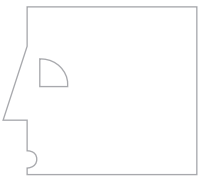
Research Report 2005–2006

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, but concentrate on the evolutionary, social, historical, and institutional contexts of human development. The disciplines of education, psychology, and history reflect the current directors' backgrounds, but the Institute's scholarly spectrum is enriched by the work of colleagues from such fields as behavioral developmental neuroscience, sociology of education, mathematics, economics, computer science, evolutionary biology, and the humanities.

The Institute for Human Development is one of about 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.

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

MAX-PLANCK-GESELLSCHAFT



Research Report 2005–2006

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

Impressum

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Introduction

Introduction

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

The Institute is one of about 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 total permanent staff at the Institute is 110, including 35 researchers, supplemented by a varying number of predoctoral, postdoctoral, and affiliate researchers and visiting fellows.

Research Centers

Research into processes of human development is conducted primarily from the theoretical vantage points offered by models of bounded rationality and risk behavior, institutionalized learning, lifespan psychology, life-course sociology, and, as of 2007, cultural history.

In the 2005–2006 period, research at the Institute was primarily organized in three research centers:

The **Center for Adaptive Behavior and Cognition** (Director: Gerd Gigerenzer) investigates human rationality, in particular decision making and risk perception in an uncertain world. Current research focuses on (1) bounded rationality, that is, the simple heuristics—cognitive, emotional, and behavioral—that laypeople and experts use to make decisions under constraints of limited time and knowledge, (2) social intelligence in cooperation and competition, and (3) risk understanding and uncertainty management in everyday life, including applications in medicine, law, and education. Each of these research areas emphasizes the evolutionary foundations of behavior and cognition, in particular their domain specificity and functional adaptiveness (pp. 31–65).

The **Center for Educational Research** (Director: Jürgen Baumert) examines learning and development from an institutional point of view. Educational settings, such as schools, offer a variety of developmental opportunities, but, at the same time, exclude others. The impact of such settings is investigated from three perspectives: (1) the long-term consequences of schools' opportunity structures on individual development in terms of cognitive competencies as well as motivational and social resources, (2) international comparison of the outcomes of schooling in the fields of reading comprehension, mathematics and science literacy, and cross-curricular competencies, and (3) improvement of learning and instruction in terms of the cognitive activation of students, mainly in science and mathematics (pp. 66–125).

The **Center for Lifespan Psychology** (Director: Ulman Lindenberger) is characterized by a lifespan perspective and a concern with the optimization of human potential. Empirical investigations of infants, children, adolescents, adults, and the elderly concentrate on the domains of cognition, sensorimotor functions, affect, and motivation, the interplay among these domains within individuals of different ages, and on interpersonal action coordination and codevelopment. The plasticity of human behavior and the potential for successful development, including their neural and societal causes and effects, play a central role in theory, research design, and methodology (pp. 126–179).

In 2007, the **Center for the History of Emotions** (Director: Ute Frevert) will be added to the research profile of the Institute. Karl Ulrich Mayer, the Director of the former Center for Sociology and the Study of the Life Course, left the Institute in July 2005. He is now at Yale University, New Haven, USA,

where he directs the Center for Research on Inequalities and the Life Course.

The Institute also houses an **Independent Junior Research Group on the Neurocognition of Decision Making** (Head: Hauke Heekeren). Using a combination of psychophysical methods, functional and structural neuroimaging, modeling, and pharmacological intervention, this group investigates mechanisms of decision making in the human brain (pp. 180–199).

An important collaborative effort involving all Centers at the Institute as well as universities in Berlin and the United States is the **International Max Planck Research School "The Life Course: Evolutionary and Ontogenetic Dynamics (LIFE),"** which is currently co-chaired by Ulman Lindenberger, Berlin, Jacquelynne S. Eccles, University of Michigan, and John R. Nesselroade, University of Virginia. This interdisciplinary graduate program brings together doctoral students from the United States and Germany but also from many other countries (see pp. 21–26).

Another international project organized by the Max Planck Society and housed at the Institute is the **International Max Planck Research Network on Aging (MaxnetAging).** This network was directed by the late Paul B. Baltes (Deputy Directors: Shu-Chen Li and Jacqui Smith). The general focus of the network is on research, theory, and method of the behavioral and social science of aging. Specific objectives include the development of new interdisciplinary research initiatives, and providing a forum for promoting the careers of young scientists interested in the study of aging. The institutional collaboration involves several Max Planck Institutes, the Karolinska Institute, Stockholm, and the University of Virginia (see pp. 28–29).

Paul B. Baltes (1939–2006)

The Institute parts in gratitude from Paul B. Baltes, who passed away on November 7, 2006, at the age of 67 years, after a fierce battle against cancer. An Academic Memorial in his honor took place in January 2007 (see Program, pp. 11–12). Paul Baltes directed the Center for Lifespan Development from 1980–2004, and became the Founding Director of MaxnetAging in 2005. Paul Baltes was an innovator who reshaped the fields of lifespan psychology and gerontology. His empirical and theoretical contributions have opened up new perspectives and pathways for science and society, and his contributions to the welfare of the Institute are immense.

Continued p. 13

Paul B. Baltes (1939–2006)
Academic Memorial

AKADEMISCHE GEDENKFEIER

10:00 Uhr — **Beginn**

Aus der Partita a-Moll, Sarabande, J. S. Bach
Dominik Wollenweber — Solo-Englischhornist der Berliner Philharmoniker

Begrüßung

Ulman Lindenberger — Geschäftsführender Direktor, Max-Planck-Institut für Bildungsforschung

Grußworte

Peter Gruss — Präsident der Max-Planck-Gesellschaft

Volker ter Meulen — Präsident der Deutschen Akademie der Naturforscher Leopoldina
David Magnusson — The Royal Swedish Academy of Sciences
Günter Stock — Präsident der Berlin-Brandenburgischen Akademie der Wissenschaften
Klaus Jacobs — Jacobs Foundation
Gene Block — Vice President and Provost, University of Virginia
Ursula Staudinger — Stellvertretende und Designierte Präsidentin, Deutsche Gesellschaft für Psychologie
Jacquelynne Eccles — Co-Speaker of the International Max Planck Research School LIFE, University of Michigan
Jacqui Smith — Deputy Director, Max Planck International Research Network on the Behavioral and Social Sciences of Aging, University of Michigan
Denise Park — Chair of Advisory Board of the Max Planck Institute for Human Development, University of Illinois, Urbana-Champaign

Reflektionen

Wolfgang Lepenies — Permanent Fellow, Wissenschaftskolleg
Günther Uecker — Künstler, Orden Pour le mérite für Wissenschaft und Künste

Sonate a-Moll, Adagio, C. P. E. Bach

12:30 Uhr — **Reception**

Poster Session of predoctoral students from the LIFE Research School and the Lifespan Psychology research unit of the MPI for Human Development

12 January 2007
Harnack House, Berlin

SYMPOSIUM

Lifespan Development in an Aging Society: The Legacy of Paul B. Baltes

14:00 Uhr **Beginn**

Einführung

Gerd Gigerenzer Direktor, Max-Planck-Institut für Bildungsforschung

Vorträge

Jürgen Kocka Präsident, Wissenschaftszentrum Berlin für Sozialforschung
Chancen und Probleme alternder Gesellschaften

Ulman Lindenberger Max-Planck-Institut für Bildungsforschung
Lifespan Psychology and Developmental Neuroscience:
Propositions for a Constructive Alliance

John Nesselroade University of Virginia
Another Look at Factorial Invariance and Developmental Change Measurement

Laura Carstensen Stanford University
Life-Span Developmental Trajectories of Motivation, Emotion, and Cognition

Jochen Brandtstädter Universität Trier
Rationality, Wisdom, and Awareness of Life's Finitude

Alexandra Freund Universität Zürich
Regulating the Incompleteness and Imperfection of Life:
An Emerging Theory on Sehnsucht

16:30 Uhr **Ende**

Simultaneous interpreting from German to English will be provided.

Governance of the Institute

The Institute is governed by a Board of Directors, currently consisting of the four members of the Institute who are Fellows (Wissenschaftliche Mitglieder) of the Max Planck Society (Jürgen Baumert, Ute Frevert, Gerd Gigerenzer, Ulman Lindenberger).

The Board is augmented by one member from the Institute's research staff (Ulrich Trautwein) and the Head of Administration (Olaf von Maydell). On a rotational basis, one of the Directors is elected by the Board to serve as Managing Director, usually for a period of two years.

Several in-house committees composed of representatives elected by the entire scientific staff or by appointment 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), which is elected by all scientists.

The **International Board of Scientific Advisors** offers an important source of external review and advice to both the Directors and the scientific staff on matters of research 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 biannually to discuss completed, ongoing, and future research projects at the Institute. A list of the current members can be found on the front matter of this report.

Organization of the Annual Report

This research report is organized in the following manner:

- The presentation of each research center begins with an introductory overview summarizing its program.
- The introduction is followed by descriptions of the center's research areas and selected projects along with a list of scientific publications.
- The supportive activities of the service units—library and computing services—are described in a special section at the end of the report (pp. 203–206).
- The appendix provides information on the research colloquia held at the Institute, the visiting scholars, and the cooperation of the Institute's scientific staff with projects outside the Institute. It also includes an index of the scientific staff and their research interests (pp. 208–227).

Berlin, June 2007

For the Board of Directors:
Ulman Lindenberger

Highlights

Honors and Awards 2005–2006

Paul B. Baltes Award for Distinguished Career Contributions to the Study of Human Development across the Life Span, Society for the Study of Human Development
Jürgen Baumert Vice-President, Max Planck Society for the Advancement of Science
Jürgen Baumert EARLI Oeuvre Award, European Association for Research on Learning and Instruction
Jürgen Baumert National Leadership Award, Economic Forum Germany
Natalie C. Ebner Heinz Heckhausen Prize for Young Scientists, German Psychological Association
Wolfgang Edelstein Order of Merit of the Federal Republic of Germany
Wolfgang Gaissmaier New Investigator Award, Brunswik Society
Gerd Gigerenzer Honorary Professor of Psychology, Humboldt University Berlin
Monika Keller Honorary Professor of Psychology, Free University Berlin
Ulman Lindenberger Member, German Academy of Sciences Leopoldina, Section "Empirical Psychology and Cognitive Sciences"
Martin Lövdén Sofja Kovalevskaja Prize, Alexander von Humboldt Foundation
Jacqui Smith New South Wales Return Award for an Expatriate Researcher
Elsbeth Stern Invited contribution to the yearbook "Highlights of German Science 2005", edited by the German Universities Association

Students Awards
Nathalie C. Ebner Best Poster Prize, German Psychological Association, Section for Developmental Psychology
Jutta Mata (Wittig) Springer Prize for Best Diploma Thesis, Humboldt University Berlin, Dept. of Psychology
Gabriel Nagy Junior Researcher Award, German Psychological Association, Section for Educational Psychology
Susanne Scheibe Otto Hahn Medal for Young Researchers, Max Planck Society
Andreas Wilke Owen F. Aldis Award, International Society for Human Ethology

Where Have Our Researchers Gone?
New Positions 2005–2006

Research Scientists

Cordula Artelt 2005, University of Bamberg, Full Professor of Pre- and Elementary School Research
Arndt Bröder 2005, Max Planck Institute for Research on Collective Goods
Martin Brunner 2006, University of Luxemburg, Assistant Professor
Anja Dieckmann 2005, Institute for Research in Consumer Goods, Nuremberg
Stefan Krauss 2007, University of Kassel, Assistant Professor
Martin Lövdén 2006, Lund University, Associate Professor
Britta Matthes 2005, Institute for Labor Market and Employment Research (IAB), Nuremberg, Research Scientist
Antje Mertens 2005, Berlin School of Economics, Professor of Economics
Maike Reimer 2005, Bavarian State Institute for Research in Higher Education, Munich, Research Scientist
Florian Schmiedek 2006, Humboldt University Berlin, Junior Professor for Cognitive Developmental Psychology
Holger Seibert 2005, Institute for Labor Market and Employment Research, Berlin-Brandenburg, Research Scientist
Jacqui Smith 2006, University of Michigan, Ann Arbor, Full Professor of Psychology, and Institute for Social Research (ISR), Research Professor
Heike Solga 2005, University of Göttingen, Full Professor of Sociology
Petra Stanat 2005, University of Erlangen-Nuremberg, Full Professor of Empirical Research in Teaching and Instruction
Elsbeth Stern 2006, Swiss Federal Institute of Technology (ETH), Zurich, Full Professor for Empirical Research in Teaching and Instruction
Masanori Takezawa 2006, Tilburg University, Faculty of Social and Behavioural Sciences, Lecturer
Peter Todd 2005, Indiana University, School of Informatics, Professor of Informatics, Cognitive Science, and Psychology
Heike Trappe 2005, German Institute for Economic Research (DIW), Managing Director Council of Socio-economic Data
Rainer Watermann 2005, University of Göttingen, Full Professor of Educational Sciences

Postdoctoral Research Fellows

Will Bennis 2005, Northwestern University, Postdoctoral Researcher
Natalie C. Ebner 2007, Yale University, Postdoctoral Researcher
Rocio Garcia-Retamero 2006, University of Granada, Department of Experimental Psychology, Associated Professor
Denis Gerstorf 2005, University of Virginia, Assistant Professor
Shenghua Luan 2006, Singapore Management University, Social Sciences and Humanities, Assistant Professor
Rui Mata 2006, University of Michigan, Ann Arbor, Department of Psychology, Postdoctoral Researcher
Thorsten Pachur 2006, University of Basel, Department of Psychology, Assistant Professor
Justin J. W. Powell 2005, University of Göttingen, Assistant Professor
Torsten Reimer 2006, University of Maryland, Department of Communication, Assistant Professor
Susanne Scheibe 2007, Stanford University, Postdoctoral Researcher
Andreas Wilke 2006, University of California, Los Angeles, Postdoctoral Researcher

Predoctoral Research Fellows
Yvonne Brehmer 2006, Karolinska Institute Stockholm, Postdoctoral Researcher
Katarzyna Buzcek 2006, University of Warszaw
Zoe Daniels 2005, Rehabilitation Hospital Garder-See, Lohmen
Daniel Grühn 2006, University of Geneva, Postdoctoral Researcher
Michaela Gummerum 2005, University of Vancouver, Postdoctoral Researcher
Stefanie Gundert 2006, Yale University, Postdoctoral Researcher
Anke Höhne 2005, University of Halle-Wittenberg, Assistant Professor
Tim Johnson 2006, Stanford University
Christina K. Limbird 2006, Berlin-Brandenburg International School
Andrea G. Müller 2007, German Youth Institute (DJI), Munich
Lisa Pfahl 2005, University of Göttingen, Assistant Professor
Christina Röcke 2006, Brandeis University, Boston, Postdoctoral Researcher
Henrik Saalbach 2006, Swiss Federal Institute of Technology (ETH), Zurich, Postdoctoral Researcher
Michael Schneider 2006, Swiss Federal Institute of Technology (ETH), Zurich, Postdoctoral Researcher

Cooperation with Universities

Teaching and Academic Degrees

The Institute has always considered its cooperation with universities as very important, especially by participating in teaching activities. Researchers from our Institute teach courses at three universities in Berlin and at the University of Potsdam as well as at many other universities in Germany and abroad.
In the years 2005–2006, more than 100 courses were taught by scientific staff members —directors, research scientists, postdoctoral as well as predoctoral fellows—of the Institute.
In addition, Institute members were supported in completing their academic degrees in cooperation with the universities in Berlin and elsewhere. In the years 2005–2006, 6 habilitations and 24 doctoral dissertations were completed by scientific staff members of the Institute.
All degrees are listed in the Appendix.

Exhibition in the Institute's entrance hall. Sculptures by Özgür Emeklier

International Max Planck Research School The Life Course: Evolutionary and Ontogenetic Dynamics (LIFE)

This graduate program on the Life Course (LIFE) is part of the Max Planck Society's framework of International Max Planck Research Schools. It was established in 2002 as a collaboration between the Max Planck Institute for Human Development, Berlin, the Humboldt University Berlin, the Free University Berlin, and the University of Michigan, Ann Arbor. The University of Virginia, Charlottesville, joined in October 2004.

The goal of the Research School is advanced research training in the study of human behavior and institutional systems over evolutionary and ontogenetic (life cycle) time. LIFE takes an integrative and interdisciplinary approach to understanding human development in a changing world, connecting evolutionary, ontogenetic, historical, and institutional perspectives.

The target groups of the Research School are post-diploma or post-master's graduate students who intend to pursue a doctorate in one of the relevant disciplines (biology, psychology, neuroscience, sociology, anthropology, educational science). As a collaborative Research School, LIFE offers students a unique education experience: Discipline-based training in the study of the life course/life cycle that is enriched by interdisciplinary and international perspectives.

