied Sciences, Germany, 2019 (accepted).

Brehmer, Yvonne   Full Professor of Developmental Psychology, Tilburg University, Netherlands, 2018 (accepted).

Brod, Garvin   Assistant Professor of Psychology (Individualized Learning), Goethe University Frankfurt am Main, Germany, 2017 (accepted).

Dai, Junyi   Assistant Professor of Psychology, Zhejiang University, Hangzhou, China, 2017 (accepted).

Gammerl, Benno   Full Professor of History, European University Institute, Fiesole, Italy, 2020/21 (accepted).

Gerlach, Philipp   Full Professor of Experimental and Social Psychology, Hochschule Fresenius, Hamburg, Germany, 2019 (accepted).

Jensen, Uffa   Full Professor of History, Technische Universität Berlin, Germany, 2017 (accepted).

Karch, Julian D.   Assistant Professor of Methods and Statistics, Leiden University, Netherlands, 2017 (accepted).

Luan, Shenghua   Associate Professor of Psychology, Tsinghua University, Beijing, China, 2017 (accepted); Full Professor of Psychology, Chinese Academy of Sciences, Beijing, China, 2017 (accepted).

Markant, Douglas   Assistant Professor of Psychological Science, The University of North Carolina at Charlotte, USA, 2017 (accepted).

Pleskac, Timothy J.   Full Professor of Psychology, The University of Kansas, Lawrence, USA, 2018 (accepted).

Ruggeri, Azzurra   Associate Professor of Cognitive and Developmental Psychology, Technical University of Munich, Germany, 2017 (accepted).

Schulze, Christin   Adjunct Associate Professor of Psychology, The Arctic University of Norway, Tromsø, Norway, 2019 (accepted).

Schroeder, Sascha   Full Professor of Educational Psychology, University of Göttingen, Germany, 2018 (accepted).

Shing, Yee Lee   Full Professor of Developmental Psychology, Goethe University Frankfurt am Main, Germany, 2017 (accepted).

Takao, Makoto Harris   Assistant Professor of Musicology, University of Illinois at Urbana–Champaign, USA, 2019 (accepted).

van den Bos, Wouter   Assistant Professor of Psychology, University of Amsterdam, Netherlands, 2017 (accepted); Associate Professor of Developmental Psychology, University of Amsterdam, Netherlands, 2018 (accepted).

2. Research Colloquia 2017–2019/20

Ablin, Richard
University of Arizona College of Medicine, Tucson, USA
PSA: People seeking answers
03.07.2017

Agelink van Rentergem, Joost
University of Amsterdam, Netherlands
Decisions from experience: A summary of clinical neuropsychology and developmental decision-making research, and a vision for the future
03.08.2017

Allefeld, Carsten
University of London, UK
Population inference for multivariate pattern analysis
07.05.2019

Allen, Jennifer
Yale University, New Haven, USA
Archives of salvation: The fight to save humanity in Cold War Germany
18.06.2019

Bahador, Bahrami
University College London, UK
Uncertainty in social deliberation: Persuasion and consensus
16.08.2018

Bang, Dan
University College London, UK
Neural and computational mechanisms of decision confidence
20.06.2017

Becker, Tobias
German Historical Institute London, UK
Historicising nostalgia
12.02.2019

Bender, Andrew R.
Michigan State University, East Lansing, USA
Retest learning and practice effects in neuro-cognitive aging
05.09.2019

Benninghaus, Christina
Justus Liebig University Giessen, Germany
The virtue of silence: Coping with infertility in 19th and early 20th century Germany
09.01.2018

Betts, Matthew
Otto von Guericke University Magdeburg, Germany
In vivo MRI assessment of the human locus coeruleus using neuromelanin-sensitive MRI
10.02.2017

Bhatia, Sudeep
University of Pennsylvania, Philadelphia, USA
Knowledge representation in decision-making
07.03.2019

Bhui, Rahul
Harvard University, Cambridge, USA
Context-sensitive judgement reflects efficient neural coding
14.03.2019

Biess, Frank
University of California, San Diego, USA
German Angst: Fear and democracy in Postwar Germany
10.12.2019

Blanchard, Matthew
The University of Sydney, Australia
The relationship between metacognition and error rates for collective behavioral decisions
01.08.2019

Bohlman, Andrea
The University of North Carolina at Chapel Hill, USA
Overwriting sound: Warsaw, amplification, and the sing-along
27.06.2017

Boker, Steve M.
University of Virginia, Charlottesville, USA
Theory, methods, and data: A dance and a conversation
03.05.2018

Borck, Cornelius
Universität zu Lübeck, Germany
Theory in exile: On Kurt Goldstein's "The Organism"
10.01.2017

Bossetta, Michael
Lund University, Sweden
The digital architectures of social media: Information, manipulation, and weaponization in a political context
06.12.2018

Bourgeois-Gironde, Sacha
École normale supérieure, Paris, France
Short-term reward experience biases inference despite dissociable neural correlates
18.10.2018

Bresnahan, Keith
OCAD University, Toronto, Canada
Curious, but not angry: Emotional responses to the destruction of Paris after the commune
23.05.2017

Bröder, Arndt
University of Mannheim, Germany
Metamemory viewed through the judgment lens
06.06.2019

Brookes, Matthew Jon
University of Nottingham, UK
Quantum sensing the brain: Next generation neuroimaging
09.10.2018

Brown, Gordon
University of Warwick, Coventry, UK
A social sampling model of social norm effects and polarization
16.04.2019

Brunner, José
Tel Aviv University, Israel
Amoral, immoral, hypermoral: A history of the emotional economies of posttraumatic disorders
02.05.2019

Budde, Gunilla
Carl von Ossietzky Universität Oldenburg, Germany
Gefühle in den Zeiten des Krieges 1914–18
19.11.2019

Cabeza, Roberto
Duke University, Durham, USA
Memory networks and representations
06.07.2017

Charland, Louis Christian
Western University, London, Canada
Anorexia nervosa as a passion: Historical, philosophical, and clinical aspects
27.11.2018

Conze, Eckart
Philipps-Universität Marburg, Germany
Dynamiken der (Un-)Sicherheit: Entwicklung und Potentiale historischer Sicherheitsforschung
28.05.2019

Coricelli, Carol
Neuroscience and Society Lab, Cognitive Neuroscience Sector, SISSA, Trieste, Italy
Disentangling the representations of visually presented food stimuli
11.11.2019

Crozier–de Rosa, Sharon
University of Wollongong, Australia
Violent transgressions: Militant women and emotional codes in early twentieth century Britain and Ireland
09.10.2018

Dayan, Peter
MPI for Biological Cybernetics, Tübingen, Germany
The cortical dynamics of integrative decision-making
20.06.2019

Defrance, Corinne
University of Paris 1 Panthéon-Sorbonne, France
Versöhnung: Ein emotionsgeschichtlicher Ansatz der internationalen Beziehungen
08.01.2019

Dekker, Jeroen
University of Groningen, Netherlands
Rembrandt and cats on the regulation of children's emotions in early modern Europe
09.05.2017

Dhami, Sanjit
University of Leicester, UK
Public goods games and psychological utility: Theory and evidence
06.09.2017

Diehl, Paula
Princeton University, USA
Right-wing populism and the media: An essay on the normalization of the anti-democratic thinking
12.06.2018

Dohmen, Thomas
University of Bonn, Germany
Risk attitudes across the life course to pique your curiosity
13.11.2017

Dosenbach, Nico Urs Felix
Washington University in St. Louis, USA
Precision functional mapping of individual human brains
28.11.2017

Dubnov, Shlomo
University of California, San Diego, USA
Man-machine creative interaction and improvisation
14.05.2018

Dubnov, Shlomo
University of California, San Diego, USA
Understanding human-machine creative interaction though rate-distortion theory
19.11.2019

Dürr, Renate / Strasser, Ulrike
University of Tübingen, Germany
Performing Jesuit emotions: Global knowledge, voyages and Jesuit ethnography in Joseph Stöcklein's "Neuer Welt-Bott" (18th century)
03.12.2019

Fleming, Steve
University College London, UK
Thinking about thinking: The neuroscience of metacognition
04.05.2017

Friedrichs, Anne
Leibniz Institute of European History, Mainz, Germany
Emotional communities and the problem of representation: Polish-German migrations into the Ruhr Valley around 1900
17.12.2019

Fuhrmann, Delia
University of Cambridge, UK
Using large data sets to understand windows of opportunity & vulnerability across the lifespan
03.12.2019

Fulawka, Kamil
SWPS University, Warsaw, Poland
Beyond lotteries: Modeling risky choice with nonmonetary consequences
28.02.2019

Garvert, Mona M.
University of Oxford, UK
Constructing and updating models of others and the world
07.02.2017

Gazzaley, Adam
University of California, San Francisco, USA
Neuroscience meets technology: A vision of the future of brain optimization
26.06.2017

Gegenfurtner, Karl
Justus Liebig University Giessen, Germany
The interaction between vision and eye movements
19.10.2019

Giamattei, Marcus
University of Passau, Germany
Calvo-pricing and status-quo bias: An experiment on limited foresight
04.07.2018

Giannoulis, Elena
Freie Universität Berlin, Germany
Emotional machines: Toward an affective history of technology and intimacy in Japan
16.01.2018

Gienow–Hecht, Jessica
Freie Universität Berlin, Germany
Music and human rights since World War Two
11.02.2020

Glassen, Thomas
Bundeswehr University Munich, Germany
Clustering via (hierarchical) dirchlet process mixture models
06.01.2017

Gollwitzer, Peter / Öttingen, Gabriele
New York University, USA
Future thought and behavior change
08.07.2019

Gopnik, Alison
University of California, Berkeley, USA
When children are better (or, at least, more open-minded) theorists than adults: Theory formation, causal models, and the evolution of learning
20.04.2017

Gruber, Matthias
Cardiff University, UK
States of curiosity and reward prioritize learning and memory consolidation
04.07.2018

Grüneisen, Sebastian
University of Michigan, Ann Arbor, USA
The psychological origins of trust-based cooperation
13.03.2018

Gummerum, Michaela
Plymouth University, UK
Moral decision-making (not just for the holiday season)
19.12.2017

Guye, Sabrina
University of Zurich, Switzerland
Cognitive training in adulthood: From hype to reality
06.12.2017

Harden, Paige
The University of Texas at Austin, USA
Clarifying the relationship between reward and sensation seeking: Sex-specific and hormone-specific associations
06.07.2017

Haupt, Heinz–Gerhard
European University Institute, Florence, Italy
State and violence in Europe at the end of the 19th century
14.01.2020

Hayes, Brett
University of New South Wales, Sydney, Australia
Inference and judgment using censored evidence
25.10.2018

Hayward, Rhodri
University of London, UK
Messy feelings and the magic of tidying up
07.06.2018

Hechtlinger, Shahar
The Hebrew University of Jerusalem, Israel
Making transformative decisions across the adult lifespan: An adaptive rationality perspective
14.02.2019

Heck, Daniel
University of Mannheim, Germany
Extending multinomial processing tree models to response times: The case of the recognition heuristic
23.11.2017

Hernandez, Arturo E.
University of Houston, USA
Language, development and the bilingual brain
16.06.2017

Hertz, Uri
University of Haifa, Israel
The role of confidence in social influence
04.04.2019

Herzog, Lisa
Technical University of Munich, Germany
Judgment, algorithms, and the ubiquity of Campbell's law
29.05.2018

Hills, Thomas
University of Warwick, Coventry, UK
Tracking the lexicon across the lifespan
07.08.2019

Hills, Thomas
University of Warwick, Coventry, UK
Generative self-construction and neurocognitive free will
07.11.2019

Honeck, Mischa
Humboldt-Universität zu Berlin, Germany
No country for old age: Rejuvenation in the early twentieth-century United States
26.06.2018

Iliewa, Zwetelina
MPI for Research on Collective Goods, Bonn, Germany
Can experience sampling restore invariance in financial expectations?
19.07.2018

Ioannidis, John
Stanford University, USA
The reproducibility crisis as an opportunity for improving research practices
10.05.2017

Ito, Takashi
Tokyo University of Foreign Studies, Japan
The honour of naming a new species: Emotional communities of naturalists in the early twentieth century
05.11.2019

Jacobucci, Ross
University of Notre Dame, USA
Flexible specification of large structural equation models with regularization
03.07.2018

Jarvstad, Andreas
University of London, UK
Beyond nudging: Generalisable and transferable learning in human decision-making
30.07.2019

Jayles, Bertrand
Université Toulouse III Paul Sabatier, Toulouse, France
Impact of social and environmental information on group performance
20.09.2017

Jockwitz, Christiane
RWTH Aachen University, Germany
Population neuroimaging assessing the high inter-individual variability of brain structure and function in older adults
08.11.2017

Kacelnik, Alex
University of Oxford, UK
Information seeking, uncertainty, and choice
28.11.2019

Kaiser, Tim
Universität Koblenz·Landau, Germany
Active learning fosters financial behavior: Experimental evidence from rural Uganda
25.01.2018

Kajackaita, Agne
WZB Berlin Social Science Center, Germany
Lying about luck versus lying about performance
07.06.2018

Karayanni, Michael
The Hebrew University of Jerusalem, Israel
Multiculturalism as covering: On the accommodation of minority religions in Israel
15.10.2019

Kause, Astrid
University of Leeds, UK
Consumers' perceptions of rules for reducing carbon footprints of food
11.07.2019

Kellen, David
Syracuse University, USA
Comparing formal accounts of pseudocontingencies and illusory correlations
08.10.2019

Keller, Peter Erik
Western Sydney University, Australia
From sensor-motor to social influences on musical interaction
03.12.2018

Koschut, Simon
Freie Universität Berlin, Germany
Emotional communities in international relations: The significance of emotion norms in NATO's inter-allied conflict management
04.06.2019

Krajbich, Ian
Ohio State University, Columbus, USA
The (neural) dynamics of attention and choice
23.04.2019

Krockow, Eva
University of Leicester, UK
The social dilemma of antimicrobial resistance: Is there a role for the wisdom of crowds?
21.02.2019

Krueger, Joachim
Brown University, Providence, USA
Significance testing as heuristic decision-making
28.03.2017

Krügel, André
University of Potsdam, Germany
What can be learned from deviations of optimal sensorimotor behavior?
15.05.2018

Lenoe, Matt
University of Rochester, USA
Emotional regimes and refuges in the Great Patriotic War: The case of red army soldiers
16.04.2019

Lentz, Carola
Johannes Gutenberg University Mainz, Germany
(Re)constructing belonging: Upward mobility, family ties, and funerals in Ghana
17.04.2018

Lewandowsky, Stephan
University of Bristol, UK
Beyond misinformation: Understanding and coping with the "post-truth" era
29.05.2018

Liebal, Katja
Freie Universität Berlin, Germany
Learning from great apes: A comparative approach to human emotion
16.03.2017

Lieder, Falk
University of California, Berkeley, USA
Beyond bounded rationality
20.07.2017

Lieder, Falk
MPI for Intelligent Systems, Tübingen, Germany
Rationality enhancement: Towards theories and tools for helping people become more effective
13.12.2018

Link, Daniela
University of Lausanne, Switzerland
From frequencies to fluencies: An ecological model of memory-based inference
03.08.2017

Madirolas, Gabriel
Cajal Institute, Madrid, Spain
Collective intelligence in estimation problems: How groups achieve it and how to build techniques to improve it
20.09.2017

Maercker, Andreas
University of Zurich, Switzerland
On models and metaphors in traumatic stress research
21.05.2019

Malone, Hannah
Freie Universität Berlin, Germany
Emotional attachment or manipulation? Fascist Italy and the commemoration of fallen soldiers of the First World War
23.10.2018

Manjapra, Kris
Tufts University, Boston, USA
The futures of slavery in the 19th century: Race, finance, family, and the pivot to Asia
13.02.2018

Marques, José Pedro
Radboud University Nijmegen, Netherlands
Studying myelin distribution in the brain using MRI relaometry
12.02.2019

Matt, Susan
Weber State University, Ogden, USA
Homesickness and the myth of American individualism
27.06.2017

McElreath, Richard
MPI for Evolutionary Anthropology, Leipzig, Germany
The natural selection of bad science
12.01.2017

McFalls, Laurence
Université de Montréal, Quebec, Canada
Feeling through film: The open memory box and the intimate social history of the GDR
14.05.2019

Mollerstrom, Johanna
Humboldt-Universität zu Berlin, Germany
Individual risk preferences and the demand for redistribution
09.01.2018

Monroe, Kristen
University of California, Irvine, USA
Identity, moral choice and emotions
24.04.2018

Moscoso, Javier
Centro de Ciencias Humanas y Sociales, Madrid, Spain
Passions of rivalry in the early 19th century
06.02.2018

Mousavi, Shabnam / Sunder, Shyam
Johns Hopkins University, Baltimore, USA /
Yale University, New Haven, USA
The least action principle and a three-tier theory of human behavior
05.06.2018

Murayama, Kou
University of Reading, UK
A reward-learning framework of autonomous knowledge acquisition: An integrated account of curiosity, interest, and intrinsic-extrinsic rewards
27.06.2019

Myung, Jay
Ohio State University, Columbus, USA
Bayesian adaptive experimentation: How to design smarter experiments
09.05.2019

Nachev, Vladislav
Humboldt-Universität zu Berlin, Germany
The principles of economic rationality and multi-dimensional reward evaluation in mice
29.11.2018

Nagel, Barbara
Princeton University, USA
The terror of flirtation from the 19th century to #MeToo
15.05.2018

Nash, Ulrik
University of Southern Denmark, Odense, Denmark
Sequential sampling, magnitude estimation, and the wisdom of crowds
26.09.2019

Nave, Gideon
University of Pennsylvania, Philadelphia, USA
Does oxytocin increase trust in humans?
05.07.2018

Neil, Stewart
University of Warwick, Coventry, UK
Heuristics behaviour identified from mass trans-action data
12.11.2018

Neubauer, Jack Maren
Columbia University, New York, USA
The adoption plan: China and global humani-tarianism's intimate turn
30.10.2018

Newcombe, Nora S.
Temple University, Philadelphia, USA
Development of episodic memory: Which dog did I see—and where and when did I see it?
07.09.2017

Nielsen, Philipp
Sarah Lawrence College, Bronxville, USA
Building democracy: Emotions, politics, and architecture in Postwar Germany
02.07.2019

Nyberg, Lars
Umeå University, Sweden
Memory decline in aging—a crucial role for the anterior hippocampus?
16.05.2017

Ogle, Vanessa
University of California, Berkeley, USA
Immoral economies: Tax havens and tax avoidance, 1920s–1980s
19.06.2018

Olschewski, Sebastian
University of Basel, Switzerland
Choice consistency and estimation biases in risky choice
24.07.2019

Omigie, Diana
University of London, UK
Using music to study information seeking behaviour
05.06.2019

Palmenteri, Stefano
Laboratoire de Neurosciences Cognitives, Paris, France
Humans are biased reinforcement learners: Evidence from behavioural and neural data
10.07.2018

Parianen-Leseman, Franca
MPI for Human Cognitive and Brain Sciences, Leipzig, Germany
Behavioral effects and biological bases of care and power motivation: In individual and intergroup economic decision-making
30.03.2017

Park, Soyoung Q.
Charité Universitätsmedizin Berlin and German Institute of Human Nutrition (DIfE), Potsdam-Rehbruecke, Germany
Psychological, neural and metabolic motives and modulators of human decision-making
29.08.2019

Park, Soyoung Q.
Charité Universitätsmedizin Berlin and German Institute of Human Nutrition (DIfE), Potsdam-Rehbruecke, Germany
Motives and modulators of human decision-making
21.01.2020

Parpart, Paula
University College London, UK
Heuristics as a special case of Bayesian inference
02.11.2017

Penny, H. Glenn
The University of Iowa, Iowa City, USA
Being German in Guatemala, 1880s–1960s
07.11.2017

Penslar, Derek
Harvard University, Cambridge, USA
What's love got to do with it? The emotional language of Early Zionism
13.06.2019

Pfeil, Ulrich
University of Lorraine, Metz, France
Versöhnung: Ein emotionsgeschichtlicher Ansatz der internationalen Beziehungen
08.01.2019

Pfuhl, Gerit
The Arctic University of Norway, Tromso, Norway
Who engages in deliberate reasoning?
01.10.2019

Plamper, Jan
Goldsmiths, University of London, UK
How can historical research help reduce sexualized violence committed by soldiers in times of war? First thoughts
28.01.2020