The training program involves seminars at the participating institutions, a series of Fall and Spring Academies, and collaborative supervision of research training. It also includes opportunities for research abroad at a cooperating institution. Five fellows from Berlin have made use of this in 2005 and 2006.

The strong interlocking components are two annual weeklong academies in which fellows and faculty from each university participate. During the report period, four such academies took place. The LIFE Spring Academy 2005 was held at the University of Virginia, the LIFE Fall Academy 2005 took place at the University of Michigan. In 2006, the Spring Academy was held at the MPI for Human Development in Berlin, and the Fall Academy took place at the University of Virginia. Generally, the average number of participants including faculty was about 50. The teaching faculty consisted of faculty members from Ann Arbor, Berlin, and Charlottesville as well as several guests from other institutions. The next Academy is scheduled to take place in Berlin in May 2007.

In addition, each participating university offers special courses reflecting the special profile of its graduate programs and selects a subset of fellows for the added specialization provided by LIFE. The Berlin approach is to offer weekly seminars at the MPI for Human Development taught throughout the academic year by a varying team of faculty from the three Berlin institutions.

In total, 69 faculty (Berlin: 24; Ann Arbor: 33; Charlottesville: 12), 51 fellows (Berlin: 27; Ann Arbor: 13; Charlottesville: 11) have been involved as of December 2006. In addition, 20 fellows (Berlin: 14; Ann Arbor: 4; Charlottesville: 2) completed their dissertation during the reporting period.

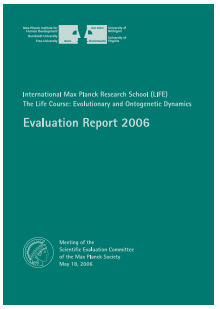
Fellows joined the program on the following annual schedule:

- 2002: 18 (Berlin: 14; Ann Arbor: 4)
- 2003: 12 (Berlin: 7; Ann Arbor: 5)
- 2004: 19 (Berlin: 10; Ann Arbor: 4; Charlottesville: 5)
- 2005: 3 (Ann Arbor)
- 2006: 23 (Berlin: 11; Ann Arbor: 4; Charlottesville: 8)

Co-chairs
Paul B. Baltes † (MPI for Human Development, until 11/2006), Ulman Lindenberger (MPI for Human Development, since 09/2006) Jacquelynne S. Eccles (University of Michigan), & John R. Nesselroade (University of Virginia)

Coordinators
Julia Delius (MPI for Human Development, until 09/2006), Sandra Fronz und Christina Röcke (MPI for Human Development, interim), Imke Kruse (MPI for Human Development, since 10/2006), Janice Templeton (University of Michigan), Juanita L. Geer (University of Virginia)

www.imprs-life.mpg.de



During the Spring Academy 2006, an independent Scientific Committee evaluated the LIFE Research School very positively. The Committee consisted of the following members: Herbert Marsh, University of Western Sydney, Denise Park, University of Illinois at Urbana-Champaign, Wolfgang Schneider, University of Würzburg, and Hannelore Weber, University of Greifswald. In addition, Wolfgang Prinz, MPI for Human Cognitive and Brain Science, and Herbert Festl, Unit for Research Strategy at the Max Planck Society, participated in the evaluation. The reviewers enthusiastically recommended continuing the IMPRS for another six-year period until 2013. For more details, see the LIFE Evaluation Report 2006.

Topics of the Berlin LIFE seminars have included:

- The Biology of Life History, Peter Hammerstein (HU) & guests
- Contexts and Dynamics of Behavior and Cognition in the Life Course, Ralf Krampe (MPI), Shu-Chen Li (MPI), Peter Todd (MPI), & guests
- The Life Course: Structures and Institutions, Martin Kohli (FU), Felix Büchel (MPI), Heike Solga (MPI), & guests
- Developmental Methodology, Ulman Lindenberger (MPI-FU-HU) & guests
- Norms and Development: Interdisciplinary Approaches, Monika Keller (MPI), Masanori Takezawa (MPI), & Gerd Gigerenzer (MPI-FU)
- Biological, Psychological, and Social Constraints on the Development of Learning across the Life Course, Jens B. Asendorpf (HU), John M. C. Hutchinson (MPI), Frieder R. Lang (Universität Halle), Shu-Chen Li (MPI), Justin Powell (MPI/University of Göttingen), Alessandra Rusconi (HEMPAS/University of Bremen), Petra Stanat (MPI), and Elsbeth Stern (MPI)
- Theoretical and Methodological Approaches to the Study of the Life Cycle: Interdisciplinary Perspectives, Paul B. Baltes (MPI-FU), John M.C. Hutchinson (MPI), Ulman Lindenberger (MPI-FU-HU), Martin Kohli (FU), Ulrich Trautwein (MPI), & guests
- The Social Psychology and Sociology of Adult Development and Aging, Jacqui Smith (MPI-FU) & guests
- Research Methods, Ulman Lindenberger (MPI-FU-HU) & guests

LIFE Spring Academy 2006 at Max Planck Institute for Human Development

MPI for Human Development
Paul B. Baltes †, Psychology & Gerontology (until 11/2006)
Jürgen Baumert, Educational Science
Gerd Gigerenzer, Psychology
Shu-Chen Li, Psychology
Ulman Lindenberger, Psychology
Karl Ulrich Mayer, Sociology (until summer 2005)
Lael J. Schooler, Psychology
Jacqui Smith, Psychology (until summer 2005)
Ulrich Trautwein, Educational Science
Peter Todd, Psychology (until summer 2005)

Free University Berlin
Michael Eid, Psychology (since 2006)
Arthur Jacobs, Psychology (since 2006)
Martin Kohli, Sociology (currently European University Institute, Florence)
Hans Merkens, Educational Science
Herbert Scheithauer, Psychology
Ralf Schwarzer, Psychology & Health
Clemens Tesch-Römer, Psychology & Gerontology

Humboldt University Berlin
Jens B. Asendorpf, Psychology
Hans Bertram, Sociology
Peter Frensch, Psychology
Peter Hammerstein, Biology
Gerd Kempermann, Neuroscience
Olaf Köller, Psychology & Education (since 2006)
Rainer H. Lehmann, Educational Science
Florian Schmiedek, Psychology (since 2006)
Arno Villringer, Psychology
Oliver Wilhelm, Psychology & Education

University of Michigan
Toni C. Antonucci, Psychology
Don Brown, Psychology
Cleopatra Howard Caldwell, Health & PRBA
Kai S. Cortina, Psychology & Education
Jacquelynne S. Eccles, Psychology & Education
David L. Featherman, Sociology & Social Psychology
Richard Gonzalez, Psychology
L. Rowell Huesmann, Psychology & Communication Studies
Jeff Hutsler, Psychology
James S. Jackson, Social Psychology
Daniel Keating, Psychology
Shinobu Kitayama, Psychology
Daniel Kruger, Psychology & Public Health
Bobbi S. Low, Evolutionary & Behavioral Ecology
Betsy Lozoff, Pediatrics
Ram Mahalingam, Psychology
Kevin F. Miller, Psychology & Education
Maria Muzik, Psychiatry
Randolph M. Nesse, Psychology & Psychiatry
Richard Nisbett, Psychology
Sheryl Olson, Psychology
Thad Polk, Psychology
Patricia A. Reuter-Lorenz, Cognitive Psychology & Neuroscience
Arnold Sameroff, Psychology
John Schulenberg, Psychology
Rachael Seidler, Psychology & Kinesiology
Jacqui Smith, Psychology (since 2006)
Abigail Stewart, Psychology
Beverly Strassman, Anthropology
Twila Tardif, Psychology
Arland Thorton, Sociology
Henry M. Wellman, Psychology
Robert Zucker, Psychology & Psychiatry

University of Virginia
Steven M. Boker, Cognitive & Quantitative Psychology
Gerald L. Clore, Social Psychology
Judy DeLoache, Developmental Psychology
Chad Dodson, Cognitive Psychology
David L. Hill, Psychobiology
Angeline Lillard, Developmental Psychology
John J. McArdle, Quantitative & Developmental Psychology (until summer 2005)
John R. Nesselroade, Quantitative & Developmental Psychology
Robert C. Pianta, Education
Timothy Salthouse, Cognitive Psychology
Eric Turkheimer, Quantitative & Clinical Psychology
Timothy D. Wilson, Social Psychology

Professorial Faculty 2005/2006

LIFE Doctoral Fellows 2005/2006

Max Planck Institute for Human Development
Michael Becker (External LIFE Fellow), Psychology
Annette Brose, Psychology
Cornelia Gresch (External LIFE Fellow), Sociology
Bettina von Helversen, Psychology
Oliver Huxhold, Psychology
Kathrin Jonkmann (External LIFE Fellow), Psychology
Dana Kotter-Grühn (External LIFE Fellow), Psychology
Ana Sofia Alves Conte de Morais, Psychology
Irene Nagel (External LIFE Fellow), Psychology
Lisa Pfahl, Sociology
Yee Lee Shing, Psychology
Yi-Miau Tsai, Educational Science
Imke Vollmar (Max Delbrück Center), Molecular Biotechnology
Julius Verrel, Cognitive Neuroscience
Markus Werkle-Bergner (External LIFE Fellow), Psychology

Free University Berlin
Poldi Kuhl (External LIFE Fellow), Educational Science
Jutta Mata, Psychology
Tabea Reuter, Psychology

Humboldt University Berlin
Tobias Bothe, Psychology
Daniel Caro Vasquez, Educational Science
Robert Gaschler (External LIFE Fellow), Psychology
Fanny Jimenez, Psychology
Judith Lehnart (External LIFE Fellow), Psychology
Lars Penke (External LIFE Fellow), Psychology
Dennis Rünger, Psychology

University of Michigan
Joaquin Anguera, Psychology
Marie Burrage, Education & Psychology
Heather Fuller, Psychology
Jessica Garrett, Educational Science
Ashley Hazel, Anthropology
Justin Jager, Psychology
Xuezhao Lan, Education & Psychology
Cristine Legare, Psychology
Emily Messersmith, Psychology
Nicky Newton, Psychology
Georges Potworowski, Psychology
Besangie Sellars, Psychology
Christy Watkins, Psychology

University of Virginia
Sarah K. Galloway, Psychology
Jesse C. Graham, Psychology
Kathryn Paige Harden, Psychology
Selin Kesebir, Psychology
Vanessa LoBue, Psychology
Joshua C. Magee, Psychology
Jamie Mangold, Psychology
Felicity F. Miao, Psychology
Elizabeth R. Tenney, Psychology
Elliot Tucker-Drob, Psychology
Lijuan (Peggy) Wang, Psychology

LIFE fellows and faculty members in a poster session.

Table 1
Dissertations Completed (2005–May 2007)

Fellow	*Dissertation title*	*Institution*	*Discipline*	*Current position*
Guido Biele	No Man is an Island: Cooperation in Groups and Social Learning	MPI/FU	Psychology	MPI for Human Development
Yvonne Brehmer	Episodic Memory Plasticity Across the Lifespan	MPI/HU	Psychology	Karolinska Institute Stockholm
Jaap J.A. Denissen	Understanding and Being Understood: The Impact of Intelligence and Dispositional Valuations on Social Relationships	HU	Psychology	Utrecht University
Sean Duffy	Seeing Through Cultures	UM	Psychology	Rutgers University-Camden
Katherine Leigh Fiori	Social Relations and Health Among Older Adults: A Cross-Cultural and Pattern-Centered Approach	UM	Psychology	Long Island University
Jessica Garrett	Motivation in the Transition to Adulthood	UM	Psychology	University of Michigan
Michaela Gummerum	The Development of Prosocial Behavior: Integrating Psychological, Economic, and Evolutionary Perspectives	MPI/FU	Psychology	University of British Columbia
Stefanie Gundert	Short-Term Contracts of Entrants and Older Employees	MPI/FU	Sociology	Yale University
Jung-Hwa Ha	Determinants and Consequences of Changing Social Support Following Late Life Widowhood	UM	Sociology	Waisman Center Wisconsin
Nicole Hess	Informational Warfare: Female Friendship and the Coalitional Manipulation of Reputation	HU	Biological Anthropology	Humboldt-University Berlin
Rainer Heuer	Policy Within the Family—Intergenerational Power at Middle and Older Age. The Example of Parents' Physical Losses	FU	Sociology	Social Science Research Center Berlin
Oliver Huxhold	Processing Fluctuations in Postural Control: Relations to Adult Age and Fluctuation in Cognition	FU	Psychology	German Center of Gerontology
Helen Krumme	Parent-Adult Relationship in Later Life: A Comparative Study on Migrant and Non-Migrant Families in Germany	FU	Sociology	Social Science Research Center Berlin
Christina Karlyn Limbird	Phonological Processing, Verbal Abilities, and Second Language Literacy Development Among Bilingual Turkish Children in Germany	FU	Educational Science	Berlin-Brandenburg International School
Rui Mata	The Aging Decision Maker: Cognitive Aging and the Use of Decision Strategies	MPI/FU	Psychology	University of Michigan
Emily Messersmith	Longitudinal Correlates of Changing Educational Expectations During the Transition to Adulthood	UM	Psychology	University of Michigan
Andrea Müller	Barriers to Reaching Proficiency in School-Related Language Among Second Language Learners	FU	Psychology	German Youth Institute
Gabriel Nagy	The Relevance of Professional Interests, Cognitive and Field-Specific Competences for the Choice of Field of Study and the Success of Study	MPI/FU	Psychology	MPI for Human Development
Pablo A. Nepomnaschy	Stress and Female Reproduction in a Rural Mayan Population	UM	Anthropology	National Institute of Environmental Health Sciences
Thorsten Pachur	Ecological Rationality: Do Samples in Memory Reflect the World?	MPI/FU	Psychology	University of Basel
Nilam Ram	Emphasizing Individuality in Developmental Models of Change	UVa	Psychology	Pennsylvania State University
Christina Röcke	Intraindividual Variability in Positive and Negative Affect: Age-Related and Individual Differences in Magnitude and Coupling with Cognitive Performance	MPI/FU	Psychology	Brandeis University

Table 1 (continued)
Dissertations Completed (2005–May 2007)

Fellow	*Dissertation title*	*Institution*	*Discipline*	*Current position*
Sabine Schäfer	Concurrent Cognitive and Sensorimotor Performance: A Comparison of Children and Young Adults	MPI/FU	Psychology	MPI for Human Development
Karen Siedlecki	Episodic Memory and the Retrieval of Information Across the Adult Lifespan	UVa	Psychology	Columbia University
Andreas Wilke	Evolved Responses to an Uncertain World	MPI/FU	Psychology	University of California, Los Angeles
Nicole Zarrett	The Dynamic Relation Between Out-of-School Activities and Adolescent Development	UM	Psychology	Tufts University

Presentation of LIFE Certificates at the first LIFE Commencement Event.

MaxnetAging

MaxnetAging

Max Planck International Research Network on Aging

Based on deliberations in the Max Planck Presidential Committee on Aging, the Max Planck International Research Network on Aging was established in the Fall of 2004. The initial time window for this Network is five years (2005–2009). During this period, the substantive task of the Network is to focus on the behavioral and social sciences of aging, broadly defined, with topical emphases on research about aging reflected in such fields as cognitive and social neuroscience, demography, psychology, law, history of science, cultural studies, sociology, economics, and the humanities. The Network consists of a core permanent group of Senior and Junior Fellows. Junior Fellows can apply for seed funds to support new research initiatives. MaxnetAging is conceived as a forum in which cross-disciplinary communication and cooperation in the study of aging is nurtured within the Human Sciences Section of the Max Planck Society and as a platform for international collaboration. Nine Max Planck Institutes have joined the network. International connections have been established with the University of Virginia and the Karolinska Institute, Stockholm.

The four profile topics of the Network are:

(1) Images and regulatory systems of the life course and aging: Historicial, legal, social, and psychological
(2) Law and aging: General and specific
(3) Plasticity in old and very old age: Neuronal, behavioral, and societal perspectives
(4) Dynamics of mortality and morbidity: Biological, psychological, and social vitality in tthe oldest ages

Semi-annual meetings, focusing on topics of human aging ranging across the full spectrum of the behavioral and social sciences and the humanities, provide the primary basis for fostering cross-disciplinary discussion and collaboration. The main Network office is located at the Max Planck Institute for Human Development in Berlin. Shu-Chen Li is the Behavioral Sciences Deputy Director and Jacqui Smith (University of Michigan) is the Social Sciences Deputy Director.

Director:
Paul B. Baltes
(† 2006)

Collaboration:
Human Sciences Section of the Max Planck Society, Karolinska Institute, Stockholm, University of Virginia

www.maxnetaging.mpg.de

Center for Adaptive Behavior and Cognition

Contents

Scientific Staff 2005–2006

Nathan Berg, Henry J. Brighton, Uwe Czienskowski, Anja Dieckmann (as of 2005: GFK, Institute for Research in Consumer Goods), **Gerd Gigerenzer,** John M. C. Hutchinson, Konstantinos V. Katsikopoulos, Monika Keller, Henrik Olsson, Jörg Rieskamp, Lael J. Schooler, Jeffrey Stevens, Peter M. Todd (as of 2005: Indiana University)

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Introductory Overview

The Center for Adaptive Behavior and Cognition (ABC) investigates reasoning and decision making under uncertainty at the levels of both individuals and social groups. The research group consists of psychologists, mathematicians, computer scientists, evolutionary biologists, economists, and researchers from other fields. With different methodological abilities, such as experimental methods, computer simulation, and mathematical analysis, they cooperate in solving the same problems.

The ABC program combines a strong theoretical focus with practical applications, that is, the research group both develops specific models and explores their applications. Applications range from helping physicians and patients understand the statistical evidence arising from medical research, helping courts, administrators, and legislators understand the importance of heuristic thinking in the law, and improving teaching practices in statistical education by introducing transparent representation formats. The theoretical focus is on rationality and can be, albeit artificially, divided into three aspects: bounded, ecological, and social rationality.

Bounded Rationality

Models of bounded rationality attempt to answer the question of how people with limited time, knowledge, money, and other scarce resources make decisions. This program is an alternative to the dominant optimization paradigm in cognitive science, economics, and behavioral biology that poses the question of how Laplacean superintelligences or near omniscient beings would behave. We study the proximal mechanisms of bounded rationality, that is, the adaptive heuristics that enable quick and frugal decisions under uncertainty. This collection of heuristics and their building blocks is what we call the adaptive toolbox.

Ecological Rationality

Models of ecological rationality describe the structure and representation of information in actual environments and their match with mental strategies, such as boundedly rational heuristics. To the degree that such a match exists, heuristics need not trade accuracy for speed and frugality. The simultaneous focus on the mind and its environment, past and present, puts research on decision making under uncertainty into an evolutionary and ecological framework, a framework that is missing in most theories of reasoning, both descriptive and normative. In short, we study the adaptation of mental and social strategies to real-world environments rather than compare strategies to the laws of logic and probability theory.

Social Rationality

Social rationality is a variant of ecological rationality, one for which the environment is social rather than physical or technical. Models of social rationality describe the structure of social environments and their match with boundedly rational strategies that people might use. There is a variety of goals and heuristics unique to social environments. That is, in addition to the goals that define ecological rationality—to make fast, frugal, and fairly accurate decisions—social rationality is concerned with goals, such as choosing an option that one can defend with argument or moral justification, or that can create a consensus. To a much higher degree than for the purely cognitive focus of most research on bounded rationality, socially adaptive heuristics include emotions and social norms that can act as heuristic principles for decision making.

These three notions of rationality, according to which the present text is largely structured, converge on the same central issue: to understand human behavior and cognition as adaptations to specific environments, ecological and social, and to discover the heuristics that guide adaptive behavior. In a fourth section, we report on work that directly relates to evolutionary psychology, which, as a metatheoretical framework, lies behind the "adaptive" in our Center's name. The research reported in the last section focuses on the applications of our research, and how it can impact on "decision making in the wild" in domains such as the law, medicine, and education.

The ABC program explores an exciting and very different perspective on rationality. Our perspective questions the familiar one we know from the many stories in cognitive science and economics, which often implicitly assume that humans and animals have unlimited time, knowledge, and operate according to the laws of logic and probability theory. The land of rationality we set out to explore is, in contrast, inhabited by people endowed with only limited time, knowledge, and computational capacities with which to make inferences about the world. The notions of bounded, ecological, and social rationality are our guides to understanding how humble humans survive without following the heavenly rules of rational choice theory.

Bounded Rationality

Humans and animals must make inferences about unknown features of their world under constraints of limited time, knowledge, and computational capacities. We do not conceive bounded rationality as optimization under constraints nor do we think of bounded rationality as the study of how people fail to meet normative ideals. Rather, bounded rationality is the key to understanding how people make decisions without utilities and probabilities. Bounded rationality consists of simple step-by-step rules that function well under the constraints of limited search, knowledge, and time—whether an optimal procedure is available or not. Just as a mechanic will pull out specific wrenches, pliers, and gap gauges to maintain an engine rather than just hit everything with a hammer, different domains of thought require different specialized tools. The notion of a toolbox full of unique single-function devices lacks the beauty of Leibniz's dream of a single all-purpose inferential power tool. Instead, it evokes the abilities of a craftsman, who can provide serviceable solutions to almost any problem with just what is at hand.

The Adaptive Toolbox

This repertoire of specialized cognitive mechanisms, which include fast and frugal heuristics, were shaped by evolution, learning, and culture for specific domains of inference and reasoning. We call this collection of mechanisms the "adaptive toolbox." We clarify the concept of an adaptive toolbox as follows:

- It refers to a specific group of rules or heuristics rather than to a general-purpose decision-making algorithm.
- These heuristics are fast, frugal, and computationally cheap rather than consistent, coherent, and general.
- These heuristics are adapted to particular environments, past or present, physical or social.
- The heuristics in the adaptive toolbox are orchestrated by some mechanism reflecting the importance of conflicting motivations and goals.

Fast and Frugal Heuristics

Fast and frugal heuristics generally consist of three building blocks: simple rules for guiding search for information (in memory or in the environment), for stopping search, and for decision making. They are effective when they exploit the structure of the information in the environment. That is, their rationality is a form of "ecological rationality" rather than one of consistency and coherence. We have continued to explore fast and frugal heuristics, and their relationship to diverse disciplines, such as biology, economics, and cognitive psychology, and have applied them in the areas of consumer behavior, medicine, and the law.

The Priority Heuristic

The priority heuristic is a simple and precise model for choices among risky options (Brandstätter, Gigerenzer, & Hertwig, 2006). When making a choice between gambles, the priority heuristic assumes that each gamble can be described by several aspects: its minimum outcome, its maximum outcome, and the probabilities of each particular outcome actually occurring. Contrary to the expected utility perspective, this heuristic does not assume that people form an overall evaluation of gambles by weighting outcomes according to their probabilities of occurring. Instead, it assumes that aspects of the gambles are compared sequentially, and that each of these comparisons can lead to a decision.

When making a choice between two gambles, their "minimum outcomes" are compared first. If the difference between two outcomes exceeds 10% of the maximum payoff that can be obtained from either of the two, the gamble with the larger minimum outcome is selected. For gambles with only positive payoffs, the minimum outcome refers to the minimum gain (i.e., the lowest payoff). If the difference does not exceed the threshold, the second aspect is examined: the probabilities of the minimum outcomes occurring. If the probabilities differ by more

Key Reference

Brandstätter, E., **Gigerenzer, G.,** & Hertwig, R. (2006). The priority heuristic: Making choices without trade-offs. *Psychological Review, 113,* 409–432.

Key References

Pachur, T., & Hertwig, R. (2006). On the psychology of the recognition heuristic: Retrieval primacy as a key determinant of its use. *Journal of Experimental Psycology: Learning, Memory, and Cognition, 32,* 983–1002.

Volz, K. G., **Schooler, L., J.,** Schubotz, R., Raab, M., **Gigerenzer, G.,** & von Crammon, D. Y. (2006). Why you think Milan is larger than Modena: Neural correlates of the recognition heuristic. *Journal of Cognitive Neuroscience, 18,* 1924–1936.

than 10%, the gamble with the lower probability of the minimum outcome is selected. Otherwise, the last aspect—the maximum outcomes of the two gambles—is considered, and the gamble with the larger maximum outcome is selected. Brandstätter et al. (2006) compared the priority heuristic to several variants of expected utility theory on gambles from four studies.

The priority heuristic was better able to predict the majority choice of participants for a wide range of gambles. Brandstätter et al. (2006) demonstrated that the systematic study of adaptive heuristics, such as the priority heuristic, can provide a psychologically informed alternative to the expected utility framework, which has been taken as the foundation (and gold standard) for much of the work in economics and the psychology of decision making.

Recognition Heuristic

A strategy that uses recognition to make inferences about the environment is what Goldstein and Gigerenzer (1999, 2002) called the *recognition heuristic*. For two-alternative choice tasks, where one has to decide which of two objects scores higher on a criterion, the heuristic can be stated as follows:

If you recognize one object but not the other, then infer that the recognized object has a higher value on the criterion.

Feeding on recognition, the recognition heuristic piggybacks on a highly efficient cognitive ability, and also exploits an environmental regularity, namely, that recognition in natural environments is often systematic rather than random. In these environments, the heuristic is *ecologically rational* and exemplifies Herbert Simon's vision of rationality as being shaped by two blades, one being the mind, the other being the environment (Simon, 1990). There has been continued progress in demonstrating the predictive power of the recognition heuristic in, for instance, soccer (Pachur & Biele, 2007) and tennis (Scheibehenne & Bröder, under review). In addition, we have further explored its cognitive and neural foundations, focusing on when people choose the recognized alternative and when they do not.

Suspending the Recognition Heuristic

The assumption underlying the recognition heuristic—one of the central components of the adaptive toolbox—is that recognition information serves as a central cue governing inferences about the environment. But why should recognition have such a prominence in decision making? Pachur and Hertwig (2006) tested and found support for the thesis that, due to the architecture of the cognitive system, recognition information is provided quickly and at little cognitive cost, and therefore precedes the retrieval of other information from memory that can be used to make inferences. In addition to these demonstrations, they examined how people deal with recognition information in environments where the recognition heuristic often leads to incorrect decisions. How might people constrain their use of recognition in such environments? A suspension hypothesis received the strongest support. According to this hypothesis, the decision not to follow recognition is made selectively and based on item-specific knowledge (rather than item-general knowledge, such as the recognition validity in the given environment). For example, even though you may have heard of leprosy, but not shigellosis, you may still infer that shigellosis could be more prevalent in Germany than leprosy, because you know that leprosy is rare in the modern world. In sum, these results provide evidence that, among the different cues a person could use to make an inference, recognition has a special status. Moreover, these results reveal more about the psychology of the recognition heuristic and the mechanisms which underlie its use as an adaptive tool.

This suspension hypothesis also received support from the neuroimaging study of Volz et. al. (2006). Understanding the neural correlates which underlie decisions consistent with the recognition heuristic could help determine whether people simply make a recognition judgment if one alternative is recognized but the other not. Alternatively, there may be an additional evaluation process which inhibits application. After checking the heuristic's ecological validity for a given situation, the authors measured brain

activity by using *functional Magnetic Resonance Imaging* (fMRI) while participants indicated which of two cities they thought was larger (Experiment 1), or which city they recognized (Experiment 2). Experiment 2 revealed that the decisional processes cannot be reduced simply to a judgment based on recognition memory. In addition, a deactivation was observed within the *anterior FrontoMedian Cortex* (aFMC) when people did not follow the recognition heuristic, but rather indicated that the unrecognized alternative was larger. As the aFMC has previously been associated with self-referential judgments, the authors concluded that the processes underlying the recognition heuristic involve an assessment about the applicability of the heuristic. A related interpretation of this deactivation in aFMC is that acting against recognition demands more cognitive effort than simply choosing the recognized alternative. It seems that the recognition heuristic is the default, so to speak, but that contradicting source knowledge and criterion knowledge can inhibit its use.

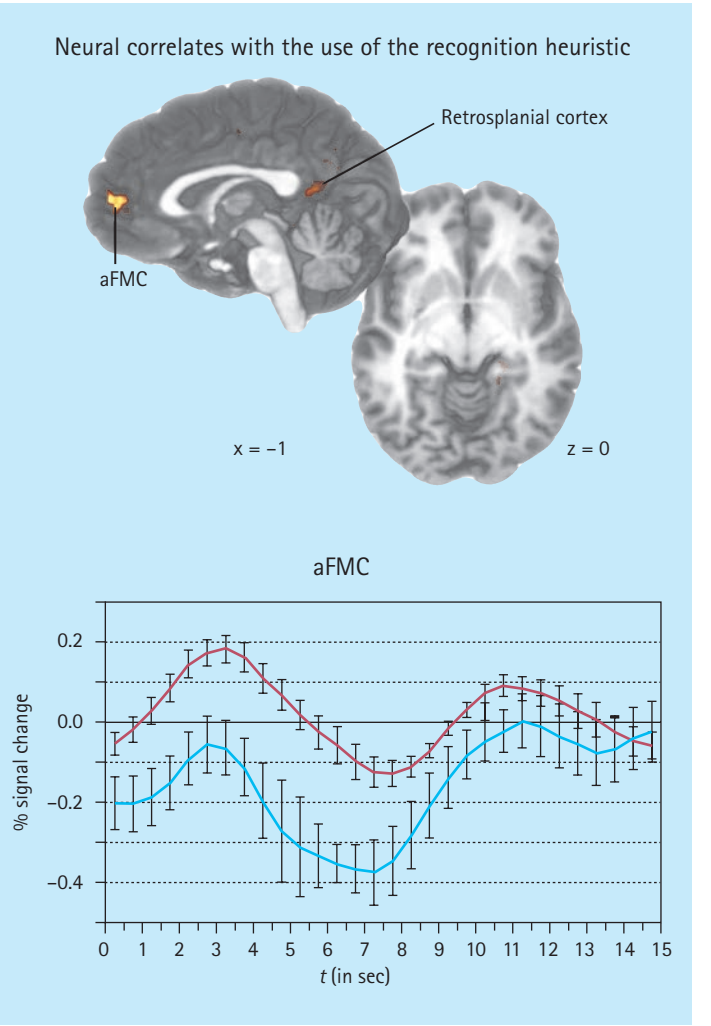


Figure 1. In the fMRI study by Volz et al. (2006), decisions in accordance with the recognition heuristic correlate with higher activation within the anterior frontomedian cortex (aFMC), and the precuneus bilaterally extending into the retrosplenial cortex. The mean percentage signal changes with error bars for the aFMC for trials in which the recognition heuristic was applied (red line) and was not applied (blue line) is shown in the accompanying plot.

Taken together the results of Pachur and Hertwig (2006) and Volz et al. (2006) suggest that processes underlying recognition-based decisions go beyond automatically choosing the recognized alternative, but include an additional judgment about whether such a recognition-based decision is appropriate.

The Benefits of Cognitive Limits

The premise that the human capacity for information processing is limited is usually accompanied by another assumption, namely, that these limitations pose a liability: They constrain our cognitive potential. These limitations bar us from performing feats, such as reciting the Iliad from memory or, for many of us, remembering the three things we were to pick up at the store. Clearly, forgetfulness is amongst our most troublesome cognitive limitations over both the long-term ("what is his name?") and short-term ("what temperature did the recipe say to set the oven?"). In contrast, we have examined the adaptive nature of forgetting.

Key References

Gaissmaier, W., Schooler, L. J., & Rieskamp, J. (2006). Simple predictions fueled by capacity limitations: When are they successful? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32*, 966–982.

Schooler, L. J., & Hertwig, R. (2005). How forgetting aids heuristic inference. *Psychological Review, 112*, 610–628.

When is Long-Term Forgetting Beneficial?
Why don't we have the perfect recall of a computer memory chip? A few theorists have argued that forgetting should not be seen as a limitation, but as key to the effective working of human memory. Essentially, forgetting prevents outdated information from interfering with more recent information that is likely to be more relevant. Schooler and Hertwig (2005) proposed that forgetting may, in addition, prove beneficial for inference heuristics that exploit mnemonic information, such as recognition and retrieval fluency. To explore the mechanisms that link loss of information and heuristic performance, they implemented the recognition heuristic (Goldstein & Gigerenzer, 2002) and the fluency heuristic (e. g., Jacoby & Dallas, 1981) in ACT-R (Anderson & Lebiere, 1998). The ACT-R research program seeks to develop a coherent theory of cognition, specified to such a degree that phenomena from perceptual search to the learning of algebra can be modeled within the same framework. Using computer simulations, the authors demonstrated that forgetting boosts the accuracy of the recognition heuristic, which relies on systematic failures of recognition to infer which of two objects scores higher on a criterion value. Similarly, simulations of the fluency heuristic, which arrives at the same inference on the basis of the speed with which the two objects are recognized, indicate that forgetting helps maintain the discriminability of recognition speeds. Thus, the ignorance that forgetting brings can, paradoxically, enhance inferences about objects in the world.