Poensgen, David
Goethe University Frankfurt am Main, Germany
Learned impatience? Delayed feedback and myopic choice
17.10.2019

Polk, Thad A.
University of Michigan, Ann Arbor, USA
Using the make command to manage neuroimaging analyses
07.07.2017

Prieto, Moises
Humboldt-Universität zu Berlin, Germany
An approach to early 19th century Latin American dictators through emotions
14.11.2017

Radano, Ronald
University of Wisconsin-Madison, USA
Black music and embodiment
07.05.2019

Rakoczy, Hannes
Georg-August University of Göttingen, Germany
In defence of a developmental dogma: Children acquire propositional attitude concepts around age 4
17.05.2018

Rapoport, Amnon
University of California, Riverside, USA
Heuristics for sequential search with relative ranks
10.10.2017

Rapoport, Amnon
University of California, Riverside, USA
Choice of routes in traffic networks: Congestion and cost-sharing
26.10.2017

Rasha, Abdel Rahman
Humboldt-Universität zu Berlin, Germany
Clear judgments based on unclear evidence: Person evaluation is strongly influenced by facts and gossip
26.07.2018

Raykov, Tenko
Michigan State University, East Lansing, USA
Examining the links of depression to mortality based on the health and retirement study
14.05.2019

Rehlinghaus, Franziska
Georg-August University of Göttingen, Germany
Kontrolle und Offenbarung: Zur Geschichte affektiven Kapitals in der bundesdeutschen Weiterbildung
29.01.2019

Rieskamp, Jörg
University of Basel, Switzerland
Does increased cognitive load change people's economic preferences or does it lead to more decision errors?
19.01.2017

Roller, Ramona
University of Amsterdam, Netherlands
Quantifying efficiency in an e-mobility system: A game theoretical approach with extensions to adaptive rationality
26.09.2017

Roodenburg, Herman
Meertens Institute, Amsterdam, Netherlands
Affective images: Exploring the devotional tears of early modern believers and the enactive mind
22.01.2019

Rosenwein, Barbara
Loyola University Chicago, USA
Practice, theory, and practicalities
11.05.2017

Salzer, Dorothea
University of Potsdam, Germany
Religion and emotion in Jewish children's bibles
04.07.2017

Schaal, Gary
Helmut-Schmidt-Universität/Universität der Bundeswehr Hamburg, Germany
"Politics of emotions"—one answer to the current crisis of democratic disengagement?
24.01.2017

Scheer, Monique
University of Tübingen, Germany
Rational enthusiasts: Handling the ambivalence of fervor
13.06.2017

Scheibe, Susanne
University of Groningen, Netherlands
Emotional aging in the work context: Hidden strength of older workers?
20.06.2017

Scheibehenne, Benjamin
University of Geneva, Switzerland
The influence of numeric cognition on experience-based economic valuation
23.01.2020

Schiffer, Anne-Marike
Associate editor at Nature Human Behaviour
Nature human behaviour: Aims, scope & editorial process
25.01.2018

Schlör, Joachim
University of Southampton, UK
Missing Berlin: "Former Berliners" from around the world in correspondence with their hometown
15.01.2019

Schneider, Max
University of Washington, Seattle, USA
Where could the big one strike? Evaluating uncertainty visualization approaches for earthquake forecasts
08.11.2018

Schneider, Robert A.
Indiana University Bloomington, USA
The rise and fall of the resentment paradigm (ca. 1935–1975)
21.05.2019

Shoham, Choshen-Hillel
The Hebrew University of Jerusalem, Israel
The roots of inequity aversion
23.08.2018

Singh, Prerna
Brown University, Providence, USA
The control of contagion: Ideas, institutions and disease in China and India
30.04.2019

Slobodian, Quinn
Harvard University, Cambridge, USA
Volk capital: The moral economy of xenophobic libertarianism from Hayek to the AfD
10.07.2018

Spotorno, Nicola
Deutsches Zentrum für Neurodegenerative Erkrankungen, Magdeburg, Germany
Looking for neuroimaging biomarkers in neuro-degeneration and "typical" aging
09.05.2017

Sprekeler, Henning
University of Freiburg, Germany
A neuronal mechanism for systems memory consolidation
23.05.2019

Stanley, Jeffrey A.
Wayne State University, Detroit, USA
Evidence of continued myelination into the middle age of healthy adults from myelin water imaging
14.06.2017

Stanley, Jeffrey A.
Wayne State University, Detroit, USA
Functional magnetic resonance spectroscopy: The new MRS
07.06.2018

Stanley, Jeffrey A.
Wayne State University, Detroit, USA
fMRS applied to OCD, schizophrenia and aging
24.06.2019

Stedman, Gesa
Humboldt-Universität zu Berlin, Germany
Sending a gush to the eyes—tears and tender affection in the Victorian discourses on emotions
20.06.2017

Stodulka, Thomas
Freie Universität Berlin, Germany
Anthropologies of human development and education
21.01.2020

Stojic, Hrvoje
University College London, UK
Trials-with-fewer-errors: Feature-based learning and exploration
15.02.2018

Stroumsa, Guy
The Hebrew University of Jerusalem, Israel
The temptation of Christianity: Henri Bergson, Simone Weil, Emmanuel Levinas
25.04.2017

Summerfield, Christopher
University of Oxford, UK
Optimality and irrationality in human decision-making
23.03.2017

Summerfield, Christopher
University of Oxford, UK
Ingredients of intelligence
10.04.2019

Teodorescu, Kinneret
The Hebrew University of Jerusalem, Israel
Reliance on small samples, the wavy recency effect, and similarity-based learning
03.04.2017

Thayer, Julian F.
University of California, Los Angeles, USA
Brain-heart interactions: Implications for cognition, emotion, and health
19.06.2019

Thorngate, Warren
Carleton University, Ottawa, Canada
Where do heuristics come from? And where do they go when they die?
24.10.2017

Toyokawa, Wataru
University of St Andrews, UK
How do groups navigate a restless multi-armed bandit?
09.11.2017

Turk-Browne, Nick B.
Princeton University, USA
Rethinking memory systems for statistical learning
09.10.2017

Turnbull, Kal
Change My View, Edinburgh UK
The functionality & future of "Change My View"
01.11.2018

van den Berg, Pieter
KU Leuven, Belgium
Uncertainty about social interactions leads to the evolution of cooperative heuristics
30.11.2017

van Vugt, Floris Tijmen
McGill University, Montreal, Canada
Motor learning and acoustics perspectives on the (baroque) oboe: A concert lecture
10.09.2018

van Vugt, Floris Tijmen
McGill University, Montreal, Canada
Learning novel sensorimotor maps
11.09.2018

Weismann, Stephanie
University of Vienna, Austria
Emotionalized odours: Polish smellscapes under transition
25.06.2019

Weitzenkorn, Rachel
Emory University, Atlanta, USA
The paradox of observational psychoanalysis: Rene Spitz and the psychoanalytic case study
21.11.2017

West, Stephen G.
Arizona State University, Tempe, USA
Why might an experiment not replicate?
11.07.2018

White, Daniel
Freie Universität Berlin, Germany
Emotional machines: Toward an affective history of technology and intimacy in Japan
16.01.2018

White, Paul
University of Cambridge, UK
The emotional specimen: Darwin, Duchenne, and the science of expression
16.05.2017

Wolf, Lavi
Ben-Gurion University of the Negev, Beer-Sheva, Israel
A linguistic approach to the conjunction fallacy
10.08.2017

Yaniv, Ilan
The Hebrew University of Jerusalem, Israel
Social learning in an advice-taking paradigm
03.07.2018

Yarkoni, Tal
The University of Texas at Austin, USA
Generalization, fast and slow
03.09.2018

Yechiam, Eldad
Technion—Israel Institute of Technology, Haifa, Israel
On loss attention, the hot stove effect, and the endowment effect
27.04.2017

Zatorre, Robert Jorge
McGill University, Montreal, Canada
Predispositions and plasticity in auditory-motor learning: Hemispheric asymmetries
06.12.2018

Zhou, Alice (Xiaoqing)
The University of Queensland, Brisbane, Australia
Physical exercise improves cognition by including hippocampal structural and functional changes in the aged murine brain that are dependent on neurogenesis
20.05.2019

Zwaan, Laura
Amsterdam UMC (University Medical Centers), Netherlands
Cognitive causes of diagnostic error
23.02.2017

3. Conferences, Workshops, and Seminars 2017–2019/20

H2020 Project FORECEE, Ethics and Implementation Workshop
Harding Center workshop, jointly organized with University College London & Erasmus University Medical Center Rotterdam
07.02.–08.02.2017

Feeling Close: A Workshop on the History of Intimacy in the 20th Century
HoE workshop
03.03.2017

WEXICOM Grant Evaluation
ARC workshop in cooperation with Hans-Ertel-Centre for Weather Research (FU Berlin)
27.03.–31.03.2017

Evidence of Feeling: Law, Science and Emotions in Modern Europe
HoE workshop
10.04.–11.04.2017

Learning, Memory, and Forgetting from a Lifespan Perspective
LIFE seminar (weekly sessions)
April–July 2017

Developmental Theory: The Lifespan Perspective
LIFE introductory workshop
28.04.2017

Moral Economies Academic Writing Seminar
MEMS workshop (weekly sessions)
May–June 2017

Tutorial for the 7th International Verification Methods Workshop (WEXICOM Project: Communication of Extreme Weather Events)
ARC workshop in cooperation with Hans-Ertel-Centre for Weather Research (FU Berlin)
01.05.–06.05.2017

Cognition, Brain, and Aging (COBRA)
LIP meeting in cooperation with Umeå University & the Aging Research Center at Karolinska Institutet, Stockholm
15.05.–16.05.2017

LIFE Spring Academy 2017
LIFE international academy in Ann Arbor, jointly organized with LIFE Michigan, LIFE Virginia, LIFE Zurich
21.05.–24.05.2017

Predictions Under Uncertainty
16th Summer Institute on Bounded Rationality, hosted by ABC and ARC, funded by the Joachim Herz Stiftung
06.06.–14.06.2017

Conflict Management for IMPRS Coordinators
MEMS workshop in cooperation with MPG
19.06.–20.06.2017

Moral Economies—*Geschichte und Gesellschaft* Special Issue Workshop
MEMS workshop
14.09.–15.09.2017

LIFE Fall Academy 2017
LIFE international academy in Zurich, jointly organized with LIFE Michigan, LIFE Virginia, LIFE Zurich
15.10.–19.10.2017

Evolutionary Approaches to Human Development
LIFE seminar (weekly sessions)
November 2017 – February 2018

Basel Berlin Risk Study Meeting
ARC workshop
17.11.2017

COMP2PSYCH Dissertation Workshop 2017
IMPRS workshop, jointly organized with Raymond J. Dolan
23.11.–24.11.2017

Multilevel Modeling/Analysis of Incomplete Data Sets
LIFE workshops
08.12.2017

Project VISUAL (Focus: Visualisation in Medicine)
Harding Center workshop
02.02.2018

Project VISUAL (Focus: Problem Solution in Medicine)
Harding Center workshop
07.03.2018

Visual History in the Twentieth Century: Bodies, Practices and Emotions
ERC "Body Capital" spring school, jointly organized with HoE
09.04.–13.04.2018

Foundations of Lifespan Research
LIFE introductory workshop
23.04.–25.04.2018

LIFE Presentation Training
LIFE workshop
29.05. and 12.06.2018

LIFE Spring Academy 2018
LIFE international academy in Berlin, jointly organized with LIFE Michigan, LIFE Virginia, LIFE Zurich
31.05.–04.06.2018

Excess? Images of Body, Health, Morality and Emotions Across the Media
International HoE/ERC "BodyCapital" workshop
07.06.–08.06.2018

Rhythms of the Brain
LIFE seminar (weekly sessions)
June–July 2018

Epigenetics: Innovation of Memory? Life Science Paradigms as Challenge and Opportunity for Historians
HoE conference
13.06.–15.06.2018

In Place of Healing: The Dangers of Therapeutic Models of Remembrance
HoE lecture as part of the conference "Epigenetics: Innovation of Memory? Life Science Paradigms as Challenge and Opportunity for Historians"
13.06.2018

Do Epigenetics Matter? A Historian's Issues With Memories, Narratives and Intergenerational Transfer
HoE lecture as part of the conference "Epigenetics: Innovation of Memory? Life Science Paradigms as Challenge and Opportunity for Historians"
15.06.2018

IMPRS–MEMS–Berkeley Workshop "Moral Economy"
MEMS workshop in cooperation with the working group "Der Kreis" of the University of California, Berkeley
19.06.–20.06.2018

Strategies X Environments
17th Summer Institute on Bounded Rationality, hosted by ABC and ARC, funded by the Joachim Herz Stiftung
19.06.–26.06.2018

Application for a WEXICOM Grant (2019–2022)
ARC meeting in cooperation with Hans-Ertel-Centre for Weather Research (FU Berlin)
10.07.–12.07.2018

Annual FLUX Congress, Berlin
LIP conference in cooperation with FLUX: The Society for Developmental Cognitive Neuroscience
30.08.–01.09.2018

Max Planck Day 2018
Workshop for young journalists in cooperation with ems—electronic media school
14.09.2018

4th Max Planck UCL Centre Symposium and Advanced Course on Computational Psychiatry and Ageing Research
Max Planck UCL Centre conference at Ringberg Castle, jointly organized with Raymond J. Dolan
23.09.–29.09.2018

The Multifaceted Relationship Between Fear and Technology
HoE workshop
10.10.–12.10.2018

LIFE Fall Academy 2018
LIFE international academy in Virginia, jointly organized with LIFE Michigan, LIFE Virginia, LIFE Zurich
12.10.–15.10.2018

Fellows' Projects Presentations
LIFE seminar (weekly sessions)
November–December 2018

Writing Sweatshop Workshop
MEMS workshop
04.12.–06.12.2018

Capitalist Cold. Debating and Depicting Callousness in Europe and America
HoE conference
06.12.–07.12.2018

Consciousness: Nature/Culture
MPG symposium, jointly organized with HoE
14.12.–15.12.2018

Academic Writing
    LIFE workshop
    18.02. and 25.02.2019
Representations of Migration and Emotions of Exclusion
    HoE conference
    20.03.–21.03.2019
Foundations of Lifespan Research
    LIFE workshop
    02.04.–04.04.2019
BELCOMM Berlin–Leipzig COgnitive Map Meeting
    NeuroCode workshop, jointly organized with MPI for Human Cognitive and Brain Sciences
    11.04.2019
VW AI Workshop 1
    ARC workshop in cooperation with VW Foundation
    24.04.–26.04.2019
Methods in Research on Human Development
    LIFE seminar (weekly sessions)
    May–June 2019
Beteiligung oder Protest—Diskussionsreihe "Politik (o)der Gefühle: Der Demokratie–Dialog"
    HoE public event
    22.05.2019
Recht oder Gefühl—Diskussionsreihe "Politik (o)der Gefühle: Der Demokratie–Dialog"
    HoE public event
    27.05.2019
LIFE Spring Academy 2019
    LIFE international academiy in Ann Arbor, jointly organized with LIFE Michigan, LIFE Virginia, LIFE Zurich
    28.05.–31.05.2019
Streit oder Kompromiss—Diskussionsreihe "Politik (o)der Gefühle: Der Demokratie–Dialog"
    HoE public event
    03.06.2019
Presentation and Communication
    MEMS workshop
    06.06.–07.06.2019
Heimat, Heimweh, Geschichte: Geschichtskulturen als Projektionen emotionaler Aushandlung von Heimat. Bestandsaufnahmen und Perspektiven
    HoE workshop
    06.06.–07.06.2019
Bounded Rationality in a Digital World
    19th Summer Institute on Bounded Rationality, hosted by ABC and ARC, funded by the Joachim Herz Stiftung
    11.06.–19.06.2019
Reden oder Schweigen—Diskussionsreihe "Politik (o)der Gefühle: Der Demokratie–Dialog"
    HoE public event
    12.06.2019
Long Night of the Sciences
    Public event
    15.06.2019
Religion as Emotion Knowledge: Religious Knowledge Systems and Emotions From the 18th to the 21st Century
    HoE conference
    20.06.–21.06.2019
Career Strategies
    MEMS workshop
    03.07.2019
Project RisikoAtlas, Expert Workshop (Topic: Online Shopping)
    Harding Center workshop
    05.07.2019
VW AI Workshop 2
    ARC workshop in cooperation with VW Foundation
    13.08.–16.08.2019
Editorial Meeting Ernst Strüngmann-Forum on "Deliberate Ignorance"
    ARC workshop
    23.08.–24.08.2019
Kick–Off–Meeting des BMG-Projekts Experiencing the Risks of Overutilizing Opioids Among Patients With Non–Tumor Chronic Pain in Ambulant Care/ERONA
    ARC kick-off meeting
    10.09.2019

LIFE Presentation Training
 LIFE workshop
 24.09.–25.09.2019
Grant Proposal Writing
 LIFE workshop
 29.09.–30.09.2019
LIFE Fall Academy 2019
 LIFE international academy in Zurich, jointly organized with LIFE Michigan, LIFE Virginia, LIFE Zurich
 11.10.–15.10.2019
Project RisikoAtlas (Topics: Health, Finance, Digital)
 Harding Center expert workshop
 15.10.2019
Project RisikoAtlas
 Harding Center network event
 15.10.2019
Emotions at Work: Intimacies, Labor, and Urban Space in the 20th Century
 HoE workshop
 23.10.–25.10.2019
Emotions, Labor and the City: A New Paradigm?
 HoE public round table discussion as part of the conference "Emotions at Work: Intimacies, Labor, and Urban
 Space in the 20th Century"
 23.10.2019
Practical Seminar on Bayesian Statistics
 LIFE seminar (five sessions)
 October–December 2019
Project RisikoAtlas
 Harding Center journalist workshop
 29.10.2019
COMP2PSYCH Dissertation Workshop 2019
 IMPRS workshop, jointly organized with Raymond J. Dolan
 31.10.–01.11.2019
Lifebrain
 LIP meeting and conference, jointly organized with Lifebrain, Silver Santé Study, German Brain Council
 04.11.–06.11.2019
LIFE Presentation Training
 LIFE workshop
 12.11.–13.11.2019
Good Scientific Practice
 LIFE workshop
 14.11.–15.11.2019
Empathie oder Toleranz—Diskussionsreihe "Politik (o)der Gefühle: Der Demokratie-Dialog"
 HoE public event
 27.11.2019
Zugänge zu einer Sozial- und Kulturgeschichte der Adoption
 HoE workshop, jointly organized with Philipps-Universität Marburg
 28.11.–29.11.2019
Kooperation oder Konfrontation—Diskussionsreihe "Politik (o)der Gefühle: Der Demokratie-Dialog"
 HoE public event
 28.11.2019
Between Social Discipline and Pleasure: The Politics and Practices of Play and Games in State Socialism
 HoE conference, jointly organized with University of Augsburg & German Historical Institute, Warsaw, and
 financed by "Gerda-Hermann-Weber-Stiftung"
 04.12.–06.12.2019
Feeling DIS/EASE: New Perspectives on Modern History
 HoE/Minerva conference
 29.01.–31.01.2020

4. Other Professional Activities 2017–2019/20

Arslan, Ruben C.
– Research Data Management Group of the MPI for Human Development (Member), 2018–

Baumert, Jürgen
– European Research Council (ERC) (Panel Member for the 2017 Consolidator Grant call)
– LEAD (Learning, Educational Achievement, and Life Course Development), Graduate School & Research Network, Tübingen (Advisory Board)
– Waxmann Verlag's series on educational psychology and developmental psychology (Advisory Board)
– *Psychologie in Erziehung und Unterricht* (Advisory Board)
– *Schweizerische Zeitschrift für Bildungswissenschaften* (Advisory Board)
– *Zeitschrift für Erziehungswissenschaft* (Co-Editor)

Beljan, Magdalena
– Dahlem International Network Junior Research Group "Art Couples: Relationship Dynamics and Gender Relations in the Arts" (Freie Universität Berlin/MPI for Human Development), 2014–2017
– *Body Politics: Zeitschrift für Körpergeschichte* (Co-Editor)

Bender, Andrew R.
– Hippocampal Subfields Group, Boundaries Working Group (Contributing Member)

Brandmaier, Andreas M.
– International Max Planck Research School on Computational Methods in Psychiatry and Ageing Research (COMP2PSYCH) (Faculty Member)
– Ombudsperson of the MPI for Human Development to secure the Max Planck Society's guidelines on "Good scientific practice and procedures for handling misconduct and fraud in science
– Research Data Management Group of the MPI for Human Development (Member), 2018–
– *Journal of Quantitative and Computational Methods in Behavioral Sciences* (Editor), 2019–