When is a Limited Short-Term Memory Capacity Beneficial?
Would we be better off if we could reason more logically, and remember more? The following scenario illustrates one such apparent failure in human reasoning. A person must choose repeatedly between red and green envelopes, one of which has a crisp dollar bill tucked inside. In a particular sequence of 100 trials, say, 70 % of the green envelopes hold a dollar, while in the remainder the dollar is in the red envelope. Rational choice theory dictates a *maximizing* strategy; that is, always choosing the green envelopes, or at least, doing so after establishing that the green envelopes are the better bet. Such a strategy maximizes the expected gain, which is $ 70 in this example. However, people normally adopt a strategy known as *probability matching,* which, in this example, means choosing an envelope in proportion to its chances of being the right bet. Here, this would mean picking the green envelope in 70 % of the trials and the red in 30 %. On average, this will yield only $ 58 = 0.7 x 70 + 0.3 x 30.
In such an envelope task, Kareev, Lieberman, and Lev (1997) found that people with smaller short-term memory capacity were more likely to adopt a maximizing strategy than people with larger capacities. Kareev et al.'s original explanation was that those with low digit spans perceived the correlations between the color of the envelope and the probability of winning as more extreme because their limited short-term memory capacity limited the size of the samples they could draw inferences from. Such small samples tend to overestimate correlations, and this overestimation can be advantageous in correlation detection. Instead of assuming that people differ in how they perceive the correlations, Gaissmaier, Schooler, and Rieskamp (2006) hypothesized that people differ in the degree to which they explore their environment. Their modeling efforts showed that the low levels of exploratory behavior associated with having a smaller working memory capacity leads to a maximizing strategy, whereas the more exploratory behavior associated with greater capacity leads to probability matching. Congruent with this hypothesis, two experiments revealed a low-capacity advantage in a stable environment, but a high-capacity advantage when the correlations were subject to change. Our findings suggest that the exploratory behavior that leads to suboptimal probability matching in psychological laboratories may be the right strategy to use in the world, where many sequences of events follow specific patterns that are well worth trying to figure out.

Ecological Rationality

Fast and frugal heuristics can not only perform as well as more complex algorithms, they can also perform better. Even if humans and other animals had the computational resources to use such complex algorithms, following them might be inefficient and result in poor performance. The surprisingly high performance of heuristics results from their ecological rationality. A heuristic is ecologically rational when it performs well by exploiting the statistical structure of the environment. We study ecological rationality from several perspectives, three of which we will focus on in this section. First, we use computer simulation to test fast and frugal heuristics in different environments. Second, we derive analytic results which specify the conditions under which a simple heuristic can match or outperform more complex strategies. Finally, we explore whether people use heuristics, and how they adapt to different environments by selecting different heuristics from the adaptive toolbox.

Simple Heuristics for Inductive Inference

Humans and other animals need to make inductive inferences. This is the task of making an informed guess about the future using observations of the past. An influential trend in contemporary psychology is to examine human performance from the perspective of rational principles of induction, such as Bayesian statistics. This poses a puzzle. Although humans appear to be extremely effective at making inductive inferences, and sometimes act as if they followed rational principles, decades of research into machine learning and pattern recognition have shown that classically rational induction becomes intractable, from a mechanistic perspective, for anything but trivial problems (Brighton & Todd, 2006). How can humans perform so effectively despite constraints on speed, computational resources, and the availability of information?

We examine how simple cognitive mechanisms adapted to natural contexts can shed light on this puzzle. Previously, we have shown that the simple heuristic Take The Best often makes more accurate predictions than sophisticated linear regression models (Czerlinski et al., 1999). Many found these results surprising, but others proposed putting our models to a far tougher test. Addressing this challenge, we compared Take The Best with several resource intensive and sophisticated nonlinear models. These models are commonplace in research into artificial intelligence as well as cognitive modeling. Figure 2 outlines three classic approaches to nonlinear processing: connectionist models, exemplar models, and decision tree models.

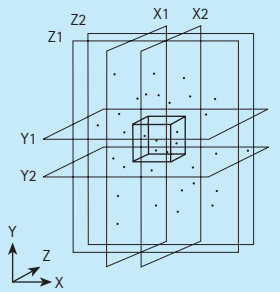
How well does Take The Best compare to the more resource intensive connectionist, exemplar, and rule-based methods? In particular, by performing *less* processing, will performance suffer? For a number of environmental settings, we performed a model comparison to assess the predictive ability of Take The Best and several nonlinear models. In a learning phase, each model is first presented with partial experience of the environment. We then examine how well each model predicts future events in the same environment. Examples of environments include the population of German cities where the task is to infer which of two novel cities has a greater population, or the salaries of professors, where the task is to infer which of two professors earns more. Brighton (2006) demonstrated that Take The Best, even though it performs less processing, can outperform five well-known connectionist, exemplar, and rule-based models of inductive inference.

For three environments, the impressive performance of Take The Best is shown in Figure 3, which plots the predictive accuracy of Take The Best and three competing models as a function of degree of exposure to the environment. Take The Best outperforms the other models by a significant margin. These results strengthen our previous findings which suggested that inductive inference does not demand intensive and domain-general processing methods in order to achieve high performance. Simple heuristics

Key Reference

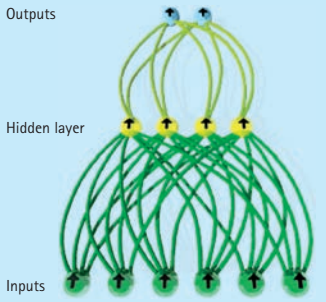
Brighton, H. J. (2006). Robust inference with simple cognitive models. In C. Lebiere & B. Wray (Eds.) *Between a rock and a hard place: Cognitive science principles meet AI-hard problems. Papers from the AAAI Spring Symposium* (AAAI Tech. Rep. No. SS–06–03, pp. 17–22). Menlo Park, CA: AAAI Press.

(A) Exemplar Models



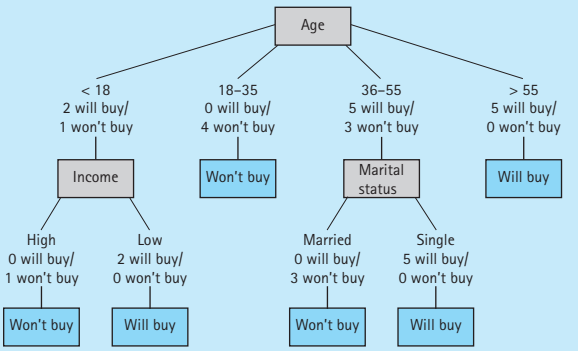
Exemplar models use the metaphor of the memory system, and simply store past observations. These observations are represented as points in a multidimensional feature space. When a novel problem is encountered, the most relevant past observations are retrieved and used to make a prediction.

(B) Neural Network Models



Neural network models use the metaphor of the brain to inform the processing problems by implementing networks of artificial neurons. During learning, the strength of the connections between neurons is adjusted to fit past experience. Neural activations resulting from novel problems are then used to derive a prediction.

(C) Decision Tree Models



Decision tree models construct hierarchies of if-then rules to describe and categorize past experiences. These rules define the patterns that are used to make inferences about novel problems.

Figure 2. Learning algorithms simulate the task of making inductive inferences. They process sequences of observations in an attempt to uncover predictive patterns. Once found, these patterns are then used to predict future events. We evaluated the simple heuristic Take The Best by examining how well it predicts future events in comparison to a number of resource-intensive processing models drawn from three well-known paradigms: (A) exemplar/nearest neighbor models, which store past experiences verbatim, and then retrieve relevant ones them when a confronted with a new problem; (B) feed-forward neural network models, which encode past experiences by learning activation strengths between simulated neurons that map inputs to outputs; (C) decision tree induction models which construct hierarchies of IF-THEN rules to categorize past observations.

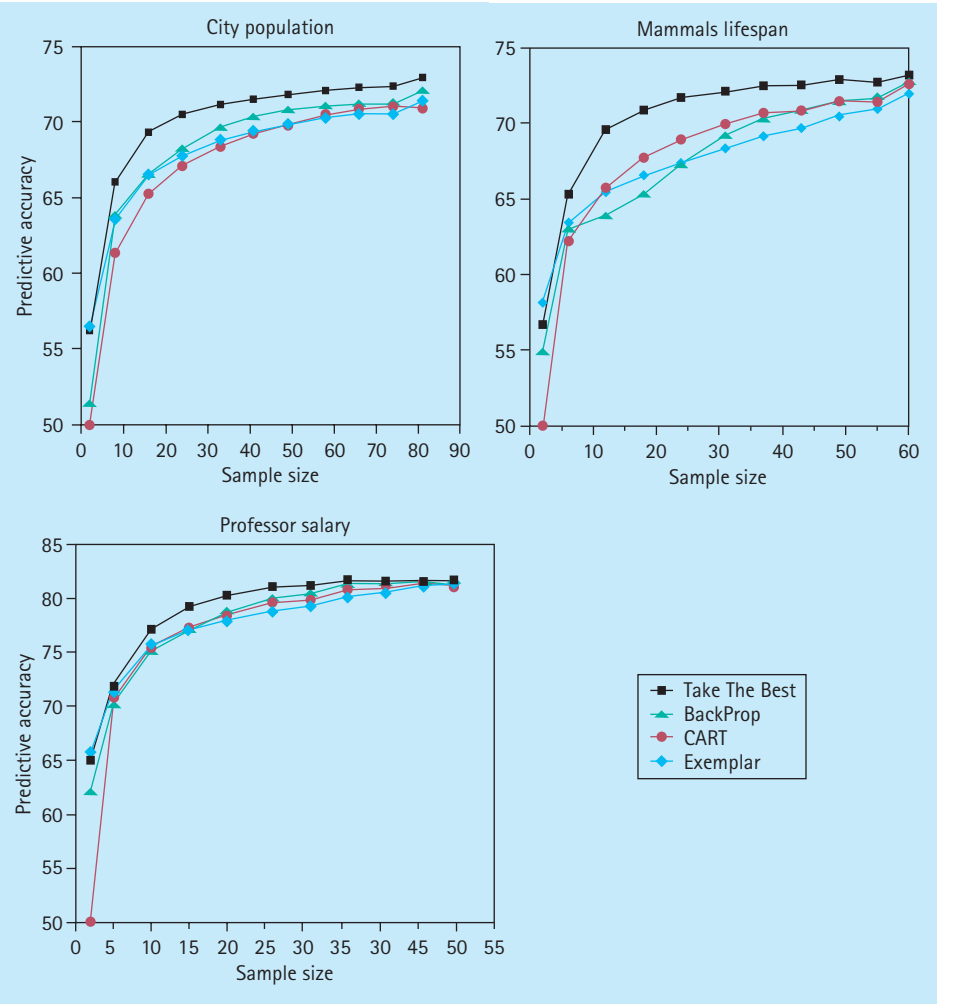


Figure 3. These plots show how the predictive accuracy of the simple heuristic Take The Best compares to three standard machine learning algorithms, in three environments. The rival algorithms include a decision tree induction model (CART), an exemplar model (Exemplar), and a neural network model (BackProp). As a result of performing less processing, Take The Best can often significantly outperform these standard models.

selected from the mind's adaptive toolbox, which fit the problem at hand, do just as well or better. This is a clear and striking example of how simple processes, by being ecologically rational, can lead to adaptive behavior.

When Do Simple Heuristics Perform As Well As a Naive Bayesian?

Simple heuristics can perform as well or better than more resource-intensive models when observations are limited, but can simple heuristics also compete with these models when the decision maker has had complete exposure to the environment? A decision maker who ranks two objects on a criterion (e.g., price) by using several probabilistic cues is *naive* if he or she assumes that cues are independent when the value of the criterion is known. This independence assumption has been made by many authors when examining Bayesian methods for inductive inference (Domingos & Pazzani, 1997; Krauss & Martignon, 2003). Katsikopoulos and Martignon (2006) have studied under which conditions simple heuristics perform as well as a Naive Bayesian model, which assumes independent cues. In particular, they focus on *Take The Best,* which searches through cues in order of their validity, and makes a decision on the basis of a single cue. They also examined *Tally,* which sums up the positive evidence for each object and selects the object with the largest sum. Katsikopoulos and Martignon (2006) showed that Tally is as accurate as Naive Bayes when all cues have the same

Key Reference

Katsikopoulos, K. V., & Martignon, L. (2006). Naive heuristics for paired comparisons: Some results on their relative accuracy. *Journal of Mathematical Psychology, 50,* 488–494.

Key Reference

Rieskamp, J., & Otto, P. E. (2006). SSL: A theory of how people learn to select strategies. *Journal of Experimental Psychology: General, 135,* 207–236.

validity. Furthermore, they show that Take The Best performs as well as Naive Bayes when the odds ratio of the cues validities follow a specific structure. The odds ratio is the validity of a cue divided by 1 minus the validity. If this ratio for each cue is larger than the product of the odds ratio for all other cues with lower validities, the *odds condition,* then Take The Best performs as well as Naive Bayes.

These results extend our previous analytic work, studying under which conditions Take The Best is more or equally accurate as Tally, and the converse (Martignon & Hoffrage, 1999, 2002). Among 20 natural environments tested, Katsikopoulos and Martignon (2006) found that the odds condition held in three of them, and speculated that the human mind could be wired to detect the presence of this condition, which, in turn, might trigger the use of Take The Best. In previous work, Krauss and Martignon (2003) found that the proportion of participants that used Take The Best jumped from 20% to 75% in these cases. This work provides a valuable insight into what features of the environment might trigger the selection of one strategy over another.

Selecting Strategies From the Adaptive Toolbox

The adaptive toolbox is the repertoire of specialized cognitive mechanisms, which includes fast and frugal heuristics. One open question is how heuristics are selected from the adaptive toolbox. The idea that people are equipped with a repertoire of cognitive strategies can be found in many areas of psychology, and this makes the strategy selection problem a pressing issue for many researchers. The traditional view follows a cost-benefit approach, where individuals are viewed as trading off the cost of a strategy against its benefits when performing strategy selection. The cost of a strategy is related to the cognitive effort required to execute it, and the benefits are related to its accuracy. According to this view, people *anticipate* both the benefits and costs associated with different strategies, and choose the most cost effective strategy for the problem at hand. This approach has been criticized as not being sufficiently well-specified, making it necessary to advance the theoretical approach by providing a computational model that describes the strategy selection process more precisely.

Rieskamp and Otto (2006) have argued that people do not apply a metastrategy which trades off costs and benefits. If they did, how would they select the metastrategy? To avoid the problem of infinite regress, Rieskamp and Otto (2006) suggested that people select strategies through learning. They aimed to shed light on three fundamental questions: First, do people select different strategies in different environments? Second, do people learn to select the strategy of the adaptive toolbox that performs best in a particular environment? Finally, how can the learning

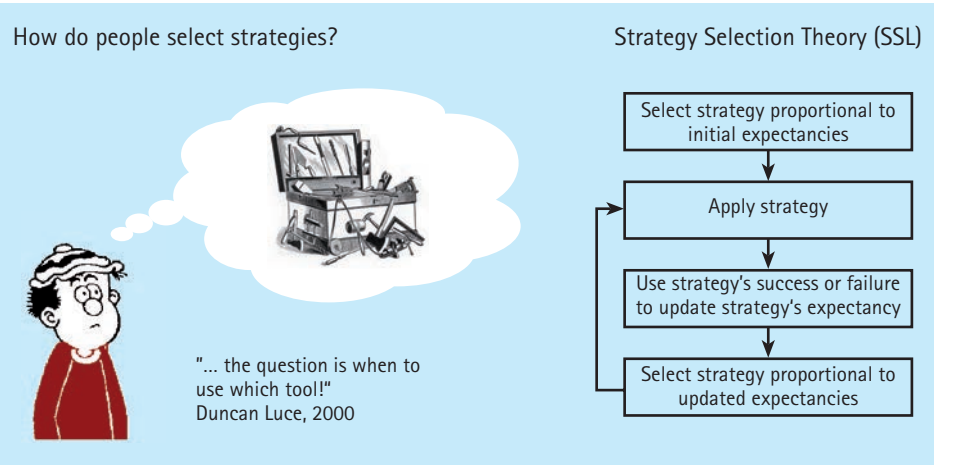


Figure 4. Rieskamp and Otto (2006) consider the problem of how the cognitive system selects between the heuristics in the adaptive toolbox. They propose that these heuristics are undergoing reinforcement. Reinforcement occurs as a result of feedback reflecting how well each heuristic performs in the given context.

process underlying strategy selection best be described? Rieskamp and Otto (2006) focused on the problem of choosing which of two alternatives, described by several probabilistic cues, has a higher criterion value. For instance, which of two companies described by several cues is most creditworthy? When making such an inference, a number of inference strategies could be applied, for example, Take The Best, Tally, or a Weighted Additive strategy. Recent studies have shown that noncompensatory strategies like Take The Best perform well at predicting inferences when participants are under time pressure, when there are high costs in information acquisition, or when information about cues has to be retrieved from memory. In contrast, compensatory strategies like the Weighted Additive strategy were more suitable for making inferences in situations of low time pressure, low information acquisition costs, or when the information was provided simultaneously via a computer screen.

Rieskamp and Otto (2006) proposed a new *Strategy Selection Learning* (SSL) theory, which views strategy selection as a process of reinforcement learning (Figure 4). According to SSL, people use unobservable cognitive strategies, rather than stimulus response associations, and these cognitive strategies are reinforced though feedback. The "expectancies" of the strategies are updated through reinforcement learning, which relies on feedback on past performance. SSL predicts that the strategy that performs best will be selected, given sufficient learning opportunity. Rieskamp and Otto (2006) tested SSL against four alternative models, including three general learning models and one exemplar model. They performed a number of experimental studies in which participants made repeated inferences in different environments, and were given feedback on their performance. In one study, participants had to select which of two unnamed companies was more creditworthy. This experiment considered two environment conditions. In the first condition, featuring a noncompensatory environment, Take The Best yielded the highest performance. In the second condition, featuring a compensatory environment, a Weighted Additive strategy achieved the highest per-

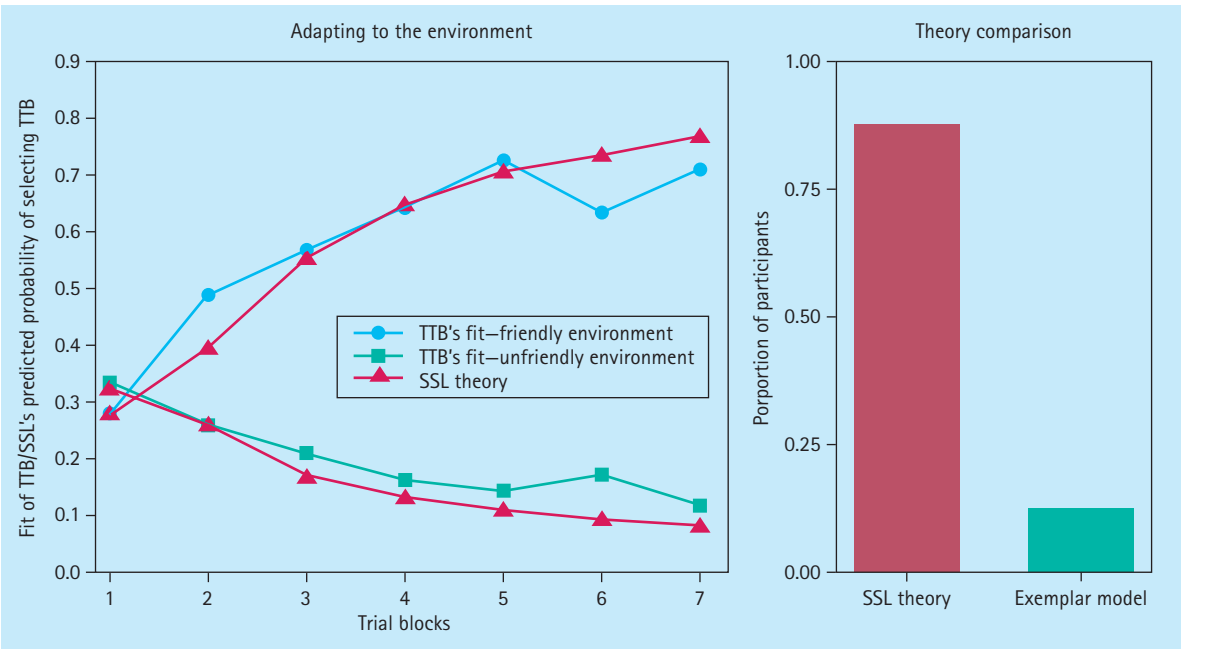


Figure 5. The proportion of choices predicted by the simple heuristic Take The Best increases over time in the Take The Best-friendly environment (left). This adaptation process is predicted by the SSL Theory. The SSL Theory also predicts the behavior of the majority of participants better than a competing exemplar model (right).

Key References

Rieskamp, J. (2006a) Perspectives of probabilistic inference: Reinforcement learning and an adaptive network compared. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32,* 1355–1370.

Hutchinson, J. M. C., & **Gigerenzer, G.** (2005b). Simple heuristics and rules of thumb: Where psychologists and behavioural biologists might meet. *Behavioural Processes, 69,* 97–124.

formance. This study demonstrated that when people repeatedly make probabilistic inferences, their performance improves. Figure 5 shows that the participants initially had a preference to integrate the provided information, which is not surprising, given that all information was provided and information search was not required. This initial preference changed very quickly depending on the structure of the environment. When the environment structure favored the integration of the available information, people selected the Weighted Additive strategy more frequently. However, when the structure of the environment favored the selection of Take The Best, people selected Take The Best more frequently.

At the end of the experiment, the strategy that performed best in the environment was also the strategy that predicted participants' inferences most accurately. This learning process was also accurately described by the SSL theory (see Figure 5). Interestingly, the more complex learning models and the exemplar model failed to describe the learning process more accurately. This finding was consistent across several inference situations, including a situation involving costly information search, and a situation where a choice between three rather than two alternatives was required. Furthermore, Rieskamp (2006a) compared the SSL theory with a well-established connectionist model, and found further evidence for the adaptive selection of strategies from an adaptive toolbox.

Do Animals Use Simple Heuristics?

For biologists, the concept of ecological rationality is uncontroversial. The assumption that organisms are often well-adapted to their environment is ubiquitous in biology. Consequently, biologists see no reason why this assumption should not be extended to the study of cognition. Furthermore, there is a long tradition in biology of explaining adaptive behavior using *rules of thumb,* which are similar in spirit to the simple heuristics studied by ABC. Hutchinson and Gigerenzer (2005b) explored the similarities and differences between ABC's work and that being carried out in behavioral ecology. The hope was that both disciplines could learn from each other.

One advantage that biologists have over psychologists is that animals can be studied in the natural environments to which they have adapted, although in both disciplines it is often maladaptive behavior in atypical environments that spurs research. Interestingly, the range of animal behavior described using rules of thumb is far broader than the range of human behavior explored by ABC. The rules of thumb used by animals have been discovered largely through careful empirical observation and experiments, and there are real prospects for understanding the neurological and physiological processes underlying them. Mirroring ABC's approach, there are also simulation studies in biology that assess the performance of rules of thumb.

Can biologists learn from ABC's work? The idea that simple rules of thumb can outperform more complex processes has not been thoroughly explored, or widely appreciated, in biology. From ABC's perspective, a rule of thumb is likely to exist as an adaptive response to the ecological structure of the task environment, rather than existing merely as a result of a simple brain. Other aspects lacking in biology are (a) a theoretical perspective capable of explaining the enormous diversity of methods of cue integration biologists have documented and (b) the development of precise models specifying how multiple cues are processed. Although ABC also has much progress to make in explaining why the statistical structure of environments favors particular methods of cue integration, biologists could benefit from our attempts to model and understand this aspect of cognition. Ultimately, the conceptual vocabulary needed to address this fundamental problem is likely to be the same for both disciplines.

Social Rationality

Social rationality is a specific form of ecological rationality, one capturing the fact that social species need to make decisions in an environment which may be constructed by the actions of others. In studying social rationality, we attempt to understand the cues and heuristics that underlie cooperation and group decision making, and to uncover the potential role of emotional states in the functioning of social heuristics. These social heuristics could represent adaptive solutions to recurring social problems faced by humans during their phylogenetic and ontogenetic development.

Cross-Cultural and Developmental Perspectives on Decision Making

In a longitudinal project, we examined the development of sociomoral reasoning, and, in particular, we consider reasoning about close relationships and moral norms in both China and various Western countries. Children and adolescents of different age groups, and in different cultures, focus on specific defining properties (or cues) of relationships which can lead to different behavioral responses when making decisions and moral evaluations. Here, culture determines the specific meaning of obligations and responsibilities in close relationships as well as the conception of self (Keller, 2006). Some of these differences can be explained by the well-known distinction of (Western) individualism and (Asian) collectivism. However, our research indicates that cultural transformations, like the rapid process of modernization in China, can influence decision making (Keller, 2006; Keller & Krettenauer, 2007).

Moral Emotions

Moral emotions, such as guilt and shame, which are associated with the consequences of moral transgressions, are important cues for the motivational acceptance of moral norms. In our previous research, we had demonstrated that the "happy victimizer" phenomenon in young children (attributing positive feelings to a moral-rule violator in spite of moral knowledge that the violation is not right) was, in part, a result of the experimental procedure failing to distinguish between other and self. Recently, the topic of moral emotions was followed up in a cross-cultural context (Keller, Brandt, & Sigurdardottir, in press). This study avoids the problem of previous studies in the "happy victimizer" tradition, where some of the rule violations presented to children may have been unfamiliar. The dilemma approach allows us to study both moral emotions of guilt due to violating an obligation, or positive moral feelings of pride due to acting in accordance with obligations.

Four age groups (7-, 9-, 12-, and 15-year-olds) of Icelandic and Chinese participants were studied. The results revealed that the "happy victimizer" phenomenon was very infrequent, even in the 7-year-olds. Few (mostly Icelandic) children did not understand the moral aspect of the situation at all. Nearly all younger Icelandic children were "unhappy violators," feeling guilty when they gave precedence to self-interest over friendship responsibilities. On the other hand, there were some younger children (again mostly Icelandic) who were "unhappy moralists," that is, they decided to keep the promise to the friend, but felt bad because they missed out on a good opportunity. In general, the Icelandic participants interpreted the dilemma as a conflict between friendship obligation and self-interest. In contrast, for Chinese children, self-interest rarely played a role in their decision making and emotions. Independent of which decision they made, either for a friend or a newcomer, they would always feel bad about leaving out one person. Thus, they can be seen as "unhappy moralists" who are stuck in a moral dilemma of conflicting obligations of friendship and altruism across all four age groups. This research demonstrates that decision making in people of different ages and different cultures will depend on different cues and emotions.

Key Reference

Keller, M., Brandt, A., & Sigurdardottir, G. (in press). Happy victimizers and unhappy moralists: The development of moral emotions in a cross-cultural perspective. In W. Koops & A. Sanders (Eds.), *The development and structure of conscience*. Hove, UK: Psychology Press.

Cognition and Emotion in Cooperative Decision Making

In a series of studies, we explored children's and adolescents' sharing of resources in the context of bargaining games (Gummerum, 2005; Gummerum, Keller, Takezawa, & Mata, in press; Keller & Canz, 2007; Takezawa, Gummerum, & Keller, 2006). These studies relate developmental, social, and cognitive psychological perspectives to research in economic game theory and evolutionary anthropology and biology. This integration leads to a comprehensive, multidisciplinary, and multimethod perspective on the development of cooperation. Economic game theory allows us to conduct an experimental investigation into unresolved questions in moral development theory, such as the connection between moral reasoning and action, ontogenetic changes in the manifestation of selfish and moral behavior, and the ability to negotiate a common decision.

Previously, economic studies show that adults do not only act according to the principle of utility maximization, but reveal fairness and prosocial preferences. For the dictator and ultimatum game, we studied the problem of sharing in groups of children and adolescents of ages 9, 12, 14, and 17 years (Figure 6). In both games, one group (proposer) decides whether, and how, to share a sum of money (20 coins of different value) with another anonymous group (responder). In the dictator game, the proposer group unilaterally decides how much money each player receives. Therefore, from a game theoretical point of view, each distribution that allocates money to the responder can be regarded as prosocial. In contrast, in the ultimatum game, the responder group can reject the offer of the proposer. In this case, no player receives any money. If the responder accepts the offer, however, the money is distributed according to the suggestion of the proposer. Hence, a positive offer of the proposer can be motivated both by strategic and prosocial considerations. Three same sex, same age members of the groups had to first make an individual decision, and then negotiate a common decision within ten minutes. In general, individual offers in the dictator game were more prosocial than those of adults in previous studies, and the modal offer in all age groups was the equal split. Individual offers demonstrated no age effect in either game, and altruistic preferences predicted individual offers in both the dictator and ultimatum games. Furthermore, individual offers were, on average, more prosocial than group offers. Analyses of the group decision-making process showed differences in the process used at the level of the group, which might either be explained by a majority or averaging model or the influence of prosocial and selfish group members during the group discussion in the dictator game.

A qualitative analysis of the video-taped group discussions in the dictator game revealed different types of argument. These arguments can be seen as based on social heuristics that serve to increase or decrease group offers, such as reciprocity, hierarchy, and group membership. In particular, the negative use of these arguments tends to diminish the offers made to the other group. Thus, the argument that the other group would also give little (negative tit-for-tat) could convince others to make a more selfish offer. The youngest age group usually proposed an offer and stated factual (nonnormative) preferences, the two middle groups deal with facts and norms while the oldest age group initiates discussion about norm conflicts and the justification of norms.

Figure 6. To share or not to share? Three 9-year-olds discussing how to share a sum of money with another (anonymous) group of children.

Information Processing and Decision Making in Groups

How do groups of people make joint decisions? Using group experiments, computer simulations, and mathematical analyses, ABC examines efficient and effective decision strategies that can be used by committees and groups who have to come to a joint decision (Reimer & Hoffrage, 2005, 2006, in press; Reimer, Hoffrage, & Katsikopoulos, 2007; Reimer & Katsikopoulos, 2004; Reimer, Kuendig, Hoffrage, Park, & Hinsz, 2007). The predominant view is that a good group decision requires intensive information exchange, and a pooling of resources. But one frequent complaint by group members is that such a strategy leads to excessive amounts of time being spent when reaching group decisions. Furthermore, ABC's findings on decision making in individuals, where less information processing can be shown to be beneficial, suggests that extending heuristics used in individual decision making to the context of groups and teams may be fruitful. In particular, we examine the ecological rationality of these heuristics when used in the context of a group, and test their ability to describe group behavior.

Figure 7. Five adults arriving at a group decision.

The Information Processing Cube

We distinguish between combination- and communication-based heuristics (Reimer & Hoffrage, 2005, 2006). These two classes of group decision strategies can be framed in terms of the information processing cube displayed in Figure 8 (Adamowicz, Hanemann, Swait, Johnson, Layton, Regenwetter, Reimer, & Sorkin, 2005; Reimer & Hoffrage, in press). The information-processing cube has three dimensions: the members of the group, the choice alternatives, and the cues used to describe the alternatives. A cell in this cube refers to the knowledge a group member has about a certain choice alternative on a certain cue.

Key References

Reimer, T., Kuendig, S., Hoffrage, U., Park, E., & Hinsz, V. B. (2007). Effects of the information environment on group discussions and decisions in the hidden-profile paradigm. *Communication Monographs, 74,* 1–28.

Reimer, T., & Hoffrage, U. (2006). The ecological rationality of simple group heuristics: Effects of group member strategies on decision accuracy. *Theory and Decision, 60,* 403–438.

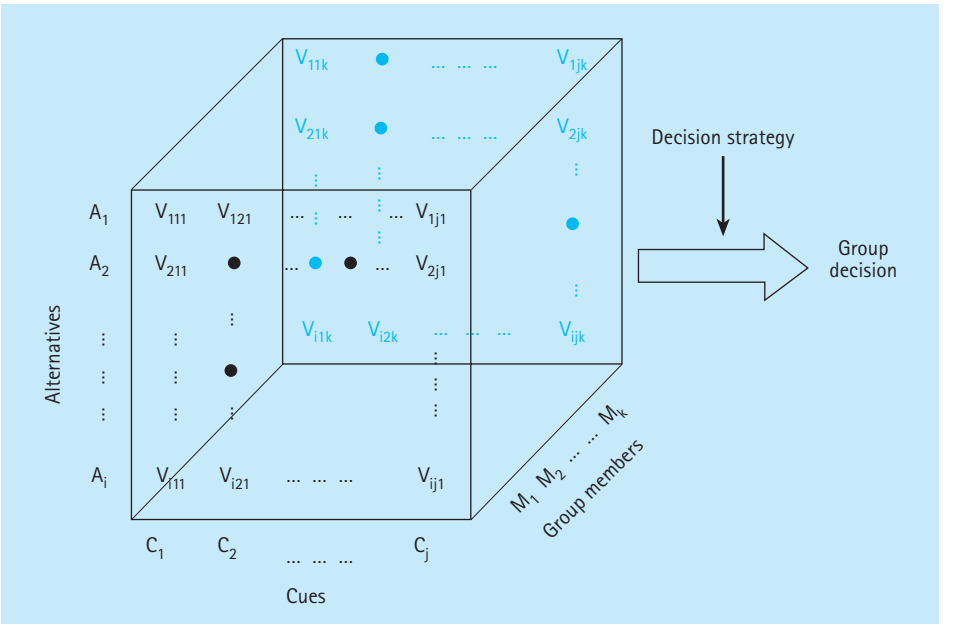


Figure 8. The information processing cube highlights three dimensions that frame the group decision making problem: the members of the group, the choice alternatives, and the cues used to describe these alternatives. A cell in the cube represents an individual's knowledge about a cue for one of the alternatives.