Brauer, Juliane
– Richard Koebner Minerva Center for German History, The Hebrew University of Jerusalem (Stavenhagen Guest Professorship), 2019

Chien, Samson
– Ethics Committee of the MPI for Human Development (Member), 2019-

Cummins, Stephen
– Scientific Staff Committee of the MPI for Human Development (Member), 2019–

Czienskowski, Uwe
– Ethics Committee of the MPI for Human Development (Member)

Domberg, Andreas
– Ethics Committee of the MPI for Human Development (Member), 2019–

Düzel, Sandra
– *Frontiers in Psychology: Cognition* (Review Editor)

Edelstein, Wolfgang
– Buddy e.V. (Advisory Board)
– Deutsche Gesellschaft für Demokratiepädagogik (German Association for Democratic Education) (Member)
– Institut für angewandte Familien-, Kindheits- und Jugendforschung e.V., Potsdam (Scientific Advisory Board)
– *International Journal of Developmental Scienc*e (Editorial Board)

Fandakova, Yana
– Ethics Committee of the MPI for Human Development (Member)

Fleischhut, Nadine
– Ethics Committee of the MPI for Human Development (Member)

Frevert, Ute
– Berlin-Brandenburg Academy of Sciences and Humanities (Member)
– British Academy for the Humanities and Social Sciences, London (Corresponding Fellow)
– Deutschlandjahr (Year of Germany) USA 2018/2019 of the Federal Foreign Office, Goethe-Institut and BDI (Advisory Board), 2017–2019
– Einstein Forum, Potsdam (Advisory Board)
– Emotions in History, Oxford University Press series (Co-Editor)
– European Research Council (Panel Member), 2012–2017
– Foundation Deutsches Hygiene Museum, Dresden (Board of Trustees), 2012–2017
– German National Academy of Sciences Leopoldina (Member)

- German Historical Institute, Washington DC (Chairperson of the Advisory Board), 2016–2019
- German-Israeli Foundation for Scientific Research and Development (GIF) (Member of the Board of Governors), 2013–2018
- Institute for Human Sciences, Vienna (Advisory Board)
- International Max Planck Research School for Moral Economies of Modern Societies (Principal Investigator and Spokesperson)
- Körber Foundation (Board of Trustees)
- Leopoldina Centre for Science Studies (Deputy Member of the Scientific Advisory Board), 2017–
- Leuphana University of Lüneburg, Bachelor Program Liberal Education/Studium Individuale (Advisory Board)
- Ludwig Boltzmann Institute for the History and Theory of Biography, Vienna (Advisory Board), 2011–2017
- Scientific Council of the Max Planck Society (Chairperson), 2014–2017
- Society for the History of Emotions (Council Member)
- University Council Konstanz (Chairperson)
- Van Leer Jerusalem Institute, Israel (Board of Trustees), 2018–
- Working group for Modern Social History (Member)
- *Emotions and Society* (Editorial Advisory Board), 2018–
- *European Studies Review* (Advisory Board)
- *Geschichte und Gesellschaft. Zeitschrift für Historische Sozialwissenschaft* (Co-Editor/Managing Director)
- *Historical Journal, Cambridge University Press* (Advisory Board)
- *Journal of Contemporary History* (Advisory Board)
- *Journal of Modern History* (Advisory Board)
- *L'Homme: Zeitschrift für Feministische Gesellschaftswissenschaft* (Advisory Board)
- *Sensibilités. Histoire, critique & sciences sociales* (Advisory Board)

Gammerl, Benno
- Archive for Life Stories of LGBTI* People at Federal Foundation Magnus Hirschfeld (Advisory Board), 2015–2018
- Berlin Senate, Committee for LGBTI* History (Advisory Board), 2014–2018
- Palgrave Studies in the History of Experience (Editorial Board), 2019–
- QueerSearch—Dachverband deutschsprachiger queerer Archive, Bibliotheken und Sammlungen [umbrella organisation of German-language queer archives, libraries and collections] (Member), 2017–
- *Emotions and Society* (Editorial Advisory Board), 2018–

Garrett, Douglas D.
- International Max Planck Research School on Computational Methods in Psychiatry and Ageing Research (COMP2PSYCH) (Faculty Member)
- International Max Planck Research School on the Life Course (LIFE) (Faculty Member), 2018–
- Scientific Staff Committee of the MPI for Human Development (Member), 2014–2020

Gigerenzer, Gerd
- ALLEA (All European Academies) (Member, Expert Committee, "Democracy in a Digital Society Task Force"), 2019–
- American Institute for Behavioral Research and Technology (AIBRT) (Scientific Advisory Board)
- Berlin-Brandenburg Academy of Sciences (Member, "Zukunft der Medizin," Interdisciplinary Working Group [IAG]), 2018–
- BERLIN.MINDS (Advisory Board)
- Board of the APS Policies (Advisory Committee of International Scholars)
- Bundesinstitut für Risikobewertung (Federal Institute for Risk Assessment) (Advisory Board), 2015–2017
- Bundesverband Managed Care e.V. (BMC) (Advisory Board), 2014–2018
- Center for Interdisciplinary Research, Bielefeld (Advisory Board), 2010–2017
- Centro de Investigación Avanzada en Educasión, Universidad de Chile, Santiago (International Scientific Committee)
- Continuing medical education (CME) classes for professors of medicine, certified with 7 points by Ärztekammer Sachsen, 2017
- DVFA (Deutsche Vereinigung für Finanzanalyse und Asset Management) (Member, Ethics Panel)
- Elsevier Books Series "Perspectives on behavioral economics and the economics of behavior" (Editorial Board), 2017
- European Society for Philosophy and Psychology (ESPP) (Advisory Board)
- Federal Ministry of Education and Research, "Recht und Ethik," Lernende Systeme—die Plattform für Künstliche Intelligenz (Member), 2018–

- Frankfurt Big Data Lab, Goethe University Frankfurt am Main (Associated Faculty), 2020–
- German National Academy of Sciences Leopoldina, Task Force "Wissenschaft, Öffentlichkeit und Medien" (Member)
- German National Academy of Sciences Leopoldina and Robert Bosch Stiftung, Risk Literacy Training for journalists, 2016–2017
- German Ministry of Justice and Consumer Protection (Sachverständigenrat für Verbraucherfragen des Ministeriums der Justiz und für Verbraucherschutz) (Member, German Council of Consumer Affairs), 2014–2018
- Herbert Simon Society (President)
- International Union of Psychological Science (Member, Jury for the Major Advancement in Psychological Science Award)
- Scientific Council of the European Research Council (Member), 2020–
- Summer Institute on Bounded Rationality, Berlin (Co-Director)
- Technical University of Munich (Advisory Board, "Risk and Security")
- www.unstatistik.de, Unstatistik des Monats (False statistics of the month), with T. K. Bauer & W. Krämer (Co-Author)
- Yidan Prize for Educational Research (Jury Member), 2019–2020
- *Decision* (Editorial Board)
- *Industrial and Corporate Change on Macroeconomics and Development,* yearly special issue (Senior Editorial Board), 2020–
- *International Journal of Psychology* (Editorial Board)
- *Journal of Behavioral Decision Making* (Editorial Board)
- *PLOS ONE* (Guest Editor), 2018
- *PsyCh Journal* (China) (Editorial Board), 2016–2019
- *Psychological Inquiry* (Editorial Board)
- *Theory & Psychology* (Co-Editor)

Hachmann, Wibke
- Ethics Committee of the MPI for Human Development (Member), 2016–2017

Hertwig, Ralph
- Association for Psychological Science (Fellow)
- Consumer Research Network, Federal Ministry of Justice and Consumer Protection (Member), 2020–
- Ernst Strüngmann Forum on "Deliberate Ignorance. Choosing Not to Know", Frankfurt Germany (Programm Committee Member), 2019
- Excellence Cluster "Science of Intelligence", funded by the German Science Foundation (Principal Investigator), 2018–
- German National Academy of Sciences Leopoldina, Ad Hoc Committee on the Corona Virus (Medicine) (Member), 2020
- German National Academy of Sciences Leopoldina, Section 26 "Psychology and Cognitive Sciences" (Member)
- German National Academy of Sciences Leopoldina, Scientific Commission "Individual Action—Societal Consequences" (Individuelles Handeln—Gesellschaftliche Konsequenzen) (Member)
- German National Academy of Sciences Leopoldina, Task Force "Digizitation and Democracy" (Digitalisierung und Demokratie) (Member), 2019–
- International Max Planck Research School on Computational Methods in Psychiatry and Ageing Research (COMP2PSYCH) (Faculty Member)
- International Max Planck Research School on the Life Course (LIFE) (Faculty Member)
- Leibniz-Science Campus Primate Cognition (Advisory Board)
- Max Planck School of Cognition (Faculty Member), 2019–
- Max Wertheimer Minerva Center for Cognitive Processes and Human Performance, Haifa (Advisory Board)
- MobileMed: Mobile Consultation and Learning System (Advisory Board)
- Steering Committee JRC Report Enlightenment 2.0 (Member), 2018–
- Steering Committee of the DFG Priority Program "New Frameworks of Rationality" (Member)
- Summer Institute on Bounded Rationality, Berlin (Co-Director)
- Wilhelm Wundt Society (Elected Member)
- *Experimental Psychology* (Editorial Board)
- *Journal of Behavioral Decision Making* (Editorial Board)
- *Thinking & Reasoning* (Editorial Board)
- *Topics in Cognitive Science* (Editorial Board), 2016–2017

Hitzer, Bettina
- Scientific Staff Committee of the MPI for Human Development (Member), 2015–2019

Horn, Sebastian S.	– Scientific Staff Committee of the MPI for Human Development (Member), 2014–2018
Jayles, Bertrand	– Scientific Staff Committee of the MPI for Human Development (Member), 2018–
Jenny, Mirjam A.	– BfR-Kommission Risikoforschung und Risikowahrnehmung (Member), 2018– – Equal Opportunities Representative of the MPI for Human Development, 2016–2019
Jensen, Uffa	– Mailing List H-Soz-u-Kult (Review Editor) – *Culturas Psy/PsyCultures* (Editorial Committee)
Jones, Angela	– Max Planck Society PhDnet (Executive Representative of the MPI for Human Development), 2019–2020
Kämmer, Juliane E.	– Working Group "Progress Test Medizin," Charité Universitätsmedizin Berlin (Head Research Scientist), 2016–2020
Keller, Monika	– *Erwägen, Wissen, Ethik* (Advisory Board) – *International Journal of Developmental Science* (Advisory Board)
Kloosterman, Niels A.	– Scientific Staff Committee of the MPI for Human Development (Member), 2020–
Koch, Christoph	– International Max Planck Research School on the Life Course (Fellow Speaker), 2017–2018
Köhncke, Ylva	– International Max Planck Research School on Computational Methods in Psychiatry and Ageing Research (COMP2PSYCH) (Faculty Member), 2018–
Konovalova, Elizaveta	– Sustainability at Work Committee of the MPI for Human Development (Member), 2019–
Kruse, Imke	– Research Data Management Group of the MPI for Human Development (Member), 2018–
Kühn, Simone	– International Max Planck Research School on the Life Course (LIFE) (Faculty Member)
Lau, Sebastian	– Ausbildungsverbund Fachinformatik Berlin—afib (Coordinator) – Research Data Management Group of the MPI for Human Development (Member), 2018–
Laube, Corinna	– Max Planck Society PhDnet (Executive Representative of the MPI for Human Development), 2016–2017 – Representative of the MPIB in the Human Science Section of the MPG, 2018–2020
Laukötter, Anja	– Internet Portal "History of Emotions—Insights into Research" (Co-Editor) – Research group "The healthy self as body capital: Individuals, market-based societies, and body politics in visual twentieth century Europe" (Co-Director), 2016–2021
Lichau, Karsten	– Internet Portal "History of Emotions—Insights into Research" (Co-Editor), 2018–2019
Lindenberger, Ulman	– Advisory Committee of CIFAR Child & Brain Development Research Program, Canadian Institute for Advanced Research (Member) 2019– – Academia Europaea (Member) – Alexander von Humboldt Foundation (Fellow) – American Psychological Association (Fellow, Div. 20) – Association for Psychological Science (Fellow) – Behavioral Genetics Association (Fellow) – Berlin School of Mind and Brain (Faculty Member) – CARINA Stiftung (Board of Trustees) – C. L. de Carvalho-Heineken Prize for Cognitive Science (Jury Member), 2016–2020 – Cognitive Neuroscience Society (Fellow)

McDowell, Michelle	– CAPUR Scientific Committee of international experts on risk at Atomium—European Institute for Science, Media and Democracy (EISMD) (Member), 2018–2020
Mikulová, Soňa	– Sustainability at Work Committee of the MPI for Human Development (Member), 2019–
Nix, Sebastian	– German Library Association, commission for customer-oriented services (Member) – Group of speakers of the MPS information professionals (Member), 2018– – Research Data Management Group of the MPI for Human Development (Member), 2018–
Oberländer, Alexandra	– *Kritika: Explorations in Russian and Eurasian History* (Associate Editor), 2018–
Obradovic, Nick	– Climate Lab, Skoll Global Threats Fund (Advisory Council Member), 2014–2017
Oña, Linda S.	– Ethics Committee of the MPI for Human Development (Member), 2019–
Pachur, Thorsten	– International Max Planck Research School on the Life Course (LIFE) (Faculty Member) – International Max Planck Research School on Computational Methods in Psychiatry and Ageing Research (COMP2PSYCH) (Faculty Member) – *Decision* (Editorial Board) – *Journal of Behavioral Decision Making* (Editorial Board) – *Journal of Experimental Psychology: Applied* (Consulting Editor) – *Journal of Experimental Psychology: Learning, Memory, and Cognition* (Consulting Editor)
Pernau, Margrit	– AK im VdH Weltreligion und Globale Geschichte (Board), 2018–2019 – Berlin Graduate School Muslim Cultures and Societies, Freie Universität Berlin (Principal Investigator) – Freie Universität Berlin, MA Global History (Faculty Member) – German Historical Institute London (Advisory Board), 2019– – History of Concepts Group (Vice Chair), 2018– – International Max Planck Research School for Moral Economies of Modern Societies (Principal Investigator) – Internet Portal "History of Emotions—Insights into Research" (Co-Editor) – Series "Globalgeschichte: Theorien, Ansätze, Themen" (Co-Editor) – Sustainability at Work Committee of the MPI for Human Development (Co-Coordinator), 2019 – The History of Concepts Group (HCG) (Executive Board Member) – *Contributions to the History of Concepts* (Co-Editor), 2017– – *Emotions: History, Culture, Society* (Editorial Board), 2017 – *Geschichte und Gesellschaft. Zeitschrift für Historische Sozialwissenschaft* (Editorial Board)
Pietraszewski, David	– *Evolution and Human Behavior* (Editorial Board)
Pleskac, Timothy J.	– Association for Psychological Science (Fellow) – *Decision* (Editorial Board) – *Journal of Behavioral Decision Making* (Editorial Board) – *Journal of Experimental Psychology: General* (Associate Editor) – *Psychological Science* (Associate Editor)
Rahwan, Iyad	– Council on Extended Intelligence, initiative of IEEE & MIT Media Lab (Member), 2018–2020 – Institute for the Development of Internet, Spain (Scientific Advisory Board) – International Conference on Artificial Intelligence, Ethics and Society (AIES) (Programm Committee Member), 2018 – International Conference on Computational Social Science (IC2S2) (Programm Committee Member), 2017, 2018, 2019 – International School & Conference on Network Science (NetSci) (Programm Committee Member), 2017, 2018, 2019 – UAE Artificial Intelligence Strategy, Dubai Future Foundation (Advisory Group Member), 2018 – *Artificial Intelligence* (Editor), 2017–2020 – *Autonomous Agents and Multiagent Systems* (Associate Editor), 2010–2018 – *MIT Technology Review (Arabic edition)* (Advisory Board), 2018–2020

Raz, Naftali	– International Max Planck Research School on the Life Course (LIFE) (Faculty Member), 2017–
Reiber, Lisa	– Research Data Management Group of the MPI for Human Development (Member), 2018–
Rioux, Camille	– Scientific Staff Committee of the MPI for Human Development (Member), 2017– – Sustainability at Work Committee of the MPI for Human Development (Member), 2019–
Ruggeri, Azzurra	– Ethics Committee of the MPI for Human Development (Member), 2017, 2018–2019 – International Max Planck Research School on the Life Course (LIFE) (Faculty Member)
Sander, Myriam C.	– Berlin School of Mind and Brain (Faculty Member), 2018 – International Max Planck Research School on the Life Course (LIFE) (Faculty Member)
Schroeder, Sascha	– Ethics Committee of the MPI for Human Development (Member), 2012–2017 – EU-COST Action E-REaD (Workgroup Coordinator), 2014–2018 – PISA 2018 Reading Expert Group (Member), 2014–2018 – Scientific Advisory Board for Higher Education Statistics, Federal Statistical Office of Germany (Member)
Schröer, Frederik	– Contributions to the History of Concepts (Social Media Editor), 2017–2019 – German research group "Arbeitskreis Geschichte-Gesellschaft-Gewalt" (Member), 2019– – International research group "Aesthetics of Religious Belonging: Asian Perspectives" (Founding Member), 2018– – Sustainability at Work Committee of the MPI for Human Development (Member), 2019–
Schuck, Nicolas W.	– Einstein Center Neurosciences, Berlin (Member), 2018– – Ethics Committee of the MPI for Human Development (Member), 2018– – International Max Planck Research School on Computational Methods in Psychiatry and Ageing Research (COMP2PSYCH) (Faculty Member), 2017 – International Max Planck Research School on the Life Course (LIFE) (Faculty Member), 2017– – Research Data Management Group of the MPI for Human Development (Member), 2018– – *Neuropsychologia* (Guest Editor), 2019–2020
Schulze, Christin	– Equal Opportunities Representative of the MPI for Human Development, 2020– – International Max Planck Research School on the Life Course (Faculty), 2018–
Spitzer, Bernhard	– Berlin School of Mind and Brain (Associated Member) – International Max Planck Research School on Computational Methods in Psychiatry and Ageing Research (COM2PSYCH) (Faculty Member), 2018– – Research Data Management Group of the MPI for Human Development (Member), 2018–
Thoma, Anna	– Research Data Management Group of the MPI for Human Development (Member), 2018–
van den Bos, Wouter	– International Max Planck Research School on Computational Methods in Psychiatry and Ageing Research (COMP2PSYCH) (Faculty Member) – *Frontiers in Human Neuroscience* (Review Editor) – *Frontiers in Psychology: Decision Neuroscience* (Review Editor) – *Journal of Open Psychology Data* (Editorial Board)
von Oertzen, Timo	– International Max Planck Research School on Computational Methods in Psychiatry and Ageing Research (COMP2PSYCH) (Faculty Member) – International Max Planck Research School on the Life Course (LIFE) (Faculty Member)

Wagner, Gert G.	– Advisory Council for Consumer Affairs (Sachverständigenrat für Verbraucherfragen), German Ministry of Justice and Consumer Protection (BMJV) (Member)
	– Ethics board of AEGIS (Advanced Big Data Value Chain for Public Safety and Personal Security), an EC H2020 Innovation Action (Member), 2018–2019
	– Ethics board of the European Social Survey; a European Research Infrastructure Consortium (ESS-ERIC) (Member), 2019–
	– Federal Government's Commission on a "Reliable Intergenerational Contract" (Kommission Verlässlicher Generationenvertrag) (Member), 2018–2020
	– German Data Forum (RatSWD), Member, 2002–2017
	– German Federal Government's Social Advisory Council (Sozialbeirat der Bundesregierung) (Member)
	– German Institute for Economic Research (DIW Berlin) (Member of the Executive Board), 2017
	– German Socio-Economic Panel Study (SOEP) (Senior Research Fellow), 2018–
	– Interdisciplinary working group "Implications of Digitalization for the Quality of Science Communication" of the Berlin–Brandenburg Academy of Sciences and Humanities (BBAW) (Member), 2018–2021
	– IPD-Work Consortium (Member)
	– National Academy of Science and Engineering (acatech) (Elected Member)
	– Social Science Genetic Association Consortium (SSGAC) (Member)
	– Technische Universität Berlin (Full Professor of Economics), 2002–2018
	– The Leibniz Association's Commission for Research Ethics (Member), 2018–
	– Research Data Management Group of the MPI for Human Development (Member), 2018–
	– *PLOS ONE* (Editorial Board), 2018–
Wambach, Julia	– Sustainability at Work Committee of the MPI for Human Development (Member), 2019–
Wegwarth, Odette	– BMBF project "Preference of elderly people presenting with multimorbidity: An evidence map and systematic review," Goethe University Frankfurt am Main, Institute for General Medicine (Scientific Advisory Board), 2018–
	– G-BA-Innovationsfond–Project "ERIC: Enhanced recovery after intensive care," Charité Universitätsmedizin Berlin, Department of Anesthesiology/Division of Operative Intensive Care Medicine (Scientific Advisory Board), 2019–
	– World Health Organization (WHO)/Regional Office Europe (Invited Expert for the WHO initiative on improving policy decision-making on screening), 2019–
	– *Scientific Reports* (Editorial Board), 2019–
Werkle–Bergner, Markus	– International Max Planck Research School on the Life Course (LIFE) (Faculty Member)
	– Representative of the MPI for Human Development in the Human Science Section of the MPG, 2012–2018
Wertz, Annie E.	– 30th Annual Human Behavior and Evolution Society Conference (Program Committee Member), Amsterdam, Netherlands, 2018
	– Ethics Committee of the MPI for Human Development (Member)
	– Faculty Search Committee, Einstein Professorship, Department of Psychology, Humboldt-Universität zu Berlin (External Member), 2019
	– International Max Planck Research School on the Life Course (LIFE) (Faculty Member)
	– Leipzig Centre for Early Child Development (LFE) (Affiliate), 2017–
	– Selection Committee, Free-Floating Max Planck Research Group Leader Positions, Max Planck Society (Member), 2018
	– *Evolution and Human Behavior* (Consulting Editor), 2019–
Wittkuhn, Lennart	– Organization for Human Brain Mapping (OHBM) (Member), 2019
Woike, Jan K.	– *Frontiers in Psychology: Cognitive Science* (Review Editor)
Wu, Charley M.	– Max Planck Society PhDnet (Executive Representative of the MPI for Human Development), 2017–2018

5. Academic Degrees 2017–2019/20

Habilitations

Brauer, Juliane (2018). Zukunft als Programm: Jugend, Musik und die Erziehung der Gefühle in der Sowjetischen Besatzungszone und der DDR (1945–1973). Technische Universität Dresden.

Gammerl, Benno (2018). anders fühlen: Homosexualitäten und Gefühlsleben zwischen Stadt und Land in der Bundesrepublik (1960-1990). Freie Universität Berlin.

Hitzer, Bettina (2017). Krebs fühlen: Die Emotionsgeschichte der Krebserkrankung im 20. Jahrhundert. Freie Universität Berlin.

Laukötter, Anja (2018). Politik im Kino: Eine Emotions- und Wissenschaftsgeschichte des Sexualaufklärungsfilms im 20. Jahrhundert. Humboldt-Universität zu Berlin.

Schulte-Mecklenbeck, Michael (2017). Opening the blackbox: Information processing in human decision-making. University of Bern.

Werkle-Bergner, Markus (2019). Associative and strategic components of memory development across the lifespan: Towards the neural correlates. Ruhr-Universität Bochum.

Doctoral Dissertations

Adolf, Janne (2017). Contextualizing the dynamics of affective functioning: Conceptual and statistical considerations. Humboldt-Universität zu Berlin.

Bähr (Menniken), Marvin T. (2020). Grassroots veterans: The American legion and conservative change in California, 1945-2000. Freie Universität Berlin.

Benger Alaluf, Yaara (2018). The emotional economy of British seaside holidaymaking 1870–1918. Freie Universität Berlin.

Dahl, Martin J. (2019). Neuromodulation and rhythmic neural activity shape cognition across the adult lifespan. Freie Universität Berlin.

Dallacker, Mattea (2017). Social determinants of obesity: How parents shape the eating behavior and body weight of their children. Freie Universität Berlin.

de Groot, Timon (2018). Shame and the search for rehabilitation: Pardoning practices in Germany 1870–1933. Humboldt-Universität zu Berlin.

Driver, Charles C. (2017). Hierarchical continuous time dynamic modelling for psychology and the social sciences. Humboldt-Universität zu Berlin.

Franke, Paul (2019). The production of "Monaco" and "Las Vegas" as sites of (un)moral economies. Humboldt-Universität zu Berlin.

Gerlach, Philipp (2017). The social framework of individual decisions. 570+1 experiments in (un)ethical behavior. Humboldt-Universität zu Berlin.

Hartmann, Sophie (2017). Risikobewältigung in der Luftfahrt und in der Medizin: Eine vergleichende Untersuchung. Humboldt-Universität zu Berlin.

Hilbrand, Sonja (2017). Why care? The impact of ancestral grandparental investments on caregiving and health today. University of Basel.

İlengiz, Çiçek (2019). Politics of madness: Narrativizing, memorializing, sacralizing Şeywuşen (1930–1995) in Dersim, Turkey. Technische Universität Berlin.

Kleemeyer, Maike M. (2017). Exercise—A cerebral anti-aging cure? Effects of regular physical activity on the senescent brain and cognition. Humboldt-Universität zu Berlin.

Kvam, Peter (2017). Modeling decisions among many alternatives. Michigan State University.

Laube, Corinna (2018). Teens, testosterone and time: Neural, endocrinological and contextual correlates of adolescent impulsivity. Humboldt-Universität zu Berlin.

Leuker, Christina (2018). Risks, rewards, and rationality: How knowing that you probably won't hit the jackpot affects your judgments and decisions. Humboldt-Universität zu Berlin.

Lindner, Thomas (2020). Transnational networks of anti-imperialism: Mexico in the long 1920s. Technische Universität Berlin.

Litvinova, Aleksandra (2019). Extending the wisdom of crowds: How to harness the wisdom of the inner crowd. Freie Universität Berlin.

Mühlroth, Beate E. (2020). Sleep-associated consolidation of espisodic memories in old age: The challenge of studying cognitive and cerebral aging. Freie Universität Berlin.

Raffington, Laurel (2018). Socioeconomic disparities in children's cognitive development: Longitudinal dynamics and stress mechanisms. Humboldt-Universität zu Berlin.

Rohrer, Julia M. (2019). Empirical and conceptual perspectives on the determinants of subjective well-being. Leipzig University.

Schmitterer, Alexandra (2017). Lesevorbereitung—Die Entwicklung lexikalischer Repräsentationen im Zusammenhang mit dem Schriftspracherwerb. Freie Universität Berlin.

Schnädelbach, Sandra (2017). Entscheidende Gefühle: Rechtsgefühl und juristische Emotionalität in der deutschsprachigen Jurispridenz 1870–1933. Freie Universität Berlin.

Steininger, Fabian (2017). Morality, emotions, and political community in the late Ottoman Empire (1878–1908). Freie Universität Berlin.

Szymanski, Caroline (2017). Neural synchronization patterns during interpersonal action coordination. Humboldt-Universität zu Berlin.

Trautwein, Jutta (2019). The mental lexicon in acquisition—Assessment, size & structure. University of Potsdam.

Włodarczyk, Aleksandra (2019). Response to naturalistic threats in infancy. Freie Universität Berlin.

Wu, Charley M. (2019). Guided by generalization and uncertainty: A theory of human learning and exploration. Humboldt-Universität zu Berlin.

Yahosseini, Kyanoush S. (2020). Experimental study and modeling of three classes of collective problem-solving methods. Freie Universität Berlin.

Master's and Diploma Theses

Boer, Maurice (2018). For the bond of love: Colonial knowledge, philanthropy, and the society "Oost en West" (1899–1933). Freie Universität Berlin.

Bögl, Katharina (2018). Early stress in body, brain, and behavior. Modeling the relations of a chronic stress measure, hippocampal subfield volume, and mnemonic similarity decision in six-to-seven-year old children. Humboldt-Universität zu Berlin.

Berner, Marie / Schieck, Diana (2018). Prokrastination. Subjektivierung. Affekt: Eine qualitative Untersuchung der begleitenden Affekte bei der Prokrastination vor dem Hintergrund der Subjektivierung von Arbeit. International Psychoanalytic University Berlin.

Brenner, Marta (2017). Die Erfassung antizipatorischer Blickbewegungen als Maß der Kategorisierungsfähigkeiten im frühen Kindesalter. University of Potsdam.

Bretzke, Maria (2017). Active control of study leads to improved word learning in children. Otto von Guericke University Magdeburg.

Dähmlow, Marie (2018). How does your garden grow? How children learn about their natural environment. Humboldt-Universität zu Berlin.

De Simone, Costanza (2017). Gesture imitation in a naturalistic context. MSB Medical School Berlin.

Fischer, Lina–Mieke (2018). Exploring the quality of family meals—Associations between meal duration and atmosphere. University of Greifswald.

Gerbaulet, Kimberly (2019). Under pressure: The effect of time pressure on directed and random exploration. Osnabrück University.

Gerdemann, Stella (2018). Categorization of plants and novel artifacts in infancy. Leipzig University.

Güner, Hilal Sahesde (2019). Effects of online information search on learning outcomes. TUM School of Education, Technical University Munich.

Hell, Kseniya (2019). The politicization of the issue of comfort women. Freie Universität Berlin.

Hille, Maike (2019). The neural basis of motor sequence learning in children and adults. Freie Universität Berlin.

Klimin, Tatiana (2019). A threat to itself: "Civilization" in international law and politics. Freie Universität Berlin.

Koch, Christoph (2017). The architecture of parieto-frontal white matter tracts predicts interindividual differences in intelligence. Ruhr-Universität Bochum.

Kozodoi, Nikita (2017). Predicting box-office revenues: Heuristics versus computer-driven methods. Humboldt-Universität zu Berlin.

Krause, Maria–Thea (2020). Analysis of information in leaflets on ovarian cancer screening. Jade University for Applied Science.

Krause, Michael (2017). Decoding digit representations from EEG data. Freie Universität Berlin.

Kundu, Arunima (2018). England as a transformative experience: Indian students' perception of the self and the other in late 19th century Britain (1878–1894). Freie Universität Berlin.

Link, Leonhard (2018). Entmündigungen und die Psychopathologie ehelicher Gewalt: Wissenskonstruktion und forensische Begutachtung, ca. 1900–1915. Freie Universität Berlin.

Löwe, Anika (2020). Trial-wise feedback leading to uninstructed spontaneous strategy switches. Freie Universität Berlin.

Maier, Patrizia M. (2018). Do neural processes in visual short-term memory change over the life span? Age differences in hemispheric lateralization in contralateral delay activity. Humboldt-Universität zu Berlin.

Meine, Laura E. (2017). The effects of chronic stress on reward anticipation-mediated memory enhancement in children. Freie Universität Berlin.

Mende, Melinda A. (2017). The combination of EEG hyperscanning and EEG neurofeedback in social interaction. Humboldt-Universität zu Berlin.

Mohn, Johannes J. (2019). Testing the longitudinal links among executive functions, prefrontal cortex structure, and socioeconomic status in middle childhood. Humboldt-Universität zu Berlin.

Moneta, Nir (2019). Value spillover: How contextually irrelevant values influence choice behavior. Freie Universität Berlin.

Morina, Fitore (2020). Differences in oscillatory mechanisms of episodic memory formation in younger and older adults. Ruhr-Universität Bochum.

Nüesch, Lorena (2018). Morphological decomposition of German particle and prefixed verbs in single-word and sentence reading. Universities of Groningen, Potsdam, and Eastern Finland.

Pauley, Claire (2020). Age differences in the effects of contextualisation on the similarity of memory representations. Carl von Ossietzky Universität Oldenburg.

Polk, Sarah E. (2019). Exercise and the brain: Changes in gray matter and cognition in older adults. Freie Universität Berlin.

Pöthke, Sarah (2017). Determinanten des Schriftspracherwerbs: Zum Einfluss kognitiver, sozialer und behavioraler Merkmale auf die Lese- und Rechtschreibkompetenz von Grundschülern. University of Rostock.

Remer, Felicitas (2019). Between Degania and Tel Aviv: Urbanism and ruralism in Zionist settlement ideology and nation-building, c. 1890–1939. Freie Universität Berlin.

Riccius, Lana J. A. (2018). The effects of curiosity and information prediction error on memory in children and adolescents. University of Potsdam.

Roth, Veronika (2018). Ermittlung und Analyse von Nutzerbedarfen im Rahmen der Entwicklung eines neuen Nutzungskonzepts am MPI für Bildungsforschung: Eine Befragung. Humboldt-Universität zu Berlin.

Ruthe, Marcella (2017). Infants' descent strategies in the transition phase from crawling to walking. Freie Universität Berlin.

Salholz–Hillel, Maia (2017). Inferring binary choice from Bayesian estimates of medical diagnostic test outcomes. Humboldt-Universität zu Berlin.

Samartzidis, Lasare (2019). Who finds what repugnant and why? Kiel University.

Schirren, Clara (2018). Modeling utility of tests in medical diagnosis: Beyond purely informational approaches. Humboldt-Universität zu Berlin.

Skowron, Alexander (2019). Dopaminergic effects on reinforcement learning in older adults: BOLD variability as a marker of individual differences. Freie Universität Berlin.

Sommer, Andreas (2019). Contributing factors to active learning. Humboldt-Universität zu Berlin.

Thoma, Anna (2018). When actions do not speak louder than words: A multi-method approach to dyadic multiple-cue inference. Humboldt-Universität zu Berlin.

Tochadse, Marija (2019). Neural dynamics of scene viewing. Freie Universität Berlin.

Trouillet, Léonie (2017). Investigation of the relationship of the P3 to indices of noradrenergic activity. Freie Universität Berlin.

Trüggelmann, Ute (2017). Selbstregulativer Prozess und subjektives Wohlbefinden über die Lebensspanne. University of Potsdam.

Unger–Nübel, Anna (2019). Spatial navigation and microstructural brain plasticity in overwinterers at Neumayer III Station in Antarctica. Humboldt-Universität zu Berlin.

van den Elzen, Evi (2019). Human single- and multi-cell variability in response to image feature-richness as a marker of effective memory encoding. Tilburg University.

Vidal Orga, Blanca (2020). The role of social information in non-human great apes' behavioral responses to plants. Humboldt-Universität zu Berlin.

Vogt, Karoline (2017). Koffein als Einflussfaktor bei struktureller und funktioneller Magnet-Resonanz-Tomografie (MRT). Freie Universität Berlin.

Walther, Anna (2017). "Der Frosch war so in ein Dose drin. Und danach wollte er wieder raus. Er ist rausgegangen": Der Einfluss einer Sprachfördermethode auf die Entwicklung der narrativen Fähigkeiten bei bilingualen Vorschulkindern. University of Potsdam.

Wehmeier, Sarah (2018). Sleep-dependent memory consolidation in 5- to 6-year-old children. Freie Universität Berlin.

Wilhelm, Christoph (2017). Umweltgerechtigkeit: Eine Analyse sozialraumbezogener gesundheitsrelevanter Ungleichheiten zur Information der Stadtplanung. Pilotstudie zur Stadt Fulda. Fulda University of Applied Sciences.

Wright, Chelsea (2019). A preliminary analysis exploring young children's touch behavior towards plants in a naturalistic garden setting. University of Potsdam.

6. Research and Academic Staff 2017–2019/20

The positions given represent the latest level held at the Institute.

Abbott, Joshua T.
Postdoc (B.A. [Hons.] in Computer Science, 2009, New College of Florida; MPhil in Computer Science (CSTIT), 2010, University of Cambridge; PhD in Psychology, 2016, University of California, Berkeley): Computational models of cognition; generalization, concept learning, and categorization; semantic representations; approximations to Bayesian inference. (ARC)

Adolf, Janne
Postdoc (Diploma in Psychology, 2013, Humboldt-Universität zu Berlin; Dr.rer.nat. in Psychology, 2017, Humboldt-Universität zu Berlin): Statistical modeling of psychological data; multivariate modeling of change; measurement (in-)variance; methodological strategies and theoretical principles that integrate intra- and interindividual psychological findings. (LIP)

Afacan, Şeyma
Postdoc (B.A. in History, 2008, Boğaziçi University Istanbul; M.A. in History, 2010, Sabancı University Istanbul; DPhil in History of Medicine, 2017, University of Oxford): History of emotions; history of medicine; history of science; late Ottoman cultural and intellectual history. (HoE)

Amico, Michael
Researcher (B.A. in Women's and Gender Studies, 2007, Dartmouth College; MPhil in American Studies, 2012, Yale University; PhD in American Studies, 2017, Yale University): Emotion; sexual desire; sexual difference; same-sex attraction; psychoanalysis; material culture and the built environment; theater and dramaturgy; sound and music; American history; critical theory and philosophy of history; aesthetics. (HoE)

Appelhoff, Stefan
Predoc (B.A. in Integrated Social and Cognitive Psychology, 2015, Jacobs University Bremen; M.Sc. in Social, Cognitive, and Affective Neuroscience, 2017, Freie Universität Berlin): Decisions from experience; exploration vs. exploitation; statistical learning; reinforcement learning; artificial intelligence; machine learning; electroencephalography (EEG); brain-computer-interfaces. (ARC)

Arndt, Agnes
Researcher (M.A. in Modern and Contemporary History, 2006, Freie Universität Berlin; Dr.phil. in Modern History, 2012, Freie Universität Berlin): Modern European, especially East Central European, history; comparative and transnational history; history of emotions and historical semantics. (HoE)

Arslan, Ruben C.
Research Scientist (Diploma in Psychology, 2013, Humboldt-Universität zu Berlin; Dr.rer.nat. in Biological Personality Psychology, 2017, University of Göttingen): Risk preferences; intelligence; personality; biological influences on individual differences; evolutionary genetics; ovulation; evolutionary demography. (ARC/Max Planck Fellow)

Artinger, Florian
Research Scientist (B.A. [Hons.] in Politics and Economics, 2002, University of Newcastle; M.Sc. in Economics and Management, 2006, Humboldt-Universität zu Berlin; Dr.phil. in Economics, 2012, Technische Universität Berlin): Heuristics; decision strategy; ecological rationality; economics; management. (ABC/ARC)

Bähr (Menniken), Marvin
Postdoc (B.A. in Political Science and History, 2012, University of Freiburg; M.A. in History, 2015, Freie Universität Berlin): Political history; history of social movements; global history. (MEMS/HoE)

Barua, Rukmini
Researcher (B.A. in Sociology, 2002, University of Delhi; M.A. in Sociology, 2004, University of Delhi; MPhil in Sociology, University of Delhi; Dr.phil. in History, 2016, University of Göttingen): Labour history; urban history; family, kinship, and intimacy. (HoE)

Baum, Ina
Research Coordinator (B.A. in Communication Studies, International Management, 2007, Hamline University; M.A. in International Relations, 2015, Freie Universität Berlin): International institutions and negotiations; research administration. (Harding Center)

Baumert, Jürgen
Emeritus (State Examination for Teachers, 1968, Universität Hamburg; Dr.phil. in Classical Philology and Philosophy, 1968, University of Tübingen; Habilitation in Educational Sciences, 1982, Freie Universität Berlin; Fellow of the Max Planck Society; Director at the Institute until 2010; Honorary Professor of Educational Sciences, Freie Universität Berlin and Humboldt-Universität zu Berlin; Vice President of the Max Planck Society, 2006–2008): Research in learning and instruction; development of cognition and motivation during adolescence and young adulthood; teachers' professional competence; large-scale assessment and international comparison; dynamics of institutional change.