Key Reference

Reimer, T., Park, E., & Hinsz, V. B. (2006). Shared and coordinated cognition in competitive and dynamic task environments: An information-processing perspective for team sports. *International Journal of Sport and Exercise Psychology, 4,* 376–400.

In the literature, two types of aggregation mechanisms have been distinguished. *Social combination* rules, like majority and plurality rules, assume that each group member aggregates across the cues and alternatives, first by forming an individual decision, and, in a second step, the group aggregates across the preferences or opinions of the individual group members. In contrast, *social communication* rules are those where the members of a group pool their knowledge on the decision alternatives. For example, group members may infer in a discussion which candidate is best suited for the job vacancy by forming an impression on each candidate and choosing the candidate with the best overall evaluation, or a group may compare the alternatives cue-wise by reaching a consensus on which the most important cues are, and by choosing the alternative that scores highest on the most important cues (Reimer & Hoffrage, 2005).

Social Combination Rules: The Majority Rule

One of the most popular decision rules, especially when groups fail to reach a consensus, is the majority rule. The majority rule requires that group members have formed individual opinions which are then (either implicitly or explicitly) integrated by the group. Very few studies have examined how the strategies used by individual group members influence the outcome of the majority rule. In a simulation study, we tested the sensitivity of the majority rule to four different decision strategies (Reimer & Hoffrage, 2006). We considered two compensatory decision strategies, and two noncompensatory heuristics. In addition, to assess the ecological rationality of the strategies, we varied the distribution of cue validities, the quantity, and the validity of shared information. Group performance strongly depended on the distribution of cue validities. When validities were linearly distributed, groups using a compensatory strategy achieved the highest accuracy. Conversely, when cue validities followed a J-shaped distribution, groups using a simple lexicographic heuristic achieved the highest accuracy. These studies suggest that the performance of a group that integrates individual preferences on the basis of a majority rule may be strongly affected by the decision strategies used by its individual members. Furthermore, and in line with the notion of ecological rationality, the accuracy of the decision strategies depended on the structure of the environment.

Social Communication Rules: The Hidden Profile Task

The literature on the Condorcet theorem shows that the majority rule tends to accentuate differences between individuals. Specifically, the majority rule will enhance accuracy when members tend to be correct; however, when a group consists of members that tend to favor a wrong decision, the majority rule will yield even worse decisions than those arrived at by averaging the decisions of individual group members (see Reimer, Bornstein, & Opwis, 2005; Reimer, Park, & Hinsz, 2006). One situation in which the majority rule systematically fails because group members tend to fail are *hidden profile tasks* (Reimer & Hoffrage, 2005; Reimer et al., in press). Consider the following example of a hidden profile task:

> Two candidates, A and B, apply for a position, and a four-member committee has to select one of them. Overall, most arguments are in favor of candidate A. However, no single group member is aware of this because information is distributed among the committee members in a biased way, such that each group member has more arguments in favor of candidate B. As a consequence, when groups integrate their members' individual opinions on the basis of a majority rule, they will not detect the hidden profile. Experimental studies indicate that groups rarely detect hidden profiles.

The prominent explanation for the hidden profile effect is that groups fail to pool and integrate all available pieces of information. But the question of how the information

should be processed by the group has rarely been considered. In several of our simulation studies, a group version of Take The Best performed very effectively at identifying concealed alternatives in the hidden profile task, thereby demonstrating that the detection of a hidden profile does not necessarily require exhaustive information processing (Reimer & Hoffrage, 2005). This strategy requires that groups apply a cue-based strategy by identifying cues that discriminate among alternatives (e. g., a search committee might compare applicants with regard to their publication record, and choose the candidate with the most publications). Previously, studies on the hidden profile effect typically assume that all choice alternatives are described on the basis of unique cues describing only one of the choice alternatives. Because this kind of environment structure may hinder groups from applying a cue-based strategy, we conducted a study which included common cues.

In contrast to unique cues, common cues provide information on each and every option of the choice set. As expected, groups in the unique cue condition chose the hidden profile alternative less often than groups in the common cue condition (Reimer et al., in press). However, it turned out that it is not sufficient to provide groups with environments that include common cues for groups to detect hidden profiles. Common cue environments facilitated hidden profile detections, but even in these environments, most groups failed to detect the hidden profile. This seems to be due to the fact that group members entered group discussions with preconceived opinions. A follow-up study revealed that all groups detected hidden profiles when group members entered group discussions without a preconceived preference.

Key Reference

Gigerenzer, G. (2007b). *Gut feelings: The intelligence of the unconscious.* New York: Viking Press.

UK edition: *Short cuts: The intelligence of the unconscious.* London: Penguin Books, 2007c.

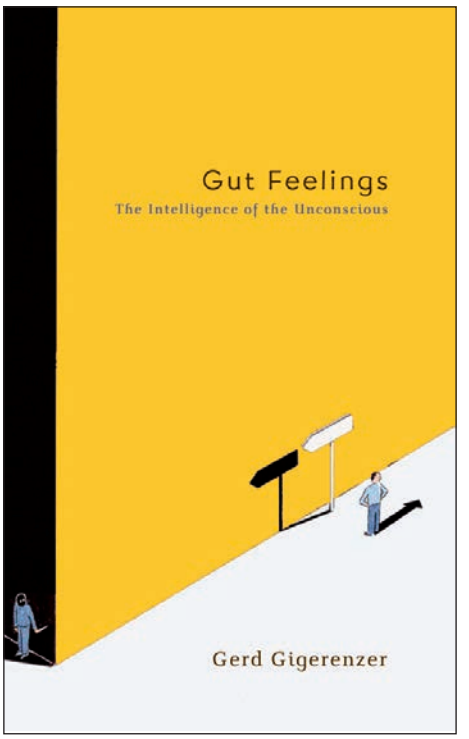
German translation: Bauchentscheidungen: Die Intelligenz des Unbewussten und die Macht der Intuition. München: Bertelsmann, 2007a.

Spanish translation: Arial.

Dutch translation: Kosmos.

Korean translation: Chugrim.

Italian translation: Raffaelo Cortina.



In his recent book *Gut Feelings*, Gerd Gigerenzer explains the science behind Malcolm Gladwell's best-selling Blink. By examining various decisions we make—how we choose a spouse, a stock, a medical procedure, or the answer to a million-dollar game show question—Gigerenzer shows how gut feelings not only lead to good practical decision but also underlie the moral choices that make our society function.

Evolutionary Psychology

Evolutionary psychology lies at the heart of many research projects undertaken by the ABC Research Group. It motivates the notion of bounded rationality, supports the significance of the environment in the notion of ecological rationality, and emphasizes the importance of social interactions in social rationality. At the same time, evolutionary psychology is grounded in ecological rationality: It assumes that our minds were designed by natural selection to solve practical problems in an efficient and effective manner.

Recently, Todd, Hertwig, and Hoffrage (2005) argued in an influential handbook of evolutionary psychology, a set of broad forces operating on multiple domains that impact on the design of specific cognitive systems. They discussed how the costs of gathering information, and of using too much information, can be reduced by decision mechanisms that rely on as little information as possible to come to their choices. They also explored how the pressures to use small amounts of appropriate information may have produced particular patterns of forgetting in long-term memory and particular limits of capacity in short-term memory. ABC's interest and research into evolutionary psychology continues, and, in this section, we focus on empirical studies of mate selection, and simulation studies focusing on the evolution of cooperation.

Key References

Wilke, A., Hutchinson, J. M. C., Todd, P. M., & Kruger, D. J. (2006). Is risk taking used as a cue in mate choice? *Evolutionary Psychology, 4,* 367–393.

Todd, P. M., Billari, F. C., & Simão, J. (2005). Aggregate age-at-marriage patterns from individual mate-search heuristics. *Demography, 42,* 559–574.

Mate Choice

One of the most evolutionarily important decisions is mate choice. By definition, sexual reproduction requires combining your own genes with another individual's genes in order to produce offspring. In mate choice, decisions made on the basis of perceived cues can influence the quality of the genes passed on to their offspring, and the quality of the parental care their offspring will receive. Previous work has emphasized the importance of mechanisms of mate choice by examining the construction of building blocks for mate choice strategies and the resulting population level pattern of mate choice behavior, such as age at marriage (Todd, Billari, & Simão, 2005). Recent work has explored possible cues used in mate choice as well as the primary evolutionary outcome of mate choice: offspring production.

For humans, the number of females in the population limits the ability of males to produce offspring; therefore, males often experience more variance in their reproductive success (some males will produce a number of offspring, while others will produce none). This variance in male mating success may favor risk taking because high potential gains (e. g., in resources promoting partner acquisition) outweigh the high risks. Additionally, males may take risks as a form of advertisement of their quality to both females and rival males. If risky behaviors are less of a danger to a high-quality male than to a low-quality male, high-quality males can afford to take such risks more often, and thus rivals and potential mates should use risk taking as a cue to quality.

Wilke, Hutchinson, Todd, and Kruger (2006) investigated the possible signalling functions of risk taking by measuring how attractive each sex finds risk taking in the opposite sex. If risk taking is used as a cue for mate choice in humans, evolutionary theory would predict that different types of risk provide different information about the condition of a potential partner. For instance, risk taking in sexual behavior may signal high probability for sexually transmitted disease, whereas participating in a risky or dangerous sport may signal physical prowess. Wilke et al. (2006) surveyed how attractive both men and women found risky behaviors in the opposite sex across a number of domains. Surprisingly, the sexes differed very little in what risky behaviors they found more attractive or unattractive, but these ratings differed across domains (see Figure 9). In particular, both men and women reported social and recreational risk taking as attractive, but other domains of risk taking as unattractive (ethical, gambling, and health) or neutral (investment). Thus, risk taking does not act as a general cue for mate choice; instead, the risk environment determines the value of information in mate choice.

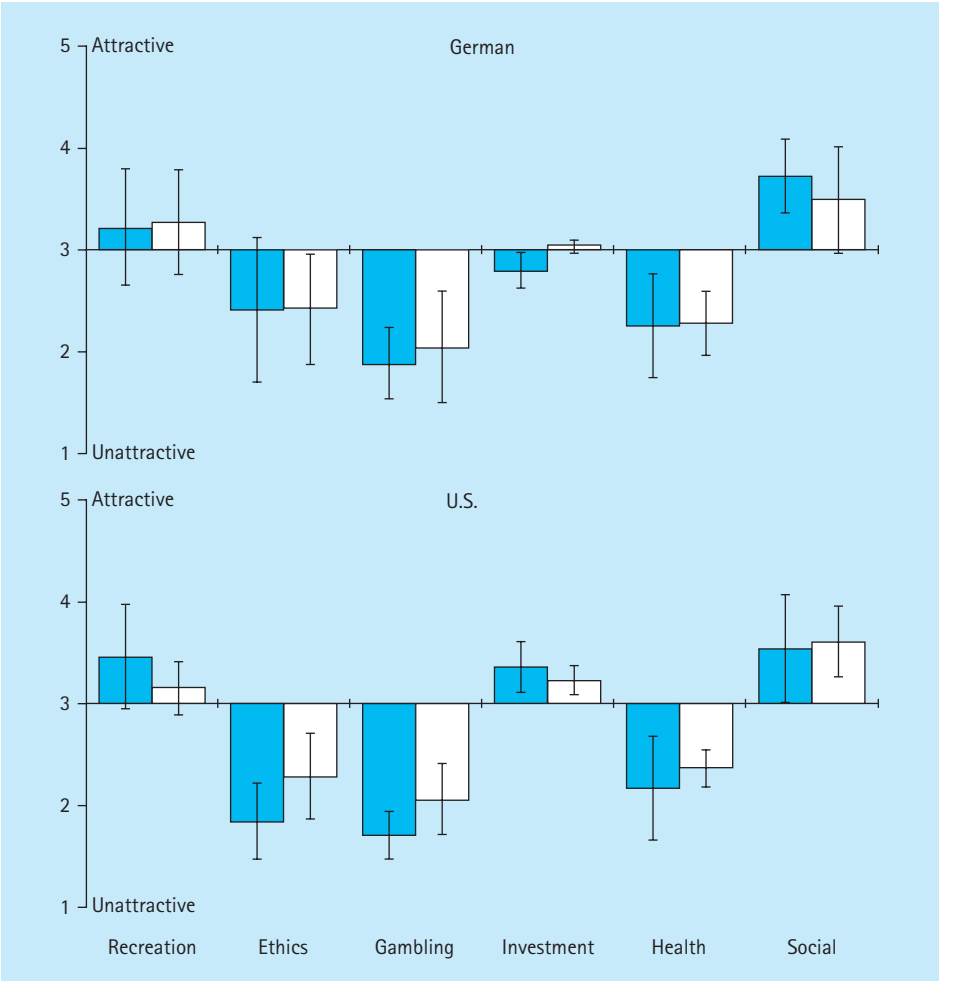


Figure 9. Risk taking is not uniformly evaluated as attractive, but depends on the domain in question. This figure shows mean domain scores (and standard deviations across items) for ratings by women of the attractiveness of male risk taking (blue) and by men of the attractiveness of female risk taking (white). A rating of 5 refers to attractive, and a rating of 1 refers to unattractive.

These results emphasize the necessity of taking a domain-specific approach to studying the functions of risk taking (see also Hanoch, Johnson, & Wilke, 2006). Although we still do not know if human mechanisms for decision making concerning risk evolved for particular domains (e.g., foraging) separately or for the more general problem of choice under uncertainty, posing these questions leads to new testable predictions and a more differentiated understanding of risk taking. Why invest so much effort into choosing an appropriate mate? Evolutionary theory suggests that better mates yield better offspring and higher probability of passing on genes. But given limited resources, is one constrained to invest heavily in few offspring or sparsely in many offspring? Hagen, Barrett, and Price (2006) asked whether parents in a small-scale society (the Shuar community of Ecuador) face this quantity-quality tradeoff by measuring proxies of quantity and quality of children in the Shuar families. As predicted, children in families with more children per adult had lower weights, shorter heights, thinner skinfold thicknesses, and narrower arm and leg circumferences. This suggests a real cost to increasing family size: More mouths to feed results in less food per mouth.

Cooperation

Cooperation poses an interesting puzzle to evolutionary theory. Why would an individual help another? Many mechanisms of cooperation have been proposed, but most of this work has been dominated by a focus on symmetric games (typically, the prisoner's dilemma game) in which both individuals

Key Reference

Hagen, E. H., Barrett, H. C., & Price, M. E. (2006). Do human parents face a quantity-quality tradeoff? Evidence from a Shuar community. *American Journal of Physical Anthropology, 130,* 405–418.

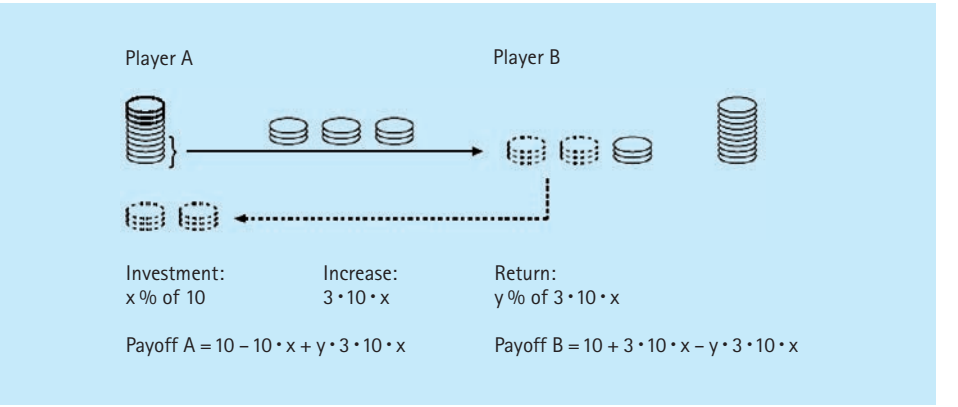


Figure 10. The investment game. The payoff of player A is defined as his endowment minus his investment plus player B's return. Player B's payoff is defined as her endowment plus the trebled investment of player A minus player B's return.

face the same strategic situation. However, social relationships are often imbalanced. Consider, for instance, an employee that might have frequently worked overtime trusting that his effort will be reciprocated, but the employer may, or may not, ultimately reward this extra effort. Whereas the two individuals in a symmetric interaction face the same decision alternatives, in an asymmetric interaction the decision alternatives differ for the two parties. Do these commonplace asymmetric interactions support or inhibit the emergence of cooperation?