Beese, Caroline
Postdoc (B.A [Hons.] in International Studies: Language and Culture, 2012, University of Greenwich London; M.Sc. in Cognitive Neuroscience Radboud University, Nijmegen: Dr.rer.nat. in Neuroscience, 2019, Universität Leipzig): Interplay between language processing and working memory; Cognitive and neural changes across the lifespan; Relation between temporal integration and structural connectivity. (LIP)

Beljan, Magdalena
Researcher (M.A. in Literature Studies, History, and Text Technology, 2006, Bielefeld University; PhD in Literature, 2010, University of Luxembourg): History of emotions and of the body; gender and sexuality; literary theory; media history; homosexuality; masculinity; design history and visual studies; popular culture. (HoE)

Bender, Andrew R.
Postdoc (B.S. in Psychology, 1998, University of Arizona; M.A. in Experimental Psychology, 2006, San Diego State University; PhD in Psychology, Behavioral & Cognitive Neuroscience, 2013, Wayne State University): Bidirectional influences between brain structure and cognition across the lifespan; structural brain correlates of individual differences in episodic memory; physiological and genetic modifiers of brain–cognition relations. (LIP)

Benger Alaluf, Yaara
Researcher (B.A. in Jewish Studies and International Relations, 2011, The Hebrew University of Jerusalem; M.A. in Sociology, 2013, The Hebrew University of Jerusalem): Entanglement of emotional and economic practices and discourses; History of sciences and expertise; History of consumer culture; therapeutic cultures. (HoE)

Binder, Julia C.
Postdoc (B.Sc. in Psychology, 2007, University of Basel; M.Sc. in Psychology, 2010, University of Basel; Dr.phil. in Psychology, 2015, University of Zurich): Cognitive training in healthy old age; cognitive and neural plasticity across the lifespan; developmental processes of learning and memory. (LIP)

Bodammer, Nils C.
Research Scientist (Diploma in Physics, 1996, Freie Universität Berlin; Dr.rer.nat. in Physics, 2005, Otto von Guericke University Magdeburg; Head of MR Physics): MR-based multiparameter imaging and MR spectroscopy (1H and 31P) in neuroscience and aging research. (LIP)

Brandmaier, Andreas M.
Senior Research Scientist (Diploma in Computer Science, 2008, Technische Universität München; Dr.rer.nat. in Computer Science, 2012, Saarland University): Brain–behavior relations across the lifespan; multivariate developmental methodology; formal models of behavioral change; machine learning and data mining; statistical and algorithmic modeling. (LIP/ Max Planck UCL Centre)

Brauer, Juliane
Researcher (M.A. in History and Musicology, 2001, Humboldt-Universität zu Berlin; Dr.phil. in History, 2007, Freie Universität Berlin; Habilitation in Modern History, 2019, Technische Universität Dresden): Music making as an emotional practice; music education and singing in Germany; history of education; music and torture; emotions and learning history; culture and practices of remembrance in European contexts; popular history culture. (HoE)

Brehmer, Yvonne
Otto Hahn Research Group Leader (Diploma in Psychology, 2003, Saarland University; Dr.rer.nat. in Psychology, 2006, Humboldt-Universität zu Berlin; Otto Hahn Research Group Leader until 04/2018): Cognitive plasticity in childhood and old age; memory training across the lifespan; neural correlates of age-related cognitive changes. (Otto Hahn Research Group)

Brose, Annette
Humboldt-Universität zu Berlin and LIP Associate (Diploma in Psychology, 2006, Freie Universität Berlin; Dr.rer.nat. in Psychology, 2009, Humboldt-Universität zu Berlin): Intraindividual variability and intraindividual change; linkages between emotion, motivation, and cognition; stress reactivity and affective dynamics. (LIP)

Buchberger, Elisa S.
Predoc (B.Sc. in Psychology, 2017, Bielefeld University; M.Sc. in Psychology, 2019, Humboldt Universität zu Berlin): Hippocampal maturation across childhood; development of memory generalisation and specificity across childhood. (LIFE/LIP)

Buscemi, Francesco
Researcher (B.A./M.A. in History, 2004– 2010, Scuola Normale Superiore; M.A. in History, 2009, University of Pisa & École Pratique des Hautes Études; PhD in History, 2016, University of Paris 1 Panthéon-Sorbonne & Scuola Normale Superiore; Postgraduate Master in Digital Humanities, 2016, Ca' Foscari University of Vencie): 18th-century culture and French revolution; Napoleonic age; history of emotions; religious reactions to the Enlightenment and the French revolution; cultural history of Catholicism; history of reading; modern Italian and French history; digital humanities. (HoE)

Butler, Oisin
Predoc (B.Sc. in Psychology, 2007, Birkbeck, University of London; M.Sc. in Neuroscience, 2010, King's College London; Dr.rer.nat. in Psychology, 2018, Humboldt-Universität zu Berlin): Neural plasticity; structural and functional neuroimaging; combat and stress exposure. (LIFE/LIP)

Cancian, Sonia
Postdoc (B.A. in French/English Translation [French Studies], 1990, Concordia University; B.A. [Hons.] in Italian Studies, 1997, York University; M.A. in Italian Studies, 1999, McGill University; PhD in History, Anthropology, 2008, Concordia University): Migration; Italy; Canada; 20th century; war; memory studies; women's and gender history; family history; social citizenship; personal correspondence; personal narratives; oral history; digital history. (HoE)

Cebrian, Manuel
Research Group Leader (B.Sc. in Computer Science, 2003, Universidad Autonoma de Madrid; PhD in Computer Science, 2007, Universidad Autonoma de Madrid): Computational social science; network science; crowdsourcing. (CHM)

Chien, Samson
Postdoc (PhD in Informatics, 2019, Universität Hamburg): Reinforcement learning; deep neural network; machine learning; convergence of neuroscience and artificial intelligence. (MPRG NeuroCode)

Christophel, Thomas
Research Scientist (Diploma in Psychology, 2008, University of Bremen; Dr.rer.nat. in Psychology, 2013, Humboldt-Universität zu Berlin): Cognitive neuroscience; neuroimaging; neural correlates of working memory; working memory storage. (ARC)

Ciranka, Simon
Predoc (B.Sc. in Psychology, 2015, Justus Liebig University Giessen; M.Sc. in Psychology, 2017, Technische Universität Dresden): Adolescence; social learning; computational modeling of decisions under uncertainty; neuronal mechanisms of adaptive learning. (COMP2PSYCH/ARC)

Clarmann von Clarenau, Verena
Predoc (B.Sc. in Biosciences; 2015, Ruprecht-Karls-Universität Heidelberg; M.Sc. in Systems Biology, 2018, Heidelberg University): Computational modeling of human decision-making; decision-making based on experience; perception of and decision-making based on numerical information and risk; interrelation of computational neuroscience and cognitive modeling. (COMP2PSYCH/ARC)

Cole, Whitney G.
Postdoc (B.A. in Psychology and French, 2006, Hollins University; M.A. in Experimental Psychology, 2008, College of William and Mary; PhD in Developmental Psychology, 2013, New York University): Perceptual motor development, motor learning and skill acquisition; locomotion, walking, crawling, and brachiating; interactions between perception, cognition, and action. (LIP)

Cummins, Stephen
Researcher (B.A. in History, 2008, University of Cambridge; MPhil in Early Modern History, 2009, University of Cambridge; PhD in History, 2015, University of Cambridge): History of emotions; history of crime and justice; history of religion; early modern European history; history of southern Italy and Spanish Naples. (HoE)

Czienskowski, Uwe
Research Scientist (Diploma in Psychology, 1990, Freie Universität Berlin; Dr. phil. in Psychology, 1995, Freie Universität Berlin; Diploma [FH] in Computer Science, 2007, Trier University of Applied Sciences): Software development for scientific research; experimental design and analysis; meta-analysis; general statistics; philosophy and history of science. (ABC/Harding Center)

Dahl, Martin J.
Postdoc (B.Sc. in Psychology, 2011, Justus Liebig University Giessen; M.Sc. in Psychology, 2014, University of Konstanz; Dr.rer.nat. in Psychology, 2020, Freie Universität Berlin): Lifespan age differences in rhythmic neural activity, their anatomical foundations and functional implications; interplay of central norepinephrine and neural oscillations in selective information processing; top-down control over memory in PTSD. (LIP)

Dai, Junyi
Postdoc (B.Sc. in Physics, 2002, Fudan University; M.Sc. in Experimental Psychology, 2005, East China Normal University; M.A. in Human Factors, 2009, University of South Dakota; M.Sc. in Applied Statistics, 2013, Indiana University Bloomington; PhD in Cognitive Psychology, 2014, Indiana University Bloomington): Intertemporal choice; cognitive modeling; Bayesian data analysis. (ARC)

Dallacker, Mattea
Research Scientist (B.Sc. in Psychology, 2011, Osnabrück University; M.Sc. in Psychology, 2014, Freie Universität Berlin; Dr.phil. in Psychology, 2017, Freie Universität Berlin): Eating behavior; health literacy; boosting decision-making. (ARC)

Dandekar, Deepra
Researcher (M.A. in History, 1997, University of Delhi; MPhil in Ancient Indian History, Culture & Archaeology, 1999, Deccan College Post-Graduate & Research Institute, Pune; Diploma in Women's Studies, 2003, University of Pune; PhD in Ancient Indian History, Culture & Archaeology, 2010, Deccan College Post-Graduate & Research Institute, Pune): South Asian studies (India); religious studies (Hinduism, Sufism, and Christian missions in India); history of the 19th and 20th century in India; gender/women's studies; postcolonialism and minority studies; literature and media studies. (HoE)

Danilina, Anna
Predoc (M.A. in Political Science, Philosophy, Religious Studies, 2013, Leipzig University): Research on antisemitism and racism; history of emotions; history of the body; critical theory; postcolonial theory; critical race theory. (MEMS/HoE)

De Simone, Costanza
Predoc (M.Sc. in Clinical Psychology, 2018, MSB Medical School Berlin): Information search; question asking; web environments; active learning; social learning; selective trust; socio-cognitive development. (MPRG iSearch)

Delius, Julia A. M.
Research Scientist (State Examination in Medicine, 1988, Universität Hamburg; Dr.med., 1993, Goethe University Frankfurt am Main; Editorial Coordinator, LIFE Newsletter Editor): Interdisciplinary gerontology; editorial projects; scientific coordination. (LIP)
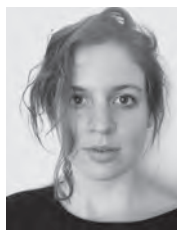
Deserno, Marie K.
Postdoc (M.Sc. [Hons.] in Psychological Methods, 2014, University of Amsterdam; PhD [Hons.] in Psychology, 2019, University of Amsterdam): Cognition in developing populations using multivariate modeling techniques; models of change using network models and structural equation modeling; developmental psychopathology. (LIP)

Domberg, Andreas
Postdoc (Diploma in Interpreting, 2010, Leipzig University; M.A. in Linguistics, 2014, Leipzig University; PhD in Psychology, 2018, University of Manchester & MPI for Evolutionary Anthropology): Reasoning; argumentation; motivation; development; social cognition; selective trust; information search; information evaluation; reason giving; pragmatics. (MPRG iSearch)

Driver, Charles C.
Research Scientist (B.A. in Psychological Science [Hons.], 2012, University of Queensland; Dr.rer. nat. in Psychology, 2017, Humboldt-Universität zu Berlin): Time series; continuous time modeling; cross-lagged panel design; structural equation modeling; causality; longitudinal data analysis; panel design; inter- and intraindividual differences; intraindividual changes. (LIP)

Düzel, Sandra
Senior Research Scientist (Diploma in Health Science, 2001, Magdeburg-Stendal University of Applied Sciences; Dr.rer.nat. in Psychology, 2010, Otto von Guericke University Magdeburg): Learning and memory; lifestyle; aging; time perspectives; subjective health horizon; brain structure; cognitive aging; structural neuroimaging. (LIP)

Edelstein, Wolfgang (†)
Emeritus (Dr.phil. in Medieval Studies, 1962, Heidelberg University; Fellow of the Max Planck Society; Director at the Institute until 1997; Dr. h.c. in Social Science, University of Iceland; Honorary Professor of Educational Science, Freie Universität Berlin and University of Potsdam): Development and socialization; social-cognitive and moral development; developmental and structural aspects of curriculum and instruction; developmental and school related conditions of successful learning; conditions of successful school transformation.

Eilers, Sarah
Predoc (B.A. in German and English Studies, 2010, University of Göttingen; M.Ed. in German and English, 2013, University of Göttingen): Cognitive language processing; reading comprehension and development; eye tracking in reading research. (MPRG REaD)

Ellermann, Christin
Research Scientist (B.A. in Public Health and Sports Science, 2010, University of Bremen; M.Sc. in Public Health, 2012, Freie Universität Berlin): Psycho-social prevention and health promotion; evidence-based nursing and public health. (Harding Center/Emeritus Group Gigerenzer)

Elsner, Claudia
Postdoc (Diploma in Psychology, 2010, Heinrich Heine University Düsseldorf; PhD in Psychology, 2015, Uppsala University): Developmental psychology; infant cognition and motor development. (MPRG Naturalistic)

Engelhardt, Nicole
Academic Librarian (M.A. in Cultural Anthropology, 2001, University of Cologne; Information Specialist, 2003, University of Applied Sciences, Potsdam): Scientific electronic information systems, information literacy, classification, bibliometrics.

Fandakova, Yana
Research Scientist (Diploma in Psychology, 2008, Humboldt-Universität zu Berlin; Dr.rer.nat. in Psychology, 2012, Humboldt-Universität zu Berlin): Learning and memory across the lifespan; development of metacognition and cognitive control across the lifespan; developmental cognitive neuroscience; functional and structural neuro-imaging. (LIP)

Fantasia, Valentina
Postdoc (M.Sc. in Clinical and Dynamic Psychology, 2010, Sapienza University of Rome; PhD in Psychology, 2015, University of Portsmouth): Early caregiver–infant interactions; use of multimodal resources in sequentially organised everyday life interactions; infants and young children acquisition and sharing of knowledge on the natural world (such as plants, leaves, flowers); language development. (MPRG Naturalistic)

Fleischhut, Nadine
Research Scientist (M.A. in Philosophy, 2006, Freie Universität Berlin; Dr.rer. nat. in Psychology, 2013, Humboldt-Universität zu Berlin): Risk and uncertainty communication; judgment and decision-making under risk and uncertainty; moral judgment and decision-making; boosting; use of behavioral insights for public benefit. (ARC)

Flitner, Ursula
Head of Library and Research Information Unit (M.A. in American Studies and German Literature, 1991, Freie Universität Berlin; State Examination in Library and Informtion Science, 1995, Senatsverwaltung für Kulturelle Angelegenheiten Berlin/Cologne): Information management; electronic resources and networked information systems; open access; digital humanities.

Freier, Monika
Research Coordinator (M.A. in German Literature and South Asian Studies, 2005, Universität Hamburg; Dr.phil. in History, 2013, Freie Universität Berlin): History of emotions; moral economies; advice literature in Hindi; modern South Asian history; languages and literatures. (MEMS)

Frevert, Ute
Director at the Institute (Dr.phil. in History, 1982, Bielefeld University; Habilitation in Modern History, 1989, Bielefeld University; Fellow of the Max Planck Society; Principal Investigator and Speaker of MEMS; Honorary Professor of History, Freie Universität Berlin; Honorary Doctorate, University of Tampere): Modern social, political, and cultural history; history of emotions; gender history. (HoE)

Gammerl, Benno
Researcher (M.A. in Cultural History, 2000, University of London; M.A. in History, 2003, Freie Universität Berlin; Dr.phil. in Modern History, 2008, Freie Universität Berlin; Habilitation in Modern History, 2018, Freie Universität Berlin): History of emotions; contemporary history of homosexuality in Germany; oral history; imperial history; citizenship and nationality. (HoE)

Garrett, Douglas D.
Senior Research Scientist (M.A. in Psychology, 2007, University of Toronto; PhD in Psychology, 2011, University of Toronto): Brain signal variability in relation to lifespan development; cognition; neurochemistry; network dynamics; brain structure. (LIP/Max Planck UCL Centre/LNDG)

Gerlach, Philipp
Postdoc (MPhil in Psychology, 2012, University of Cambridge; M.A. in Social Sciences, 2014, Humboldt-Universität zu Berlin; Dr.rer.nat. in Psychology, 2017, Humboldt-Universität zu Berlin): Experimental economics; decision and behavioral game theory; meta-analyses; social norms. (ARC)

Gigerenzer, Gerd
Emeritus (PhD in Psychology, 1977, Ludwig-Maximilians-Universität München; Habilitation in Psychology, 1982, Ludwig-Maximilians-Universität München; Fellow of the Max Planck Society; Director at the Institute until 2017; Director of the Harding Center for Risk Literacy; Honorary Professor of Psychology, Freie Universität Berlin and Humboldt-Universität zu Berlin; Batten Fellow at the Darden Business School, University of Virginia): Bounded rationality and social intelligence; decisions under uncertainty and time restrictions; competence in risk and risk communication; decision-making strategies of managers, judges, and physicians.

Grolig, Lorenz
Predoc (M.A. in Comparative Literature, Cultural Studies and English Literature, 2011, Justus Liebig University Giessen; Diploma in Psychology, 2013, Justus Liebig University Giessen): Cognitive development; learning environments; dialogic reading; print exposure; evidence-based assessment and intervention in school psychology and psychotherapy. (MPRG REaD)

Großmann, Till
Predoc (M.A. in History, 2014, Freie Universität Berlin): History of emotions; history of the self; body history; gender history; history of knowledge. (MEMS/HoE)

Grüneisen, Sebastian
Postdoc (M.A. in Evolutionary and Comparative Psychology, 2010, University of St Andrews; Dr.rer.nat. in Psychology, 2015, Leipzig University & MPI for Evolutionary Anthropology): Developmental and evolutionary origins of human cooperation; cognitive development; chimpanzee behavior; coordinated decision-making; reciprocity; trust-based cooperation; social interdependence. (ARC)

Gumenik, Ksenija
Predoc (B.A. in Educational Sciences, 2015, University of Münster; M.Sc. in Educational Sciences, 2018, University of Münster): Search and learning; decision-making under risk and uncertainty; deliberate ignorance; behavioral insights for public policy (nudging and boosting). (ARC)

Hachmann, Wibke
Research Scientist (M.A. in Linguistics, Cognitive Science, Psychology, 2008, University of Freiburg; PhD in Psychology and Cognitive Science, 2012, University of Trento): Reading development; dyslexia; serial order processing; artificial orthography learning; cross-modal coupling; representational modality; reading in aphasia. (MPRG REaD)

Hall–McMaster, Sam
Postdoc (B.Sc. (Hons) in Neuroscience, 2015, University of Otago): Motivation and reward; cognitive control; sequential choice; neural abstraction. (MPRG NeuroCode)

Hasenäcker, Jana
Research Scientist (B.A. in German Linguistics and Scandinavian Studies, 2011, Humboldt-Universität zu Berlin; M.A. in Linguistics, 2013, Humboldt-Universität zu Berlin; Dr.phil. in Psychology, 2016, Freie Universität Berlin): Early reading acquisition; visual word recognition; morphology; cognitive language processing. (MPRG REaD)

Haux, Lou M.
Predoc (B.Sc. in Psychology, 2013, Otto von Guericke University Magdeburg; M.Sc. in Psychology; 2015; Humboldt-Universität zu Berlin): Decision-making; risk; uncertainty; chimpanzees; cooperation; evolution; search. (ARC)

Hechtlinger, Shahar
Predoc (B.A. in Psychology and Philosophy, 2015, The Hebrew University of Jerusalem; M.A. in History, Philosophy, and Sociology of Science, 2018, The Hebrew University of Jerusalem): Transformative decisions; big decisions; utility uncertainty; decision-making for future selves. (ARC)

Held, Anna
Research Coordinator (M.A. in German Studies, History, and Linguistics, 2002, University of Cologne): Evidence-based medical research communication. (Harding Center)

Hertwig, Ralph
Director at the Institute (Diploma in Psychology, 1991, University of Konstanz; Dr.rer.soc. in Psychology, 1995, University of Konstanz; Habilitation in Psychology, 2003, Freie Universität Berlin; Fellow of the Max Planck Society; Honorary Professor of Psychology, Freie Universität Berlin and Humboldt-Universität zu Berlin): Bounded and social rationality; experience-based decision-making; methodology of the social sciences. (ARC)

Herwig, Maria
Research Coordinator (B.A. in German-French Studies, 2011, Universität Regensburg; M.A. in International Relations, 2015, Technische Universität Dresden): Assessing and improving risk literacy for decision-making. (Harding Center)

Herzog, Stefan M.
Research Scientist (B.Sc. in Psychology, 2003, University of Basel; M.Sc. in Psychology, 2005, University of Basel; Dr.phil. in Psychology, 2009, University of Basel): Boosting judgment and decision-making by understanding human and machine behavior using cognitive science, collective intelligence, heuristics, and algorithms; translational work in medical decision-making, meteorology, and digital environments. (ARC)

Heß, Stefan
Predoc (B.Ed. in Mathematics, 2009, University of Potsdam; M.Ed. in Mathematics, 2012, University of Potsdam): Cognitive basis of spelling and handwriting; spelling and handwriting behavior. (LIFE/MPRG REaD)

Hille, Maike
Predoc (B.Sc. in Cognitive Science, 2015, Osnabrück University; M.Sc. in Social, Cognitive and Affective Neuroscience, 2020, Freie Universität Berlin): Behavioral and neural plasticity; learning across the lifespan; functional and structural neuroimaging. (LIFE/LMG EnvNeuro/LIP)

Hinneburg, Jana
Research Scientist (M.Ed. in Health Sciences, Biology, and Education, 2015, Universität Hamburg): Evidence-based medicine; cancer screening; consumer education; (vocational) education for sustainable development. (Harding Center/Emeritus Group Gigerenzer)

Hitzer, Bettina
Minerva Research Group Leader (First State Examination in History and French, 1999, Freie Universität Berlin; Dr.phil. in History, 2004, Bielefeld University; Habilitation in Modern History, 2017, Freie Universität Berlin; Minerva Research Group Leader until 01/2020): History of emotions; history of migration; history of religion; history of medicine; history of childhood. (HoE)

Hong, Inho
Postdoc (B.Sc. in Physics, 2010, Pohang University of Science and Technology (POSTECH); M.Sc. in Physics, 2012, Pohang University of Science and Technology (POSTECH); PhD in Physics, 2019, Pohang University of Science and Technology (POSTECH)): Future of work; social mobilization; complex systems; scaling theory; cities. (CHM)

Horn, Sebastian S.
Research Scientist (Diploma in Psychology, 2007, University of Freiburg; Dr.rer. nat. in Mathematical and Cognitive Psychology, 2012, Heinrich Heine University Düsseldorf): Development of decision-making and memory across the lifespan; prospective and episodic memory; cognitive aging; cognitive modeling of elementary psychological processes (using multinomial models, sequential sampling models). (ARC)

İlengiz, Çiçek
Predoc (B.A. in History, 2011, Istanbul Bilgi University; M.A. in Cultural Studies Program, 2013, Sabancı University; M.A. in Sociology and Social Anthropology, 2014, Central European University, Budapest): History of psychiatry; urban history; nationalism; religion; secularism. (MEMS/HoE)

Jacobs, Perke
Predoc (B.Sc. in Economics, 2011, Maastricht University; M.Sc. in Behavioral Science, 2013, Tilburg University): Heuristics for sequential choice; meta-analysis. (ARC)

Jayles, Bertrand
Postdoc (M.Sc. in Theoretical and Mathematical Physics, 2014, Université d'Aix-Marseille; PhD in Social Physics, 2017, Université Paul Sabatier): Collective intelligence; collective human behavior; sensitivity to social influence; cognitive biases; social impact. (ARC)

Jenny, Mirjam A.
Senior Research Scientist (M.Sc. in Psychology, 2009, University of Basel; Dr.phil. in Psychology, 2013, University of Basel): Judgment and decision-making; subjective probability judgment; decision aids in medical decision-making; data science; risk literacy and risk communication; computational cognitive modeling; scientific publication processes. (Harding Center/Emeritus Group Gigerenzer)

Jensen, Uffa
Researcher (M.A. in History and Philosophy, 1998, Technische Universität Berlin; Dr.phil. in Modern History, 2003, Technische Universität Berlin; Habilitation in History, 2016, Freie Universität Berlin): History of emotions; history of knowledge and human sciences; transnational history; history of psychoanalysis; history of antisemitism. (HoE)

Jöchner, Ann–Kathrin
Predoc (B.Sc. in Psychology, 2015, Paris Lodron University of Salzburg; M.Sc. in Psychology, 2017, Paris Lodron University of Salzburg): Development of sleep and memory consolidation; neuronal correlates of sleep-dependent memory consolidation across childhood. (LIFE/LIP)

Jones, Angela
Predoc (M.Sc. in Neuroscience, 2016, University College London): Active learning; information search strategies; cognitive development; computational modeling. (LIFE/MPRG iSearch)
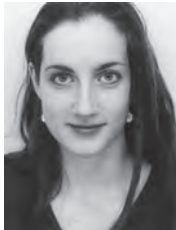
Kämmer, Juliane E.
Research Scientist (Diploma in Psychology, 2009, Humboldt-Universität zu Berlin; Dr.rer.nat. in Psychology, 2013, Humboldt-Universität zu Berlin): Medical diagnostic decision-making; heuristics in group decision-making; social and ecological rationality; advice seeking and taking. (ARC)

Karch, Julian D.
Postdoc (Diploma in Computer Science, 2012, Freie Universität Berlin; Dr.rer.nat. in Psychology, 2016, Humboldt-Universität zu Berlin): Multivariate developmental methodology; machine learning and data mining; statistical and algorithmic modeling; model selection and model combination; adapting data mining methods for psychology. (LIP)

Karlsson, Anna
Predoc (B.Sc. in Psychology, 2014, Lund University; M.Sc. in Psychology, 2016, Lund University): Neuropsychological underpinnings of episodic memory and age-related functional and structural differences therein; the neural mechanisms supporting age-differences in the representation and use of contextual information. (LIFE/LIP)

Keller, Monika
Visiting Researcher (Dr.phil. in Psychology, 1974, Heidelberg University; Habilitation in Psychology, 1996, Freie Universität Berlin; Honorary Professor of Psychology, Freie Universität Berlin): Social and moral development across childhood and adolescence in cross-cultural context; moral cognition and moral emotions; fairness negotiations in groups of different ages and different academic disciplines; social rationality; education of sociomoral competencies. (ABC/ARC)

Keresztes, Attila
Postdoc (M.A. in Political Science and Economics, 2004, Corvinus University of Budapest; PhD in Psychology, 2014, Budapest University of Technology and Economics): Cognitive and neuronal development of episodic memory across the lifespan; the role of cognitive control in forgetting and remembering; interference resolution during episodic memory retrieval; implicit and explicit memory. (LIP)

Khosravani, Neda
Predoc (B.Sc. in Clinical Psychology, 2006, Shiraz University; M.Sc. in Clinical Psychology, 2010, Shiraz University): Neural mechanisms and plasticity of cognitive functions; aging-related changes in cognitive functions; mechanisms of plasticity in child development. (LIFE/LIP)

Kleemeyer, Maike M.
Postdoc (B.Sc. in Cognitive Science, 2007, Osnabrück University; M.Sc. in Neuroscience, 2010, University of Bremen; Dr.rer.nat. in Psychology, 2018, Humboldt-Universität zu Berlin): Neuroplasticity; age related brain changes and protective factors; assessing longitudinal brain changes; open science. (LIP)

Kloosterman, Niels A.
Postdoc (B.Sc. in Psychology, 2010, University of Amsterdam; M.Sc. in Psychology, 2010, University of Amsterdam; PhD in Cognitive Neuroscience, 2015, University of Amsterdam): Brain mechanisms underlying perceptual-decision-making and bistable perception; functional role of neuromodulation in perceptual and cognitive tasks; link between age-related decline in cortical variability and cognitive factors. (LIP/LNDG)

Koch, Christoph
Predoc (B.Sc. in Psychology, 2014, Ruhr-Universität Bochum; M.Sc. in Cognitive Neuroscience and Psychology, 2017, Ruhr-Universität Bochum): Change in neural representations; spatial navigation; aging; lifespan; reinforcement learning; state-space models; attractor models. (LIFE/MPRG NeuroCode)

Köhncke, Ylva
Postdoc (Diploma in Psychology, 2012, Humboldt-Universität zu Berlin; PhD in Psychology, 2017, Karolinska Institutet): Cognitive changes across the lifespan; associations between changes in cognition and changes in brain structure; associations between lifestyle factors and neuro-cognitive changes; structural equation modeling with longitudinal data; prediction of heterogeneity in change. (LIP)

Konovalova, Elizaveta
Postdoc (PhD in Economics, 2018, Universitat Pompeu Fabra): Decision-making; judgement formation; category-based inference. (ARC)

Kosciessa, Julian Q.
Predoc (B.Sc. in Psychology, 2014, Freie Universität Berlin; M.Sc in Mind and Brain [Track Brain], 2016, Humboldt-Universität zu Berlin): Neural dynamics; rhythmic neural activity; memory; attention; aging; EEG methods. (COMP2PSYCH/LIP/LNDG)

Kozodoi, Nikita
Predoc (B.Sc. in Economics, 2014, Higher School of Economics; M.Sc. in Economics and Management Science, 2017, Humboldt-Universität zu Berlin): Decision-making under uncertainty; managerial heuristics; ecological analysis; predictive modeling. (ARC)

Kozyreva, Anastasia
Postdoc (Dipl.Phil. in Philosophy, 2004, Saint-Petersburg State University; MPhil in French and German Philosophy, 2012, Université catholique de Louvain-la-Neuve; Université de Toulouse II-le Mirail; Bergische Universität Wuppertal; Dr.phil. in Philosophy, 2016, Heidelberg University): Conceptual foundations of risk and uncertainty; bounded and ecological rationality; rationality in online environments; AI ethics. (ARC)

Krappmann, Lothar
Visiting Researcher (Dr.phil. in Sociology, 1969, Freie Universität Berlin; Honorary Professor of Sociology of Education, Freie Universität Berlin): Socialization theory; social and moral development of children in middle childhood; children's peer interactions, relationships, and groups; links between family and peer relationships; day-care institutions; child rights and children's participation; observational research methodology. (ARC)

Kruse, Imke
Head of Research Planning and Research Coordination (M.A. in Political Science, Modern History, Communication Studies, 2002, University of Potsdam and Freie Universität Berlin; Dr.phil. in Political Science, 2005, Freie Universität Berlin; LIFE Program Manager). (LIP/CHM/LMG EnvNeuro)

Kühn, Simone
Research Group Leader (Diploma in Psychology, 2006, University of Potsdam; Dr.rer.nat. in Psychology, 2009, Leipzig University; Habilitation in Psychology, 2012, Humboldt-Universität zu Berlin): Environmental neuroscience; structural and functional neuroimaging; brain plasticity. (LMG EnvNeuro)

Kurvers, Ralf H. J. M.
Senior Research Scientist (B.Sc. in Forest and Nature Conservation, 2003, Wageningen University; M.Sc. in Ecology and Management, 2005, Wageningen University; PhD in Production Ecology and Resource Conservation, 2011, Wageningen University): Collective decision-making; social networks; individual differences; nonhuman decision-making; medical decision-making. (ARC)

Lämmert, Stephanie
Researcher (M.A. in African Studies and History, 2011, Humboldt-Universität zu Berlin and Freie Universität Berlin; PhD in History, 2017, European University Institute): History of emotions; East and Central African history; history of healing, spirituality, and Christianity; history of political imagination and decolonization; Swahili literature and intellectual history. (HoE)

Lau, Sebastian
Head of Central IT Unit (Diploma [FH] in Computer Science, 2008, Hochschule Lausitz University of Applied Sciences): Medical imaging processing.

Laube, Corinna
Postdoc (B.Sc. in Psychology, 2011, University of Göttingen; M.Sc. in Psychology, 2014, Heinrich Heine University Düsseldorf; Dr.rer.nat. in Psychology, 2018, Humboldt-Universität zu Berlin): Decision and developmental neuroscience; pubertal development and hormones; impulsive behavior in adolescence (intertemporal choice); affective decision-making. (ARC/LIP)

Laukötter, Anja
Researcher (M.A. in Modern History, 2001, Humboldt-Universität zu Berlin; Dr.phil. in Modern History, 2006, Humboldt-Universität zu Berlin; Habilitation in Modern History, 2018, Humboldt-Universität zu Berlin): Cultural history and the history of knowledge in the 19th and 20th centuries; history of emotions; history of ethnology/anthropology and medicine; history of human experiments; history of (post)colonialism; media and cultural theories; history of visualization; history of medical films. (HoE)

Lein, Ines
Research Coordinator (Diploma in Chemistry, 1995, University of Göttingen; Dr.rer.nat. in Physical Chemistry, 1999, University of Göttingen; Research Coordinator EU Horizon2020 project FORECEE): Medical fact boxes; research communication. (Harding Center/Emeritus Group Gigerenzer)

Leuker, Christina
Postdoc (B.A. Liberal Arts and Sciences in Psychology and Economics, 2012, Maastricht University; M.Sc. in Social, Cognitive, and Affective Neuroscience, 2014, Freie Universität Berlin; Dr.rer.nat. in Psychology, 2018, Humboldt-Universität zu Berlin): Decision-making under risk and uncertainty; deliberate ignorance; morals in markets; repugnant transactions. (ARC)

Li, Weihua
Postdoc (B.S. in Mathematics, 2012, Beihang University; PhD in Applied Mathematics, 2017, Beihang University): Computational social science; complex systems; network science; machine learning. (CHM)

Li, Ying
Postdoc (PhD in Psychology, 2019, University of Warwick): Emotion; language; network; science. (ARC)

Lichau, Karsten
Researcher (Diploma in Education, 2000, Freie Universität Berlin and Université Paris VIII Vincennes-St. Denis; Dr.phil. in Education/Historical Anthropology, 2010, Freie Universität Berlin): Historical anthropology of the body and the senses; sound history; history of emotions; religion and the secular. (HoE)

Lieth, Julia
Predoc (B.A. in History, 2014, Philipps-Universität Marburg; MPhil in Early Modern History, 2016, Trinity College Dublin): History of religion; history of emotions; microhistory, (early) modern European history. (MEMS/HoE)

Lin, Ziyong
Postdoc (B.A. in Music, Psychology, 2012, Mills College; M.Sc. in Psychology, 2015, University of Michigan; PhD in Psychology, 2018, University of Michigan): Brain plasticity across lifespan; learning and memory in young and older adults; interaction between motivation and cognition. (LIP)

Linde–Domingo, Juan
Postdoc (B.Sc. in Psychology, 2010, University of Granada; M.Sc. in Behavioural and Cognitive Neuroscience, 2013, University of Granada; PhD in Psychology, 2019, University of Birmingham): Temporal dynamics of episodic memory; role of short and long-term memory during decision-making; malleability of memory representations. (ARC)

Lindenberger, Ulman
Director at the Institute (Diploma in Psychology, 1985, Technische Universität Berlin; Dr.phil. in Psychology, 1990, Freie Universität Berlin; Habilitation in Psychology, 1998, Freie Universität Berlin; Fellow of the Max Planck Society; Honorary Professor of Psychology, Saarland University, Freie Universität Berlin, and Humboldt-Universität zu Berlin; Co-Director of the Max Planck UCL Centre; Berlin Speaker of LIFE and COMP-2PSYCH): Behavioral and neural plasticity across the lifespan; brain-behavior relations across the lifespan; lifespan developmental theory; multivariate developmental methodology; formal models of behavioral change. (LIP/Max Planck UCL Centre)

Litvinova, Aleksandra
Postdoc (B.Sc. in Psychology, 2012, Maastricht University; M.Sc. in Neuroeconomics, 2014, Maastricht University; Dr.rer.nat. in Psychology, 2019, Freie Universität Berlin): Collective decision-making; wisdom of crowds; decisions under uncertainty; decision aids; computational modeling; Bayesian statistics. (ARC)

Lorenz, Robert C.
Postdoc (Diploma in Psychology, 2010, Humboldt-Universität zu Berlin; Dr.rer. nat. in Psychology, 2015, Humboldt-Universität zu Berlin): Developmental neuroscience; structural and functional brain plasticity; fronto-striatal neural circuitry; neurochemical imaging. (LMG EnvNeuro)

Lorenz–Spreen, Philipp
Postdoc (B.Sc. in Physics, 2013, Ludwig-Maximilians-Universität München; M.Sc. in Physics, 2016, Ludwig-Maximilians-Universität München; Dr.rer.nat. in Physics, 2018, Technische Universität Berlin): Complex systems; dynamical systems; network science; computational social science; collective behavior; popularity, attention, and opinion dynamics. (ARC)

Löwe, Anika
Predoc (B.Sc. in Psychology, 2017, Medical School Berlin; M.Sc. in Social, Cognitive and Affective Neuroscience, 2020, Freie Universität Berlin): Spontaneous attentional strategy switches; human replay during planning and value computation; computational modeling of cognitive processes. (COMP2PSYCH/MPRG NeuroCode)

Malone, Hannah
Researcher (B.A. in History of Art, 2005, Trinity College Dublin; MPhil in History of Art, 2010, University of Cambridge; PhD in History of Art, 2013, University of Cambridge): History; emotions; architecture; modern Italy; modern Germany; death; heritage. (HoE)

Månsson, Kristoffer N. T.
Postdoc (M.Sc. in Clinical Psychology, 2011, Umeå University; PhD in Clinical Psychology, 2016, Linköping University): Investigating neural dynamics in psychiatric disorders using magnetic resonance imaging, e.g., moment-to-moment variability in neural response predicts social anxiety disordered patients' outcome after cognitive-behavioral therapy. (LIP/LNDG)

Markant, Douglas
Research Scientist (B.A. in Psychology, 2005, Cornell University; PhD in Psychology, 2014, New York University): Computational models of learning and decision-making; active learning, information foraging; meta-cognitive decision-making; adaptive instruction. (ARC)

Mather, Mara
University of Southern California and LIP Associate (B.A. [Dist. & Hons.] in Psychology, Stanford University, 1994; PhD in Cognitive Psychology, 2000, Princeton University): Influences of emotion and stress on memory and decision-making. (LIP)

Mayer, Karl Ulrich
Emeritus (Dr.rer.soc. in Sociology, 1973, University of Konstanz; Habilitation in Sociology, 1977, University of Mannheim; Director at the Institute until 2005; President of the Leibniz Association, 2010–2014; Stanley B. Resor Professor Emeritus of Sociology at Yale University; Honorary Professor of Sociology, Freie Universität Berlin): Social stratification and mobility; comparative analyses of social structures; sociology of the life course; structures and processes of the labor market.

McDowell, Michelle
Research Scientist (B.A. [First Class Hons.] in Psychology, 2005, Griffith University; PhD in Psychology, 2011, Griffith University): Risk perception; decision-making; judgment; heuristics; rationality. (Harding Center/Emeritus Group Gigerenzer)

Mikulová, Soňa
Researcher (Bc. in International Area Studies, 2002, Charles University; M.A. in German and Austrian Studies, 2006, Charles University; PhD in International Area Studies, 2015, Charles University): Cultural history; history of emotions; memory studies; migration studies; contemporary German and Central European history. (HoE)

Moine, Caroline
Postdoc (PhD in History, 2005, University of Paris 1 Panthéon-Sorbonne): Cultural history of the cold war; media history; history of the international solidarity mobilizations and emotions in the 1970s and 1980s. (HoE)

Molleman, Lucas
Research Scientist (B.Sc. in Biology, 2006, University of Amsterdam; M.Sc. in Biology, 2008, University of Amsterdam; M.A. in Philosophy, 2010, University of Amsterdam): Social learning; cultural evolution; cooperation; reciprocity; evolutionary dynamics; punishment. (ARC)

Moneta, Nir
Predoc (B.A. in Psychology, 2015, The Open University of Israel; M.Sc. in Cognitive Neuroscience, 2019, Freie Universität Berlin): Decision-making; valuation; cognitive maps; fMRI. (MPRG NeuroCode)

Morais, Ana Sofia
Scientific Coordinator (M.Sc. in Psychology, 2004, University of Lisbon; Dr.rer.nat. in Psychology, 2010, Humboldt-Universität zu Berlin). (ARC)

Mousikou, Petroula
Research Scientist (B.A. in Primary Education, 2000, Aristotle University of Thessaloniki; M.A. in Evaluation and Treatment of Language Disorders, 2002, Complutense University of Madrid; M.A. in Cognitive Neuropsychology, 2004, Complutense University of Madrid; PhD in Cognitive Science, 2009, Macquarie University): Reading; computational modeling of reading; speech production; phonetics. (MPRG REaD)

Moussaïd, Mehdi
Research Scientist (M.A. in Behavioral and Cognitive Science, 2007, University of Toulouse; Dr.rer. in Ethology, 2010, University of Toulouse and ETH Zurich): Crowds; collective behaviors; self-organization; complex systems; collective intelligence; social influence; social networks. (ARC)

Mühlroth, Beate E.
Postdoc (B.Sc. in Psychology, 2013, Freie Universität Berlin; M.Sc. in Clinical and Health Psychology, 2015, Freie Universität Berlin; Dr.rer.nat. in Psychology, 2020, Freie Universität Berlin): Sleep-dependent memory consolidation; age-related changes in sleep and memory. (LIP)

Müller, Viktor
Research Scientist (Dr.rer.soc. in Psychology, 1996, University of Tübingen): Lifespan psychology and aging mechanisms; psychophysiology of social interactions; complexity and brain dynamics; cortical synchronization: local and global networks; graph-theoretical approach; network complexity. (LIP)

Ngo, Chi (Zoe)
Postdoc (B.A. in Psychology, 2010, Denison University; M.Sc. in Experimental Psychology, Behavioral Neuroscience Concentration, 2013, Seton Hall University; PhD in Psychology, Brain and Cognitive Sciences, 2019, Temple University): Memory development in early childhood. (LIP)

Nix, Sebastian
Head of Library and Research Information Unit (M.A. in Communication Studies, Political Science and Romance Studies, 2002, Johannes Gutenberg University Mainz; M.A. in Library and Information Science, 2009, Humboldt-Universität zu Berlin): Electronic resources and networked information systems; scholarly communication; information seeking behavior; Open Access.