Rieskamp and Todd (2006) explored whether decision strategies exist that can reliably lead to ongoing cooperation in an asymmetric interaction, and determined whether such strategies differ from those that are appropriate for cooperation in a symmetric interaction. They tested the evolution of strategies for the investment game (an asymmetric game) and compared it with results for the prisoner's dilemma game (a symmetric game) using evolutionary simulations. In the investment game, player A can invest any amount of an endowment, which is then tripled, before it is delivered to player B. Next, player B decides how much of the tripled amount he or she wishes to return to player A (see Figure 10). Thus, the players face asymmetrical payoffs. In contrast, players in the prisoner's dilemma game experience symmetrical payoffs by either cooperating or defecting. For both players, defecting always leads to a greater payoff regardless of whether the opponent defects or cooperates; thus, defecting is a dominant strategy. However, each player receives a greater payoff when both players cooperate than when they both defect.

The difference in symmetry between these two games yielded the evolution of different strategies. The asymmetrical investment game resulted in the unforgiving *minimum-grim* and *minimum-return* strategies in which the partner's investments and returns must exceed a minimum threshold. If they do not meet the threshold, the player never invests again. In contrast, the prisoner's dilemma game resulted in a more forgiving *cautious tit-for-tat strategy,* which initially defects, but then copies its opponent's previous behavior. Unlike the grim strategies, it will forgive a partner's defection if the partner responds with cooperation. Therefore, the strategies that enable cooperation for the asymmetric investment game react more sensitively to exploitation, meaning that cooperation can more easily break down. Furthermore, once cooperation has stopped, it is much more difficult to reestablish than in symmetric situations. If asymmetry influences decision strategies as suggested here, then the predominant use of the symmetric prisoner's dilemma game as a general model for social interactions is not justified.

Key Reference

Rieskamp, J., & **Todd, P. M.** (2006). The evolution of cooperative strategies for asymmetric social interactions. *Theory and Decision, 60,* 69–111.

Decision Making in the Wild

According to an ancient piece of wisdom, attributed to many luminaries, every good theory leads to good applications. In this section, we review the main applications of our basic research in the last 2 years.

Heuristics and the Law

What turns an issue into a public issue, and then into a law? How do jurors and judges decide whether a witness is trustworthy or a defendant guilty? Insofar as one believes that the reasoning of people involved in creating and practicing law is guided solely by logic and legal texts, heuristic thinking plays a minor role. And in fact, many lawyers would posit "heuristics and the law" to be a non-issue. Similarly, most psychologists would not think of the law when they think of heuristics. Upon closer inspection, however, one finds courts cutting through complex cases by relying on rules of thumb, administrators making decisions based on one good reason, and legislators responding to scandal. Should this be seen as irrational and irresponsible, or can simplicity, transparency, limited search, aspiration levels, and the other conceptual tools in the "adaptive toolbox" actually help? For instance, should a tax law be simple and transparent in order to create trust and compliance, or rather as complex as possible to satisfy many special situations and interests? A recent book entitled *Heuristics and the Law* (Gigerenzer & Engel, 2006) explores the intersection between legal and heuristic reasoning for both legal norms and practice. The book is based on a Dahlem Conference (at which 40 scholars met for 5 days; no talks were given; papers were written, distributed, and commented in advance; and the four group reports were written during the Conference) that centered on four questions:

(1) Are heuristics a problem or a solution?
(2) What is the role of heuristics in making law?
(3) What is the role of heuristics in litigation?
(4) How do heuristics mediate the impact of law on behavior?

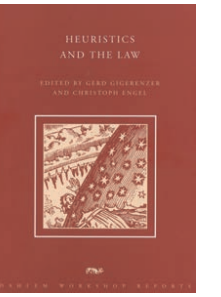
The participants included scholars from law, psychology, and economics, including the interdisplinary fields of law and economics (emphasizing the rational actor perspective), and behavioral law and economics (emphasizing the heuristics and biases perspective). The Dahlem Conference and the book are based on a year-long collaboration between the Max Planck Institute for Research on Collective Goods in Bonn and the Max Planck Institute for Human Development in Berlin. This collaboration will be extended to a joint International Max Planck Research School, together with the Max Planck Institute for Economics in Jena. The Research School will begin in 2007.

A conference at the George Mason University School of Law dealt with police hunches, and how the courts deal with them (Gigerenzer & Brighton, in press). Like other experts—from chicken sexers to chess masters to soccer players—police officers have intuitions that they cannot always verbalize. However, American courts tend to discount the hunches of police officers, requiring them to articulate specific facts that justify their decision to conduct a search, an interrogation, or to make an arrest. At issue are civil liberties. When an officer had a hunch, stopped a car, found illegal drugs or guns, and reported exactly this, judges repeatedly rejected "mere hunches" as insufficient cause for a search. Yet insisting on after-the-fact justification ignores that good expert judgment is generally of intuitive nature. As a consequence, when police officers testify before a judge, they have learned not to use terms such as *hunch* or *gut instinct,* but to produce "objective" reasons after the fact.

In contrast to the dismissal of police hunches, Gigerenzer and Brighton (in press) argued that (1) there is evidence that these hunches are based on smart heuristics, and that these heuristics can actually outperform sophisticated reason-based judgments; (2) training of police officers and judges should be geared at improving these hunches rather than discarding them; and (3) in order

Key Reference

Gigerenzer, G., & Engel, C. (Eds.). (2006). *Heuristics and the law.* Report of the 94th Dahlem Workshop on heuristics and law, Berlin, June 6–11, 2004. Cambridge, MA: MIT Press.



"I think the publication of *Heuristics and the Law* is a (rare) truly significant event in legal adacemic life."
Mark Kelman, William Nelson Cromwell Professor of Law, Stanford University.

In cooperation with the George Mason School of Law and for the second year in a row, Gerd Gigerenzer taught decision making and risk communication to American judges at the Institute on the Logic and Limits of Contract Law for Judges, Tucson, AZ.

to avoid discrimination, the legal system needs to survey the quality of police officers' hunches, that is, a detective's actual success in spotting criminals, rather than his or her ability to provide verbal after-the-fact justifications (see also Gigerenzer, 2007).

The fact that people often violate rationality axioms has provided a new rationale for paternalism to "de-bias" individuals who exhibit errors, cognitive illusions, or other allegedly pathological psychological irregularities. Legal scholars, such as Cass Sunstein, and behavioral economists, such as Richard Thaler, have used psychological experiments as the fundament for their concepts of *anti-anti-paternalism* and *libertarian paternalism* (e. g., Sunstein & Thaler, 2003). The argument that bounded rationality implies paternalism has direct implications for the degree to which individual choice (risk taking, sex, drugs, and retirement savings) is regulated by the government and restricted by institutions in order to "protect" us against our mental weaknesses. Berg and Gigerenzer (2007) asked whether this argument is actually correct, and define unbounded and bounded rationality in a context of societal risk taking. They show analytically that the argument is flawed, and that in fact both utility maximizers (who are unboundedly rational) and satisficers (who are boundedly rational) can exhibit excessive or normal risk taking, depending on auxiliary assumptions that are external to this distinction.

Risk Communication in Medicine

The term "risk" appears in the title of more than 10,000 medical articles published every year (2 % of the total). It should be alarming that, at the same time, most physicians and patients do not understand the crucial statistical numbers which with medical research provides them. Collective innumeracy impedes the efficacy of evidence-based medicine and the ideal of shared decision making. From our studies on HIV and cancer screening, summarized in Gigerenzer (2002), we estimate that some 80 % to 90 % of doctors are innumerate, that is, do not understand the outcomes of standard tests, and are confused about the meaning of basic concepts, such as sensitivity and false positive rate. To illustrate this problem, consider the two examples given in the box.

If patients knew about this degree of variability and statistical innumeracy, they would be justly alarmed. Physicians' ignorance is enhanced by the attitude of many patients not to ask questions, but instead to rely on the rule of thumb "follow the white coat." With the rise of evidence-based medicine in the last two decades, and the decline of the traditional view of the physician as an artist who does not bother with

Key References

Gigerenzer, G., & **Brighton, H. J.** (in press). Can hunches be rational? In C. S. Lerner & D. Polsby (Eds.), *Mere hunches: Policing in the age of terror.*

Berg, N., & **Gigerenzer, G.** (2007). Psychology implies paternalism? Bounded rationality may reduce the rationale to regulate risk-taking. *Social Choice and Welfare, 28,* 337–359.

Engel, C., & **Gigerenzer, G.** (2006). Law and heuristics: An interdisciplinary venture. In G. Gigerenzer & C. Engel (Eds.), *Heuristics and the law* (pp. 1–16). Cambridge, MA: MIT Press.

The misunderstanding of risks and uncertainties by German and Swiss physicians.

Example 1: German physicians with an average of 14 years of professional experience were asked to imagine using the Haemoccult test to screen for colorectal cancer. The prevalence of cancer was 0.3 %, the sensitivity of the test was 50 %, and the false positive rate was 3 %. The doctors were asked: What is the probability that someone who tests positive actually has colorectal cancer? The correct answer is about 5 %. However, the physicians' answers ranged from 1 % to 99 %, with about half of them estimating the probability as 50 % (the sensitivity) or 47 % (the sensitivity minus the false positive rate) (Gigerenzer, 2002; Hoffrage & Gigerenzer, 1998).

Example 2: After reading our publications, the head of the Department of Gynecology at the Lucerne Cantonal Hospital, Switzerland, asked his 15 gynecologists what they think the following widely publicized figure means: "Mammography screening reduces the risk of dying from breast cancer by 25 %." They were then asked: How many fewer out of 1,000 women will die of breast cancer? The physicians' answers varied between 1 in 1,000 and 750 in 1,000 (Schüssler, 2005).

numbers, this collective innumeracy is now recognized as a fundamental problem in health care. However, decision researchers' proposals to send physicians into statistics courses has been unsuccessful, given the time pressure under which doctors are under, and their common self-perception as being mathematically illiterate. In earlier research, we have shown that the problem of innumeracy is not simply in the minds of the public or physicians, but to a large degree in the external presentation of information (e. g., Gigerenzer & Hoffrage, 1995; Gigerenzer & Edwards, 2003). Numerical information cannot be communicated without a form, and some forms are easily digested by the human brain, while others tend to produce (typically unconscious) misunderstandings. Thus, teaching physicians about different representations

ABC's contribution to improving the understanding of medical risks and uncertainties

Publications in scientific medical journals with high impact factors. For instance, in the *New England Journal of Medicine,* Elmore and Gigerenzer (2005a) explained simple techniques for visually representing relative risk increases for benign breast biopsies in transparent ways.

Publications in widely read medical journals. The problem with publications in scientific medical journals is that few physicians actually read these. Thus, we also summarize our findings in journals that are widely distributed by national medical organizations. For instance, in 2005, we wrote about transparent risk communication in the *Zeitschrift für Allgemeinmedizin* and in *Hals-Nasen-Ohren Informationen.*

Further education of physicians. The German government's health system reform (GKV-Modernisierungsgesetz; effective since 2004) no longer allows the pharmaceutical industry to give presents to physicians or invite them to participate in "further training" at some nice vacation hotel, all costs paid, spouses included. Pharmaceutical companies nonetheless continue to organize further training, but are no longer allowed to promote their own products. In 2006 and 2007, Gerd Gigerenzer and other members of ABC took an active part in physicians' further education, teaching risk communication to some 1,000 German gynecologists, among others.

Keynotes to medical organizations and conferences. In the last 2 years, Gerd Gigerenzer has given some 20 keynotes and lectures to medical organizations in various countries. Wolfgang Gaissmaier has co-organized a conference on "communicating risk and benefits in medicine," together with the Evangelische Akademie (Protestant Academy), Berlin, and the Institut Mensch, Ethik und Wissenschaft (Research Institute on Medical Ethics), Berlin.

The work on risk communication in medicine is a collaboration between the Max Planck Institute for Human Development and the Berliner Ärztekammer (Berlin Medical Council), the Ärztliches Zentrum für Qualitätssicherung Berlin (Center for Quality Control in Medicine), and the University of Washington School of Medicine. A new project with the Deutsche Krebshilfe e.V. (German Cancer Aid) is currently underway. It addresses the problem that the information concerning cancer screening in its widely distributed brochures relies on exactly those representations of potential benefits and harms that are misunderstood by the public, and in its attempt to overstate the benefits of cancer screening and downplay its harms to patients also conflicts with the evidence from medical research. The Deutsche Krebshilfe has reacted positively to ABC's input on this issue, and we are now helping in the design of new brochures which will present evidence-based recommendations in a transparent manner.

Key References

Gigerenzer, G. (2005). Wie versteht man Risiken und Unsicherheiten? *HNO Informationen, 4,* 287–294.

Elmore, J. G., & **Gigerenzer, G.** (2005a). Benign breast disease—the risks of communicating risk. *New England Journal of Medicine, 353,* 297–299.

Mata, J., Dieckmann, A., & **Gigerenzer, G.** (2005). Verständliche Risikokommunikation, leicht gemacht – oder: Wie man verwirrende Wahrscheinlichkeitsangaben vermeidet. *Zeitschrift für Allgemeinmedizin, 81,* 537–541.

Gigerenzer, G., & Edwards, A. (2003). Simple tools for understanding risks: From innumeracy to insight. *British Medical Journal, 327,* 741–744.

of the same information and introducing proper representations in conversation and written communication can provide an effective remedy for physicians' and patients' lack of understanding.

Yet at present, physicians and patients alike know little about how to represent crucial statistical numbers comprehensibly. For instance, the colorectal screening example illustrates that *conditional probabilities* (such as sensitivity and false positive rate) tend to cloud physicians' minds, and we teach physicians to translate these into *natural frequencies:* think of 10,000 patients. We expect 30 to have cancer, of which 15 will test positive. Of those without cancer, some 300 will also test positive. Thus, we expect that out of a total of 330 patients who test positive, 15 actually have cancer (about 5 %). Similarly, relative risks, such as "a 25 % reduction of breast cancer," cloud physicians' minds, mostly without them noticing, whereas absolute risks or stating the number of patients needed to treat turn innumeracy into insight. The reason for the confusion, we hypothesize, is the reference class.

Sensitivities and false positive rates conditionalize numerical information with respect to different reference classes, which makes Bayesian inference computationally more complex than inference based on natural frequencies, which all relate to the same reference class. Similarly, relative risks refer to a reference class which is different from the one patients assume.

In our studies, most patients assume that "25 %" refers to the class of women who participate in screening, and conclude that 25 % of those are saved from dying from breast cancer. Yet this number refers to the class of women who die from breast cancer without screening within 10 years. In this class, 4 out of every 1,000 women die from breast cancer, whereas the corresponding number is 3 out of 1,000 among those who participate in screening. Thus, the absolute risk reduction is 1 in 1,000, while the relative risk reduction is 25 %. To promote insight into crucial numbers in health care, we have been active at various levels, as shown in Box, p. 55.

Statistics Education

Statistical thinking—learning to live with uncertainty—is the most important part of mathematics in everyday life after school. Thinking means calling certainties into question. Yet the curricula in Western countries are almost entirely preoccupied with the mathematics of certainty, from algebra to geometry to trigonometry. The central role statistical thinking plays for educated citizens in a modern technological world has not yet been recognized in elementary school, high school, or in the university education of physicians and lawyers. If it is taught, statistics is often presented as a dry subject, interest is killed by boring examples, and understanding made difficult by representations that are hard to digest by young minds. We proudly report that there is now the first textbook on stochastics used in German high schools (Jahnke & Wuttke, 2005), with a section on decision making that begins with a motivating real-world topic (HIV tests) as well as transparent representation (natural frequencies)—both taken from Gigerenzer (2002)—in order to introduce probabilistic inference.

Zhu and Gigerenzer (2006) have shown, for the first time, that by being exposed to natural frequencies (as opposed to relative frequencies or conditional probabilities), 4th, 5th, and 6th graders can solve Bayesian problems without any teaching. Note that until recently, psychological research claimed that even college students are unable to solve Bayesian problems. The older the children were, the better they performed, with 19 %, 39 %, and 53 % of the Bayesian problems being solved, respectively. At the individual level, however, the transition was not as gradual, but indicated a qualitative insight. Most children either solved all problems or none. In 6th graders, the performance with natural frequencies was as good as that of MBA students with conditional probabilities. An analysis of the process of thinking revealed several pre-Bayesian rules of thumb whose frequency distribution changed over developmental course. This result indicates that complex statistical thinking can be taught at a much earlier age

than previously assumed, provided one uses a proper representation of numerical information. In collaboration with the Pädagogische Hochschule Ludwigsburg, we design and test visual and tactile representations of numbers that can be used already in elementary school.