Oberländer, Alexandra
Researcher (Dr.phil. in History, 2010, Humboldt-Universität zu Berlin): History of Russia/Soviet Union; gender history; history of violence; history of crime; history of emotions; history of political economy; sociology of work; labor history. (HoE)

Obradovich, Nick
Senior Research Scientist (B.Sc. in Economics and Environmental Studies, 2009, Santa Clara University; M.A. in Political Science, 2012, University of California, San Diego; PhD in Political Science, 2016, University of California, San Diego): The human impacts of algorithms; the social impacts of climate change; computational social science; causal inferential methods, political economy. (CHM)

Oesterheld, Marius
Predoc (B.A. in History and European Ethnology, 2013, Humboldt-Universität zu Berlin; M.A. in Global History, 2016, Freie Universität Berlin and Humboldt-Universität zu Berlin): Global history; conceptual history; intellectual history; East Asian history; history of late imperial and Republican China. (MEMS/HoE)

Oña, Linda S.
Postdoc (Dr.rer.nat. in Biology, 2011, Freie Universität Berlin & MPI for Evolutionary Anthropology): Comparative psychology; social cognition in humans, nonhuman primates and canids; communication and emotions. (MPRG Naturalistic)

Oranç, Cansu
Postdoc (PhD in Psychology, 2020, Koç University): Cognitive development; child-technology interaction; early childhood education. (MPRG iSearch)

Pachur, Thorsten
Senior Research Scientist (M.Sc. in Health Psychology, 2002, University of Sussex; Diploma in Psychology, 2002, Freie Universität Berlin; Dr.phil. in Psychology, 2006, Freie Universität Berlin; Habilitation in Psychology, 2012, University of Basel): Decision-making; heuristics; computational modeling; memory; risky decision-making; individual differences; information search. (ARC)

Pahl, Kerstin Maria
Researcher (M.A. in Art History, 2011, Freie Universität Berlin; PhD in Art History/English Literature, 2018, Humboldt-Universität zu Berlin & King's College London): Early modern to modern history of art and literature (c. 1600 to 1900); British history and culture; portraiture and life-writing; history of physiognomy and body language; history of emotions and nonemotion(s); intermediality, word-image relations. (HoE)

Papadaki, Eleftheria
Predoc (B.A. [Hons.] in Greek Philology and Linguistics, 2013, Aristotle University of Thessaloniki; M.Sc. in Social Cognitive and Affective Neuroscience, 2018, Freie Universität Berlin): Brain plasticity induced by training; functional and structural neuroimaging; relationship of structural and functional brain plasticity. (LIFE/LIP)

Patil, Indrajeet
Postdoc (B.Sc. in Physics, 2008, Fergusson College, Pune; M.Sc. in Physics, 2010, Savitribai Phule Pune University; PhD in Neuroscience, 2015, Scuola Internazionale Superiore di Studi Avanzati [SISSA]): Moral judgement and decision-making; prosocial and altruistic behavior; social learning; computational modeling. (CHM)

Pauley, Claire
Predoc (B.Sc. in Psychology, 2015, The University of North Carolina at Chapel Hill; M.Sc. in Neurocognitive Psychology, 2020, Carl von Ossietzky Universität Oldenburg): Neural mechanisms underlying cognitive development; the role of memory representations in episodic memory decline across adulthood. (LIFE/LIP)

Pernau, Margrit
Senior Researcher (Dr.phil. in Modern History, 1991, Heidelberg University; Habilitation in Modern History, 2007, Bielefeld University; Extraordinary Professor of History, Freie Universität Berlin): Modern Indian history (18th–20th centuries); history of emotions; history of modern Islam; transnational history; history of entanglement; historical semantics; comparative studies; translation studies; conceptual history. (HoE)

Perry, Alistair
Postdoc (B.Sc. in Psychology [Hons.], 2011, University of Wollongong, Australia; PhD in Psychiatry, 2017, University of New South Wales): Brain connectivity patterns in health and developmental changes with adolescense and normal aging. (LIP/LNDG)

Pescetelli, Niccolò
Research Scientist (B.Sc. in Psychology, 2012, Università degli Studi die Padova; M.Sc. in Psychology, 2013, École Normale Supérieure and Université Pierre et Marie Curie (UPMC), Paris; DPhil in Experimental Psychology, 2017, University of Oxford): Metacognition and decision-making; group decision-making; social learning and cultural evolution; hybrid approaches to collective intelligence. (CHM)

Pietraszewski, David
Research Scientist (B.A. in Psychology, 2001, Ithaca College; PhD in Psychology, 2009, University of California, Santa Barbara): Social catagorization; psychology of coalitions and alliances; resource conflict; "Who Said What?" memory confusion paradigm; developmental, social, and cognitive psychology; evolutionary psychology/adaptationism; engineering/task analysis approaches; construct validity, measurement, and reductionism. (ARC)

Pleskac, Timothy J.
Senior Research Scientist (B.Sc. in Psychology, 2000, The University of Iowa; M.Sc. in Psychology, 2002, University of Maryland; PhD in Psychology, 2004, University of Maryland): Judgment and decision-making; cognitive and neural models of cognition; learning and memory processes used during judgment and decision-making; mathematical psychology. (ARC)

Polk, Sarah
Predoc (B.A. [Dist. & Hons.] in Psychology, 2015, University of Michigan; M.Sc. in Social, Cognitive, and Affective Neuroscience, 2019, Freie Universität Berlin): Brain plasticity across the lifespan; the effects of exercise on changes in brain function and structure, as well as cognition (AKTIV Study). (LIFE/LIP)

Polyanska, Liliana
Predoc (B.Sc. in Psychology, 2015, Humboldt-Universität zu Berlin; M.Sc. in Social, Cognitive and Affective Neuroscience, 2018, Freie Universität Berlin): Exploration-exploitation trade-off; reinforcement learning; brain signal variability as a marker for exploration-exploitation behavior; locus coeruleus–noradrenaline (LC-NA) system and it's role in managing exploration-exploitation. (COMP2PSYCH/LIP/LNDG)

Prinz, Roman
Research Scientist (B.Sc. in Psychology, 2011, Maastricht University; M.Sc. in Social & Organisational Psychology, 2013, Leiden University): Risk perception and literacy; decision-making and judgment (risky environments); bounded rationality; visualization and transfer of scientific evidence. (Harding Center)

Raffington, Laurel
Postdoc (B.Sc. in Experimental Psychology, 2010, University of Bristol; M.Sc. in Social, Cognitive, Affective Neuroscience, 2013, Freie Universität Berlin; Dr.rer.nat. in Psychology, 2018, Humboldt-Universität zu Berlin): Delineating stress-related social disparities in child neuroendocrine development. (LIP)

Rahwan, Iyad
Director at the Institute (PhD in Information Systems [Artificial Intelligence], 2005, University of Melbourne; Fellow of the Max Planck Society; Associate Professor of Media Arts & Science, The Media Lab, Massachusetts Institute of Technology): Computational social science; social and economic impact of artificial intelligence; human psychology and intelligent machines; new techniques for measuring and enabling human cooperation; human–machine cooperation; artificial intelligence ethics and governance. (CHM)

Rahwan, Zoe
Research Scientist (B.Comm. [Hons.] in Economics, 2001, The University of Melbourne; M.Sc. in Behavioural Science, 2016, London School of Economics and Political Science): Moral decision-making; pro-social behavior, dishonesty; policy-making; field experiments. (ARC)

Rajamani, Imke
Researcher (M.A. in German Language, Literature, and Media, 2011, Universität Hamburg; Dr.phil. in History, 2016, Freie Universität Berlin): History of anger and compassion in popular Indian cinema; emotions and multimedia; theorizing emotions in conceptual history. (HoE)

Raz, Naftali
Research Scientist (B.A. in Psychology, 1979, The Hebrew University of Jerusalem; PhD in Psychology, 1985, The University of Texas at Austin; Professor of Psychology and Director of Lifespan Cognitive Neuroscience Program at the Institute of Gerontology, Wayne State University): Cognitive neuroscience of aging with emphasis on the influence of vascular risk factors. (LIP)

Rebitschek, Felix G.
Research Scientist (Diploma [FH] in Media Economics, 2006, Stuttgart Media University; Diploma in Psychology, 2011, Leipzig University; Dr.rer.nat. in Psychology, 2014, University of Greifswald): Thinking and reasoning; JDM; causal reasoning; complexity, uncertainty and risk; risk literacy and risk communication. (Harding Center/Emeritus Group Gigerenzer)

Reiber, Lisa
Predoc (B.A. in Social Sciences, 2015, Humboldt-Universität zu Berlin; M.A. in Social Sciences, 2019, Humboldt-Universität zu Berlin): Development of individual risk preferences; life events; panel data analysis; statistical modeling; reproducible research; open-source structures. (LIFE/ARC/Max Planck Fellow)

Rioux, Camille
Postdoc (PhD in Psychology, 2017, Aix-Marseille University): Food learning; categorisation; food neophobia; evolutionary psychology; cognitive development. (MPRG Naturalistic)

Rohrer, Julia M.
Predoc (B.Sc. in Psychology, 2014, Leipzig University; M.Sc. in Psychology, 2016, Leipzig University; Dr.rer.nat. in Psychology, 2019, Leipzig University): Determinants of well-being across the life course; personality psychology; automated text analysis. (LIFE/Max Planck Fellow)

Rothe, Anselm
Postdoc (B.Sc. in Psychology, 2011, University of Göttingen; M.Sc. in Psychology, 2013, University of Göttingen; PhD in Psychology, 2019, New York University): Information search; active learning; question asking; computational cognitive science. (MPRG iSearch)

Rothe, Damaris
Research Coordinator (M.Sc. in Psychology, 2014, University of Göttingen): Cognitive and developmental psychology; education. (MPRG iSearch)

Rozenblatt, Daphne
Researcher (M.A. in History, 2010, University of California, Los Angeles; PhD in History, 2014, University of California, Los Angeles): History of emotions; history of human sciences; legal history; history of the self; modern Europe. (HoE)

Ruggeri, Azzurra
Max Planck Research Group Leader (M.A. in Philosophy, 2008, University of Pisa; PhD in Cognitive Science, 2012, University of Siena; Dr.rer.nat. in Psychology, 2012, Humboldt-Universität zu Berlin): Cognitive development; active learning; ecological learning; information search; exploration strategies; question asking. (MPRG iSearch)

Russell, Connair J. S.
Predoc (B.Sc. in Psychology, 2015, University of East Anglia; M.Sc. in Social and Cultural Psychology, 2016, London School of Economics and Political Science): Learning; categorisation; generalisation; induction; domain specificity; evolutionary psychology; cognitive development. (LIFE/MPRG Naturalistic)

Rutherford Alex
Senior Research Scientist (M.Sc. in Physics, 2004, University of Warwick; PhD in Physics, 2009, University College London): Network science; future of work; crowdsourcing; collective behavior; data privacy. (CHM)

Sander, Myriam C.
Minerva Research Group Leader (Diploma in Psychology, 2007, Humboldt-Universität zu Berlin; Dr.rer.nat. in Psychology, 2011, Humboldt-Universität zu Berlin): Development of perception and memory across the lifespan; neural correlates of developmental change and brain plasticity; multivariate EEG and fMRI methods. (LIP)

Santoro, Davide
Postdoc (Dottore in Fisica, 1991, Sapienza University of Rome; PhD in Physics, 2004, University of Nottingham): Developing novel methods for increasing the sensitivity of MRI techniques by means of computer simulation and design of new pulse sequences. (LIP)

Sarıoğlu, Esra
Researcher (B.S. in Philosophy, 2002, Boğaziçi University Istanbul; M.A. in History, 2004, Boğaziçi University Istanbul; PhD in Sociology, 2013, Binghamton University State University of New York): Feminist theory; phenomenology; shame and embarrasment; Turkey. (HoE)

Schaar, Katrin
Scientific Coordinator (Diploma in Pedagogy, 1992, Technische Universität Berlin; Dr.phil. in Education, 1997, Freie Universität Berlin; CASTELLUM Coordinator; BASE-II Coordinator; Online Editor of BASE-II website): Data protection, privacy, interdisciplinary gerontology; demographic change. (LIP)

Schirren, Clara
Research Scientist (M.Sc. in Psychology, 2018, Humboldt-Universität zu Berlin): Decision-making; evidence-based policymaking; computational modeling; risk and evidence communication. (Harding Center/ Emeritus Group Gigerenzer)

Schlegelmilch, Karola
Predoc (Diploma in Visual Arts, Design, 1991, Berlin University of the Arts; M.Sc. in Psychology, 2016, Humboldt-Universität zu Berlin): Infant perception and categorization of naturalistic textures; vision and cognition. (LIFE/MPRG Naturalistic)

Schmidt, Anne
Researcher (First State Examination in History and German Language and Literature Studies, 1998, Freie Universität Berlin; Dr.phil. in Modern History, 2004, Bielefeld University): Cultural, economic, and political history; media studies; history of emotions; public history. (HoE)

Schnädelbach, Sandra
Predoc (M.A. in History, 2010, University of Cologne): History of 19th and 20th century Europe; history of emotions; history of knowledge; history of science; media history; cultural history of law. (HoE)

Schroeder, Sascha
Max Planck Research Group Leader and LIP Associate (M.A. in Musicology, 2002, University of Cologne; Diploma in Psychology, 2006, University of Cologne; Dr.phil. in Psychology, 2008, University of Cologne; Habilitation in Psychology, 2011, Freie Universität Berlin; Max Planck Research Group Leader until 06/2018): Cognitive processes in language and text comprehension; reading literacy: assessment of micro- and macrostructual reading skills; research in instruction and learning; quantitative and qualitative methods in empirical research. (MPRG REaD/ LIP)

Schröer, Frederik
Predoc (Mag. in Philological and Cultural Studies, 2013, University of Vienna; M.A. in Global History, 2016, Freie Universität Berlin): History of Tibet and India in the 19th and 20th centuries; history of modern Buddhism; global history; historical semantics (MEMS/ HoE)

Schubenz, Marie
Predoc (M.A. in Modern History, 2012, Technische Universität Berlin; M.A. in Philosophy, 2012; Freie Universität Berlin): History of emotions; history of social movements; global labor history; humanist philosophy. (MEMS/HoE)

Schuck, Nicolas W.
Max Planck Research Group Leader (Diploma in Psychology, 2010, Humboldt-Universität zu Berlin; Dr.rer.nat. in Psychology, 2013, Humboldt-Universität zu Berlin): Learning; memory; cognitive control; dopamine; aging. (MPRG NeuroCode/Max Planck UCL Centre)

Schulze, Christin
Senior Research Scientist (Diploma in Psychology, 2011, Friedrich Schiller University Jena; PhD in Psychology, 2015, University of New South Wales): Experience-based decisions under uncertainty; childhood development of decision-making strategies; cognitive models of judgment and decision-making; social and group decision-making. (ARC)

Singer, Kerstin
Coordinator (M.A. in History, Italian and Portuguese Studies, 1997, University of Cologne; Dr.phil. in History, 2006, University of Cologne): History of emotions; scientific coordination; modern political and social history; modern Italian history. (HoE)

Skork, Kerstin
Head of Public Relations Unit (M.A. in German Literature, Psychology, and Sociology, 2005, Goethe University Frankfurt am Main): Integrated communications; scientific communication; corporate publishing; event management.

Skowron, Alexander
Predoc (B.Sc. in Psychology, 2016, Leiden University; M.Sc. in Social, Cognitive and Affective Neuroscience, 2019, Freie Universität Berlin): Neural computations supporting reinforcement learning under naturalistic conditions and their age-related changes; individual differences in age-related changes; multimodal neuroimaging. (LIFE/COMP2PSYCH/LIP/LNDG)

Sommer, Verena R.
Predoc (B.Sc. in Cognitive Science, 2013, Osnabrück University; M.Sc. in Cognitive Neuroscience, 2016, University of Amsterdam): Memory and perception across the lifespan; age-related changes in neural pattern distinctiveness; machine learning; multivariate pattern and representational similarity analysis. (LIFE/LIP)

Spiliopoulos, Leonidas
Research Scientist (B.A. in Economics, 1997, Yale University; M.Sc. in International and European Economic Studies, 2003, Athens University of Economics and Business; PhD in Economics, 2008, The University of Sydney): Behavioral economics; experimental economics; game theory; judgment and decision-making; neuroeconomics; model selection; computer science; machine learning. (ARC)

Spitzer, Bernhard
Senior Research Scientist (Dr. phil. in Psychology, 2007, Universität Regensburg): Cognitive neuroscience; memory; decision-making; numerical processing; neural oscillations. (ARC)

Steininger, Fabian
Predoc (M.Ed. in Social Sciences and History, 2013, Freie Universität Berlin): Theories of nationalism; historiology; late Ottoman history. (MEMS/HoE)

Stille, Max
Researcher (M.A. in History of South Asia and Islamic Studies [Arabic], 2012, Heidelberg University; Dr. in South Asian Studies, 2017, Heidelberg University): Religion; literature; global history; performance; rhetoric; Islam; Bangladesh. (HoE)

Stobbe, Emil
Predoc (B.Sc. in Psychology, 2017, Maastricht University; M.Sc. in Cognitive Neuroscience, 2019, Maastricht University): Cognitive neuroscience; environmental neuroscience, noise, and scene perception; plasticity and learning; working memory; functional magnet resonance imaging; high resolution imaging; electroencephalography. (LMG EnvNeuro)

Sudimac, Sonja
Predoc (B.Sc. in Psychology, 2015, University of Belgrade; M.Sc. in Educational Psychology, 2016, University of Belgrade; M.Sc. in Cognitive Science, 2019, Hochschule Kaiserslautern): Environmental neuroscience; environmental psychology; cognitive neuroscience; affective neuroscience; social neuroscience. (LMG EnvNeuro)

Swaboda, Nora
Predoc (M.Sc. in Mind and Brain, 2017, Humboldt-Universität zu Berlin): Cognitive development; active and ecological learning. (MPRG iSearch)
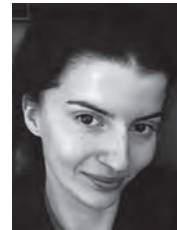
Sztuka, Izabela Maria
Predoc (B.A. in Archaeology, 2011, University of Warsaw; B.A. in Psychology, 2017, Dublin City University; M.Sc. in Psychology, 2018, The University of Edinburgh; M.Sc. in Computational Neuroscience & Cognitive Robotics, 2019, University of Birmingham): Cognitive computational neuroscience; environmental neuroscience; sensory perception; working memory; heuristic learning systems; artificial intelligence. (LMG EnvNeuro)

Szymanski, Caroline
Postdoc (B.A. in Neuroscience, 2008, University of Cologne; M.Sc. in Medical Neuroscience, 2010, Charité Universitätsmedizin Berlin; Dr.rer.nat. in Psychology, 2017, Humboldt-Universität zu Berlin): Interpersonal (action) coordination; EEG hyperscanning. (LIP)

Takao, Makoto Harris
Researcher (B.A. in Japanese, 2011, The University of Western Australia; B.A. [Hons.] in Asian Studies, 2012, The University of Western Australia; PhD in History and Music, 2016, The University of Western Australia): History of emotions; historical ethnomusicology; early music; Japanese cultural history; Jesuit history; Christian missions in Japan in 16th-20th centuries. (HoE)

Thoma, Anna
Predoc (B.Sc. in Psychology, 2016, Friedrich-Alexander-Universität Erlangen-Nürnberg; M.Sc. in Psychology, 2019, Humboldt-Universität zu Berlin): Decisions under uncertainty; lifespan development; social decision-making; computational models of learning and decision-making; ecological validity of decision strategies. (LIFE/ARC)

Tiffin-Richards, Simon P.
Research Scientist (B.Sc. in Psychology, 2006, University of Reading; M.Sc. in Methods in Psychology, 2007, University of Reading; Dr.phil. in Psychology, 2011, Freie Universität Berlin): Reading acquisition and comprehension; eye movements during reading; English as a foreign language; validity issues in educational research. (MPRG REaD)

Trippas, Dries
Research Scientist (B.Sc. in Psychology, 2008, KU Leuven; M.Sc. in Experimental Psychology, 2010, KU Leuven; PhD in Cognitive Psychology, 2013, Plymouth University): Cognitive modeling; probabilistic inference; reasoning; signal detection theory. (ARC)

Tump, Alan Novaes
Postdoc (B.Sc. in Biology, 2013, Bielefeld University; M.Sc. in Biology, 2016, Bielefeld University): Collective decision-making; social information usage; social learning strategies; ultimate aspects of behavior. (ARC)

Turner, Tamara
Researcher (B.Mus. in Composition, 2001, University of Oregon; M.Mus. in Ethnomusicology, 2012, Tufts University; PhD in Anthropology of Music, 2017, King's College London): Music, sound, and emotion/affect; the centrality of affect in ritual and religion/spirituality, particularly looking at Islam/Sufism; emotions and the body, bodily ways of knowing; trance/altered states of consciousness via musical and emotional pathways; medical humanities, medical anthropology, cultural understandings of "wellbeing"; anthropology of magic, mystery, and supernatural phenomena. (HoE)

van den Bos, Wouter
Research Scientist (M.A. in Philosophy, 2004, University of Amsterdam; M.Sc. in Cognitive Science, 2006, University of Amsterdam; PhD in Psychology, 2011, Leiden University): Development; decision-making; learning; neuroimaging; computational modeling; connectivity analyses; social behavior. (ARC)

Vidor, Gian Marco
Researcher (PhD in Modern History and Anthropology, 2008, Université de Versailles Saint-Quentin-en-Yvelines & Fondazione Collegio San Carlo—Modena [Joint Program]): History of emotions; history and anthropology of dying, death, and grief; history of childhood; history of the body; social history; history of law; history of religions. (HoE)

von Oertzen, Timo
Universität der Bundeswehr München and LIP Associate (Diploma in Computer Science, 1999, Saarland University; B.A. in Psychology, 2001, Saarland University; PhD in Computer Science, 2003, Saarland University; Habilitation in Psychology, 2013, Humboldt-Universität zu Berlin): Optimization of the translation of resources into scientific information by (1) developing methods to optimize study designs and (2) extracting a maximum of information from existing data. (LIP)

Wagner, Gert G.
Max Planck Fellow (Diploma in Economics, 1978, Goethe University Frankfurt am Main; Dr.rer.oec. in Economics, 1984, Technische Universität Berlin; Habilitation in Economics, 1992, Technische Universität Berlin; Dr.rer. pol. h.c. in Economic and Social Science, 2018, University of Cologne): Human behavior; risk attitudes; research ethics; knowledge transfer.

Wambach, Julia
Researcher and MEMS Coordinator (B.A./Licence in History and French Studies, 2006, Ruhr-Universität Bochum & Université François Rabelais Tours; M.A. in History and French Studies, 2009, Ruhr-Universität Bochum; PhD in History, 2017, University of California, Berkeley; Coordinator IMPRS Moral Economies): History of Western Europe, in particular of France and Germany; entangled history and transfers; history of emotions; wars and occupations; social history of deindustrialization; oral history. (MEMS/HoE)

Waschke, Leonhard
Postdoc (B.Sc. in Psychology, 2014, Leipzig University; M.Sc. in Neuroscience, 2016, Freie Universität Berlin): Processing of sensory information; perceptual decision-making; states of brain activity and their behavioral and perceptual relevance; intra- and interindividual variability of brain states and healthy aging. (LIP/LNDG)

Wegwarth, Odette
Senior Research Scientist (Diploma in Psychology, 2003, University of Potsdam; Dr.rer.nat. in Psychology, 2007, Humboldt-Universität zu Berlin; Habilitation in Medical Sociology, 2015, Charité Universitätsmedizin Berlin): Medical risk literacy in doctors and patients; evidence-based decision-making; fast-and-frugal decision support tools; defensive decision-making in medicine; conflict of interests in medicine. (ARC)

Wehrspaun, Claudia
Postdoc (DPhil in Psychology, 2014, University of Oxford): Brain aging across the human lifespan; neural correlates and regulators of developmental change; age-related differences in memory; impact of genetics and lifestyle measures on brain aging; risk for neurodegenerative disease; network analysis; machine learning. (LIP)

Wenger, Elisabeth
Research Scientist (Diploma in Psychology, 2010, Freie Universität Berlin; Dr.rer. nat. in Psychology, 2014, Humboldt-Universität zu Berlin): Brain plasticity across the lifespan; timing and functional nature of anatomical brain changes; structural neuroimaging. (LIP)

Werkle–Bergner, Markus
Senior Research Scientist (Diploma in Psychology, 2004, Saarland University; Dr.rer.nat. in Psychology, 2009, Humboldt-Universität zu Berlin; Habilitation in Developmental and Neuropsychology, 2019, Ruhr-Universität Bochum): Lifespan development of memory and cognitive control functions; neuronal correlates of lifespan plasticity and change; EEG methods in lifespan research; multivariate statistical models of variability and change. (LIP)

Werner, André
Research Scientist (Degree in Composition, Theory, Instruments, 1992, Berlin University of the Arts): Composition; music in science in music. (LIP)

Werner, Anna–Dorothea
Research Coordinator (M.A. in Romance Studies, Human Geography and Business Administration, 2011, University of Potsdam): RisikoAtlas (Harding Center)

Wertz, Annie E.
Max Planck Research Group Leader (B.A. in Psychology, 2003, Boston University; PhD in Psychology, 2009, University of California, Santa Barbara): Developmental and evolutionary approaches to cognition; social learning; social cognition; infancy. (MPRG Naturalistic)

Wiegand, Iris
Postdoc (Diploma in Psychology, 2009, Saarland University; PhD in Systemic Neurosciences, 2013, Ludwig-Maximilians-Universität München): Individual differences, attention and memory; visual cognition; cognitive aging; computational modeling; electroencephalography. (LIP/LNDG)

Wilhelm, Christoph
Research Scientist (B.Sc. in Healthcare Management, 2014, Fulda University of Applied Sciences; M.Sc. in Public Health, 2017, Fulda University of Applied Sciences): Health and social inequality research and shared/participative decision-making. (Harding Center/Emeritus Group Gigerenzer)

Wittkuhn, Lennart
Predoc (B.Sc. in Psychology, 2015, Technische Universität Dresden; M.Sc. in Cognitive-Affective Neuroscience, 2017, Technische Universität Dresden): Learning of sequential task states; decoding task representations from neural activation patterns; adaptive decision-making in dynamic environments. (COMP2PSYCH/MPRG NeuroCode)

Włodarczyk, Aleksandra
Postdoc (M.A. in Psychology, 2006, University of Gdańsk; Postgraduate Diploma in Advanced Clinical Psychology, 2011, Medical University of Gdańsk; Dr.phil. in Psychology, 2019, Freie Universität Berlin): Developmental psychology; social cognition; coping with developmental challenges and adversity across the lifespan; response to threat in infancy and early childhood. (MPRG Naturalistic)

Woike, Jan K.
Research Scientist (Diploma in Psychology, 2001, Ruhr-Universität Bochum; Dr.phil. in Psychology, 2008, Ruhr-Universität Bochum): Ecological rationality; human cognition and heuristics; behavioral economics; destructive competition; distributive fairness; crowdsourcing in research; big data and privacy; personal identity; philosophy of psychology. (ARC)

Wu, Charley M.
Postdoc (B.A. in Philosophy, 2009, The University of British Columbia; M.Sc. in Cognitive Science, 2015, University of Vienna; Dr.rer.nat. in Psychology, 2019, Humboldt-Universität zu Berlin): Information search; exploration-exploitation; adaptive learning; quantifying uncertainty; sampling methods. (ARC)

Yahosseini, Kyanoush Seyed
Predoc (B.Sc. in Computer Science, 2010, University of Freiburg; M.Sc. in Computer Science, 2014, Freie Universität Berlin; Dr. rer. nat. in Psychology, 2020, Freie Universität Berlin): Collective intelligence; collective problem solving; judgment propagation. (ARC)

Yu, Shuli
Postdoc (B.Sc. in Information Systems Management, 2008, Singapore Management University; B.Soc.Sc. in Psychology, 2008, Singapore Management University; M.A. in Psychology, 2013, Michigan State University; PhD in Psychology, 2015, Michigan State University): Judgment and decision-making; cognitive modeling; process tracing. (ARC)

Zika, Ondrej
Postdoc (B.Sc.Econ. in Marketing and Psychology, 2013, Aberystwyth University; DPhil in Clinical Neuroscience, 2019, University of Oxford): Computational cognitive neuroscience; computational psychiatry; neural basis of uncertainty; aversive learning; anxiety; Bayesian modeling. (MPRG NeuroCode)

Zilker, Veronika
Postdoc (B.Sc. in Psychology, 2013, Freie Universität Berlin; M.Sc. in Mind and Brain [Track Brain], 2015, Humboldt-Universität zu Berlin): Computational modeling of cognition; experimental and statistical methods; attentional processes in decision-making; decision-making under risk; theory integration. (ARC)

Zitzmann, Michael
Research Scientist (Diploma in Media Computer Science, 2010, Technische Universität Dresden): Human–computer interaction; computer vision; psychology of perception. (Harding Center/Emeritus Group Gigerenzer)

Zohar, Emma
Postdoc (B.A in Jewish History, 2007, University of Haifa; M.A. in Jewish History, 2011, University of Haifa; PhD in History, 2019, The Hebrew University of Jerusalem): Jewish history; interwar Poland; gender; cultural history. (HoE)

Zúñiga Nieto, Carlos
Postdoc (M.A. in Latin American History, 2009, Columbia University; MPhil in Latin American History, 2011, Columbia University; Dr.phil. in History, 2016, Columbia University): History of emotions; history of childhood and youth; history of education and religion; Latin American history; global history; imperial history. (HoE)

7. Where Have Our Researchers Gone? New Positions 2017–2019/20

Researchers / Research Scientists

Artinger, Florian   2019, Berlin International University of Applied Sciences, Berlin, Germany, Full Professor
Baum Ina   2017, Museum für Naturkunde Berlin, Scientific Advisor for Evaluation
Brehmer, Yvonne   2018, Tilburg University, Netherlands, Full Professor
Christophel, Thomas   2019, Bernstein Center for Computational Neuroscience, Berlin, Germany, Postdoctoral Researcher
Ellermann, Christin   2020, University of Potsdam, Germany, Research Scientist
Filimon, Flavia   2017, University of Surrey, Guildford, UK, Visiting Lecturer
Flitner, Ursula   2017, Charité Universitätsmedizin Berlin, Germany, Head of Medical Library
Freier, Monika   2019, Humboldt-Universität zu Berlin, Germany, Lecturer
Gammerl, Benno   2017, Goldsmiths, University of London, UK, Lecturer
Hachmann, Wibke   2018, Brandenburg Medical School Theodor Fontane, Neuruppin, Germany, Lecturer
Hasenäcker, Jana   2018, International School for Advanced Studies (SISSA), Triest, Italy, Postdoctoral Fellow
Held, Anna   2019, Stifterverband, Berlin, Germany, Community Manager
Herwig, Maria   2019, European Movement, Berlin, Germany, Project Manager
Hinneburg, Jana   2018, Martin Luther University Halle-Wittenberg, Germany, Researcher, and Federal Ministry of Health, Berlin, Germany, Scientific Advisor
Horn, Sebastian S.   2017, University of Zurich, Switzerland, Senior Teaching and Research Associate
Jenny, Mirjam A.   2020, University of Potsdam, Germany, Head Research Scientist and CEO
Jensen, Uffa   2017, Technische Universität Berlin, Germany, Full Professor
Keresztes, Attila   2018, Hungarian Academy of Science, Budapest, Hungary, Research Scientist
Katsikopoulos, Konstantinos V.   2017, University of Southampton, UK, Associate Professor
Kothiyal, Amit   2018, smava GmbH, Berlin, Senior Data Scientist
Lein, Ines   2020, University of Potsdam, Germany, Scientific Research Coordinator
Luan, Shenghua   2017, Chinese Academy of Sciences, Beijing, China, Full Professor
Markant, Douglas   2017, The University of North Carolina at Charlotte, USA, Assistant Professor
McDowell, Michelle   2020, University of Potsdam, Germany, Research Scientist
Molleman, Lucas   2018, University of Amsterdam, Netherlands, Research Scientist
Mousikou, Petroula   2019, University of Göttingen, Germany, Research Scientist
Nelson, Jonathan D.   2017, University of Surrey, Guildford, UK, Lecturer
Pleskac, Timothy J.   2018, The University of Kansas, Lawrence, USA, Full Professor
Prinz, Roman   2018, Deutscher Fußball-Bund, Frankfurt a.M., Germany, Project Leader
Rajamani, Imke   2018, Freie Universität Berlin, Germany, Project Manager; 2019, Falling Walls Foundation, Berlin, Germany, Head of Young Entrepreneurs in Science
Rebitschek, Felix G.   2020, University of Potsdam, Germany, Research Scientist
Riediger, Michaela   2017, Friedrich Schiller University Jena, Germany, Full Professor
Schaar, Katrin   2019, Technische Universität Berlin, Germany, Project Coordinator
Schroeder, Sascha   2018, University of Göttingen, Germany, Full Professor
Şimşek, Özgür   2017, University of Bath, UK, Senior Lecturer
Stille, Max   2019, NETZ Bangladesh: Partnership for Development and Justice, Wetzlar, Germany, Director
Takao, Makoto Harris   2019, University of Illinois at Urbana-Champaign, USA, Assistant Professor
Tiffin–Richards, Simon   2018, Freie Universität Berlin, Germany, Visiting Professor
Trippas, Dries   2018, Red Bull GmbH, Salzburg, Austria, Senior Data Scientist
Vagharchakian, Laurianne   2017, French Behavioural Insights Unit, Paris, France, Executive Advisor
van den Bos, Wouter   2018, University of Amsterdam, Netherlands, Associate Professor
Verrel, Julius   2017, Universität zu Lübeck, Germany, Research Scientist
Vidor, Gian Marco   2017, University of Geneva, Switzerland, Researcher
Werner, Anna–Dorothea   2020, University of Potsdam, Germany, Research Coordinator
Wilhelm, Christoph   2020, University of Potsdam, Germany, Research Scientist
Woike, Jan K.   2020, Plymouth University, UK, Lecturer
Zitzmann, Michael   2020, University of Potsdam, Germany, Research Scientist

Postdoctoral Fellows

Adolf, Janne   2017, KU Leuven, Belgium, Postdoctoral Fellow
Afacan, Şeyma   2018, Kırklareli University, Turkey, Faculty Member
Abbott, Joshua T.   2018, The University of Melbourne, Australia, Postdoctoral Research Fellow
Barkoczi, Daniel   2017, Linköping University (LiU), Sweden, Postdoctoral Fellow
Bender, Andrew R.   2018, Michigan State University, USA, Assistant Professor
Binder, Julia C.   2017, Merck (Schweiz) AG, Switzerland, Medical Advisor Neurology
Cancian, Sonia   2019, McGill University, Montreal, Canada, Researcher
Cole, Whitney G.   2018, New York University, USA, Research Scientist
Dai, Junyi   2017, Zhejiang University, Hangzhou, China, Assistant Professor
de Groot, Timon   2018, University of Cologne, Germany, Researcher
Elsner, Claudia   2018, District Hospital Prignitz non-profit GmbH, Perleberg, Germany, Clinical Psychologist
Fantasia, Valentina   2017, Sapienza University of Rome, Italy, Postdoctoral Fellow
Franke, Paul   2019, Centre Marc Bloch, Berlin, Germany, Researcher
Gerlach, Philipp   2018, Hochschule Fresenius, Hamburg, Germany, Full Professor
Hariskos, Wasilios   2017, University of Erfurt, Germany, Senior Scientist
Karch, Julian D.   2017, Leiden University, Netherlands, Assistant Professor
Kozodoi, Nikita   2018, Humboldt-Universität zu Berlin, Germany, Postdoctoral Fellow
Laube, Corinna   2020, Hochschule Fresenius, Hamburg, Germany, Lecturer
Mühlroth, Beate E.   2020, Bundespsychotherapeutenkammer, Berlin, Germany, Research Scientist
Perry, Alistair   2020, University of Cambridge, UK, Postdoctoral Researcher
Szymanski, Caroline   2018, Hasso Plattner Institute, Potsdam, Germany, Lecturer
Tan, Jolene H.   2018, University of Konstanz, Germany, Postdoctoral Fellow
Raffington, Laurel   2018, The University of Texas at Austin, USA, Postdoctoral Fellow
Wu, Charley M.   2019, Harvard University, Cambridge, USA, Postdoctoral Fellow
Yu, Shuli   2017, Judge.me, Lima, Peru, Product Manager
Zúñiga Nieto, Carlos   2018, Boston College, Morrissey College of Arts and Sciences, USA, Visiting Assistant Professor

Predoctoral Fellows

Bernet, Tobias   2018, Institute for Human Sciences (IWM), Vienna, Austria, Junior Visiting Fellow
Butler, Oisin   2018, Bayer AG, Berlin, Germany, Project Manger
Eilers, Sarah   2018, Senate Department for Education, Youth and Family, Berlin, Germany, Trainee Teacher
Grolig, Lorenz   2018, Senate Department for Education, Youth and Family, Berlin, Germany, School Psychologist
Heß, Stefan   2018, University of Potsdam, Germany, Research Scientist
İlengiz, Çiçek   2019, MPI for the Study of Religious and Ethnic Diversity, Göttingen, Germany, Postdoctoral Fellow
Rohringer, Thomas   2017, Kunstuniversität Linz, Austria, Junior Fellow
Schnädelbach, Sandra   2017, University of Strasbourg, France, Postdoctoral Researcher
Yahosseini, Kyanoush Seyed   2020, Robert Koch Institute, Berlin, Germany, Software Developer

The Max Planck Institute for Human Development, founded in 1963, is a multidisciplinary research establishment dedicated to the study of human development and education. Its inquiries are broadly defined, encompassing evolutionary, historical, social, and institutional contexts of individual human development from infancy to old age. The disciplines of psychology, history, and education, which reflect the current directors' backgrounds, are enriched by the work of colleagues from behavioral and developmental neuroscience, evolutionary biology, economics, mathematics, computer science, sociology, and the humanities.

The Institute is one of more than 80 research facilities financed by the Max Planck Society for the Advancement of Science (Max-Planck-Gesellschaft zur Förderung der Wissenschaften e.V.), the core support for which is provided by the Federal Republic of Germany and its 16 states.

The Institute was founded in 1963 on the initiative of Hellmut Becker—at a time when the public and policy-makers were beginning to realize that education, if it was to meet the demands of a rapidly changing society, was in need of new impulses from scientific research. In the first decade of its existence, the development of educational research and educational policy was emphasized. Becker was subsequently joined by Friedrich Edding, Dietrich Goldschmidt, and Saul B. Robinsohn (1964) as the first generation of scientific directors.

The appointment of a second generation of directors—Wolfgang Edelstein (1973, initially as a member of the management board and from 1981 as a director) and Peter M. Roeder (1973)—added a commitment to basic research in human development and educational processes to this framework.

Since the 1980s and with the appointment of a third generation of senior fellows and scientific directors—Paul B. Baltes (1980), Karl Ulrich Mayer (1983), Jürgen Baumert (1996), Gerd Gigerenzer (1997)—research at the Institute has increasingly concentrated on questions of basic research associated with the nature of human development, education, and work in a changing society. At the same time, lifespan developmental and life-course research were added as a signature profile of the Institute's research program.

Latest developments in the succession of generations were marked by the appointment of Ulman Lindenberger as new director (2004), adding an emphasis on neural correlates of human behavior and cognitive plasticity, and by the appointment of Ute Frevert (2007), adding perspectives from cultural history to the Institute's research agenda on human development. The appointment of Ralph Hertwig (2012) has further enriched the Institute's research on human decision-making processes, with a special focus on the social environment and changes across the lifespan. With the appointment of Iyad Rahwan (2019), the societal challenges of digitization have become a research topic at the Institute.

In addition, an increasing number of Max Planck Research Groups contribute to the multi-faceted scientific profile of the Institute.

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