A beneficial amount of statistical thinking could save lives. Low-probability, high-damage events in which many people are killed at one point in time are called dread risks. As opposed to situations in which a similar number of people or more are killed over a longer period of time, people tend to react to dread risks with avoidance behavior. The crash of the four planes in the terrorist attack on September 11, 2001, exemplifies such a catastrophic event. In contrast, the estimated 44,000 to 98,000 patients who die every year in U.S. hospitals because of preventable and documented medical errors do not constitute a dread risk, and public attention to these preventable death tolls is minor. In an earlier publication, Gigerenzer (2004) showed that the terrorists of September 11 did not strike once, but twice—the second time through the minds of many Americans who avoided flying, took their cars instead, and died in fatal traffic accidents (see Figure 11).

Terrorist attacks cause direct damage (the immediate consequences of terrorist action) as well as indirect damage, which is not under the terrorists' control, but due to public and institutional reactions. This initial analysis was restricted to the first 3 months after the attack. In a full analysis of the 18 months after the attack, Gigerenzer (2006f) found that, in response to the decline in air travel, car travel increased up to 5.2 % for a period of 12 months, specifically on interstate highways, and then returned to normal. During these 12 months, an estimated 1,500 Americans lost their lives on the roads in the attempt to avoid the risk of flying.

Does this dread risk avoidance generalize to other cultures? On March 11, 2004, exactly 2 1/2 years after September 11, the bombings of four commuter trains during the Madrid rush hour killed about 200 people and

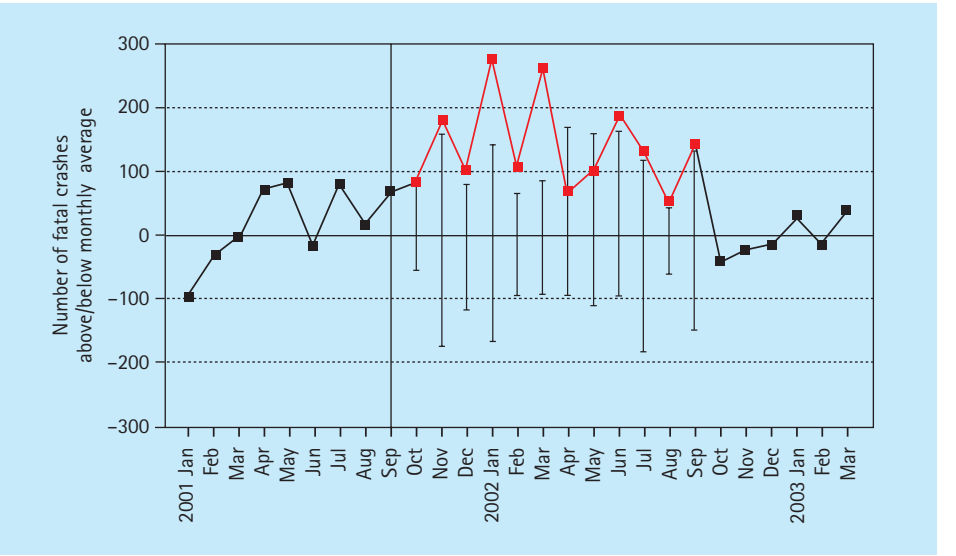


Figure 11. The number of fatal traffic accidents in the United States increased after the terrorist attacks on September 11, 2001, for a period of 12 months. Numbers are expressed as deviations from the five-year base line 1996-2000 (the zero line). The error bars (shown for the 12 months following the terrorist attacks) specify the maximum and the minimum numbers for each month of the base line. Before September 11, the average of the monthly numbers of fatal traffic accidents for 2001 was close to the zero line, and the monthly values were always within the maximum and minimum of the previous five years. Yet in the 12 months following the terrorist attacks (October 2001 to September 2002, shown in red), the number of fatal traffic accidents every month was higher than the zero line, and in most cases exceeded the maximum of the previous years. Data are taken from the U.S. Department of Transportation, Federal Highway Administration.

Key References

Gigerenzer, G. (2006f). Out of the frying pan into the fire: Behavioral reactions to terrorist attacks. *Risk Analysis, 26,* 347–351.

Zhu, L., & **Gigerenzer, G.** (2006). Children can solve Bayesian problems: The role of representation in mental computation. *Cognition, 98,* 287–308.

Krämer, W., & **Gigerenzer, G.** (2005). How to confuse with statistics or: The use and misuse of conditional probabilities. *Statistical Science, 20,* 223–230.

wounded 1,460. Like Americans avoided planes, Spaniards tended to avoid trains, but the effect was smaller and shorter—only 2 months. Yet Spaniards did not increase the intensity of their car travel, and, consequently, no additional loss of lives on the roads was observed. We can only speculate why; there is less of a car culture in Spain than in the United States, and a better developed public transport system.

It is not always possible to overcome an emotional fear reaction with statistical reasoning. Yet, the very elementary facts that would empower reasoning are not even known to most citizens. How many miles does one have to drive so that the risk of dying in a car accident is the same as in a nonstop flight, say from Boston to Frankfurt? Few are aware that the answer is about 12 miles. That is, if one arrives safely by car at the airport, the most dangerous part of the trip may be over. In collaboration with the Max Planck Institute for Foreign and International Criminal Law, we are applying presently for EU funds to study the indirect harms due to reactions of individuals and institutions to terrorist attacks and threats on a larger scale.

The ABC Research Group in February 2007

Left to right: Henry Brighton, Nils Straubinger, Juliet Conlin, Henrik Olsson, Magnus Persson, David Funder, Jing Qian, Gerd Gigerenzer, Wolfgang Gaissmaier, Shabnam Mousavi, Jörg Rieskamp, Jeffrey Stevens, Monika Keller, Lael Schooler, Ana Sofia Alves Conte de Morais, Odette Wegwarth, Mirta Galesic, Julian Marewski, Nathan Berg, Benjamin Scheibehenne.

Publications 2005–2006

(last update: May 2007)

Adamowicz, W., Hanemann, M., Swait, J., Johnson, R., Layton, D., Regenwetter, M., **Reimer, T.,** & Sorkin, R. (2005). Decision strategy and structure in households: A "groups" perspective. *Marketing Letters, 16,* 387–399.

Bachmann, L. M., Gutzwiller, F. S., Puhan, M. A., Steurer, J., Steurer-Stey, C., & **Gigerenzer, G.** (in press). Health knowledge in the community—A survey. *BMC Medicine Journal.*

Barrett, H. C., & Behne, T. (2005). Children's understanding of death as the cessation of agency: A test using sleep versus death. *Cognition, 96,* 93–108.

Barrett, H. C., **Todd, P. M.,** Miller, G. F., & Blythe, P. W. (2005). Accurate judgments of intention from motion cues alone: A cross-cultural study. *Evolution and Human Behavior, 26,* 313–331.

Bennis, W. M., & **Pachur, T.** (2006). Fast and frugal heuristics in sports. *Psychology of Sport and Exercise, 7,* 611–629.

Berg, N. (in press-a). Behavioral labor economics. In M. Altman (Ed.), *Handbook of behavioral economics.* Armonk, NY: Sharpe.

Berg, N. (in press-b). Finance, psychology, economics and the design of successful institutions. In *Shanghai Forum 2005 Anthology.* Shanghai: Fudan University Press.

Berg, N. (2006). A simple Bayesian procedure for sample size determination in an audit of property value appraisals. *Real Estate Economics, 34,* 133–155.

Berg, N. (2005a). Decision-making environments in which unboundedly rational decision makers choose to ignore relevant information. *Global Business and Economics Review, 7,* 59–73.

Berg, N. (2005b). Psychological economics and the size of government: On anti-, anti-anti-, ... , (anti-)n. In Y. Yasin (Ed.), *Economic modernization and cultivation of institutions* (pp. 367–375). HSE Publishing House (Proceedings of the 6th Annual Conference of the State University—Higher School of Economics, Moscow).

Berg, N. (2005c). Non-response bias. In K. Kempf-Leonard (Ed.), *Encyclopedia of social measurement* (Vol. 2, pp. 865–873). London: Academic Press.

Berg, N. (2005d). [Review of the book Conflict and Cooperation: Institutional and Behavioral Economics]. *Journal of Socio-Economics, 34,* 866–868.

Berg, N., & **Gigerenzer, G.** (2007). Psychology implies paternalism? Bounded rationality may reduce the rationale to regulate risk-taking. *Social Choice and Welfare, 28,* 337–359.

Berg, N., & **Gigerenzer, G.** (2006). Peacemaking among inconsistent rationalities? Comment on Alex Kacelnik et al. In C. Engel & L. Daston (Eds.), *Is there value in inconsistency?* (pp. 423–433). Baden-Baden: Nomos (Common goods: Law, politics and economics 15).

Berg, N., Gu, A., & Lien, D. (in press). Dynamic correlation: A tool for hedging house-price risk? *Journal of Real Estate Portfolio Management.*

Berg, N., & Hoffrage, U. (2005). Environmental determinants of simple decision rules: No cognitive limitations needed. In K. Opwis & I.-K. Penner (Eds.), *Proceedings of KogWis05: The German Cognitive Science Conference 2005* (pp. 9–14). Basel: Schwabe.

Berg, N., & Lien, D. (2006). Same-sex sexual behavior: U.S. frequency estimates from survey data with simultaneous misreporting and non-response. *Applied Economics, 38* (7), 757–769.

Berg, N., & Lien, D. (2005). Does society benefit from investor overconfidence in the ability of financial market experts? *Journal of Economic Behavior and Organization, 58,* 95–116.

Berg, N., & Maital, S. (in press). Tailoring globalization to national needs and wellbeing: One size never fits all. *Global Business and Economics Review.*

Boom, J., Wouters, H., & **Keller, M.** (2007). A cross-cultural validation of stage development: A Rasch re-analysis of longitudinal socio-moral reasonig data. *Cognitive Development, 22,* 213–229.

Brand, S., **Reimer, T.,** & Opwis, K. (2007). How do we learn in a negative mood? Effects of a negative mood on transfer and learning. *Learning and Instruction, 17,* 1–16.

Brandstätter, E., **Gigerenzer, G.,** & Hertwig, R. (2006). The priority heuristic: Making choices without trade-offs. *Psychological Review, 113,* 409–432.

Brighton, H. J. (2006). Robust inference with simple cognitive models. In C. Lebiere & B. Wray (Eds.), *Between a rock and a hard place: Cognitive science principles meet AI-hard problems. Papers from the AAAI Spring Symposium* (AAAI Tech. Rep. No. SS–06–03, pp. 17–22). Menlo Park, CA: AAAI Press.

Brighton, H. J., & Kirby, S. (2006). Understanding linguistic evolution by visualizing the emergence of topographic mappings. *Artificial Life, 12,* 229–242.

Brighton, H. J., Mata, R., & **Wilke, A.** (2006). Reconciling vague and formal models of language evolution. *Behavioral and Brain Sciences, 29,* 282.

Brighton, H. J., Smith, K., & Kirby, S. (2005). Language as an evolutionary system. *Physics of Life Reviews, 2* (3), 177–226.

Brighton, H. J., & **Todd, P. M.** (in press). Situating rationality: Ecologically rational decision making with simple heuristics. In P. Robbins & M. Aydede (Eds.), *Cambridge handbook of situated cognition.* Cambridge, UK: Cambridge University Press.

Bröder, A. (2006). Experiment. In J. Funke & P. A. Frensch (Eds.), *Handbuch der Allgemeinen Psychologie: Vol. 5. Kognition* (pp. 717–725). Göttingen: Hogrefe.

Bröder, A. (2005). *Entscheiden mit der "adaptiven Werkzeugkiste": Ein empirisches Forschungsprogramm.* Lengerich: Pabst Science Publishers.

Bröder, A., & Eichler, A. (2006). The use of recognition and additional cues in inferences from memory. *Acta Psychologica, 121,* 275–284.

Bröder, A., & **Gaissmaier, W.** (in press). Sequential processing of cues in memory-based multiattribute decisions. *Psychonomic Bulletin and Review.*

Bröder, A., & Schiffer, S. (2006a). Adaptive flexibility and maladaptive routines in selecting fast and frugal decision strategies. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32,* 904–918.

Bröder, A., & Schiffer, S. (2006b). Stimulus format and working memory in fast and frugal strategy selection. *Journal of Behavioral Decision Making, 19,* 361–380.

Brunner, T., **Reimer, T.,** & Opwis, K. (2005). Cancellation and focus: The impact of feature attractiveness on recall. In K. Opwis & I.-K. Penner (Eds.), *Proceedings of KogWis05: The German Cognitive Science Conference 2005* (pp. 27–32). Basel: Schwabe.

Dawes, C. T., Fowler, J. H., **Johnson, T.,** McElreath, R., & Smirnov, O. (2007). Egalitarian motives in humans. *Nature, 446,* 794–796.

Dieckmann, A., & **Gigerenzer, G.** (2005). Macht Halbwissen klug: Ist mehr Information immer besser? *Berliner Ärzte, 42,* 16–19.

Dieckmann, A., & **Krauss, S.** (2005). Wenn weniger Wissen mehr sein kann: Einfache Heuristiken zur psychologischen Entscheidungsfindung. *Zeitschrift für*

Erziehungswissenschaft, 8, 187–201.

Dieckmann, A., & **Rieskamp, J.** (in press.) The influence of information redundancy on probabilistic inferences. *Memory & Cognition.*

Dieckmann, A., & **Todd, P. M.** (2005). Simple ways to construct search order. In K. Forbus, D. Genter, & T. Reqier (Eds.), *Proceedings of the 26th Annual Conference of the Cognitive Science Society* (pp. 309–314). Mahwah, NJ: Erlbaum.

Elmore, J. G., & **Gigerenzer, G.** (2005a). Benign breast disease—the risks of communicating risk. *New England Journal of Medicine, 353,* 297–299.

Elmore, J. G., & **Gigerenzer, G.** (2005b). The editorialists reply. *New England Journal of Medicine, 353,* 1857–1858.

Elwin, E., Juslin, P., **Olsson, H.,** & Enkvist, T. (2006). Constructivist encoding: Learning from selective feedback. *Psychological Science, 18,* 105–110.

Engel, C., & **Gigerenzer, G.** (2006). Law and heuristics: An interdisciplinary venture. In G. Gigerenzer & C. Engel (Eds.), *Heuristics and the law* (pp. 1–16). Cambridge, MA: MIT Press.

Fasolo, B., McClelland, G. H., & **Todd, P. M.** (2007). Escaping the tyranny of choice: When fewer attributes make choice easier. *Marketing Theory, 7,* 13–26.

Fiddick, L., & Rutherford, M. D. (2006). Looking for loss in all the wrong places: Loss avoidance does not explain cheater detection. *Evolution and Human Behavior, 27,* 417–432.

Fowler, J. H., **Johnson, T.,** & Smirnov, O. (2005). Egalitarian motive and altruistic punishment. *Nature, 433,* E1.

Gaissmaier, W., & **Gigerenzer, G.** (2006). Wie funktioniert Intuition? In E. H. Witte (Ed.), *Evolutionäre Sozialpsychologie und automatische Prozesse: Beiträge des 21. Hamburger Symposions zur Methodologie der Sozialpsychologie* (pp. 31–49). Lengerich: Pabst Science Publishers.

Gaissmaier, W., Schooler, L. J., & **Rieskamp, J.** (2006). Simple predictions fueled by capacity limitations: When are they successful? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32,* 966–982.

Gaissmaier, W., Schooler, L. J., & **Gigerenzer, G.** (2005). Receptive memory in judgment and decision making. In M.-L. Käsermann & A. Altorfer (Eds.), *Über Lernen: Ein Gedankenaustausch* (pp. 67–79). Bern: EditionSolo.

Galesic, M., & Tourangeau, R. (2007). What is sexual harassment? It depends on who asks! Framing effects of sponsorship on survey responses. *Applied Cognitive Psychology, 21,* 189–202.

García-Retamero, R. (2007). The influence of knowledge about causal mechanisms on compound processing. *The Psychological Record,* 57, 295–306).

García-Retamero, R. (2006). Identidad de género y nivel de aspiraciones profesionales en alumnos universitarios [Gender identitiy and level of professional aspirations in undergraduates]. *Revista Mexicana de Psicología, 23,* 217–224.

García-Retamero, R., & **Dieckmann, A.** (2006). Una visión crítica del enfoque de los heurísticos rápidos y frugales [A critical view of the approach of fast and frugal heuristics]. *Revista Latinoamericana de Psicología,* 38, 509–522.

García-Retamero, R., Hoffrage, U., & **Dieckmann, A.** (in press). When one cue is not enough: Combining fast and frugal heuristics with compound cue processing. *The Quarterly Journal of Experimental Psychology.*

García-Retamero, R., Hoffrage, U., **Dieckmann, A.,** & Ramos, M. M. (2007). Compound cue processing within the fast and frugal heuristics approach in nonlinearly separable environments. *Learning and Motivation, 38,* 16–34.

García-Retamero, R., & Hoffrage, U. (2006). How causal knowledge simplifies decision-making. *Minds & Machines, 16,* 365–380.

García-Retamero, R., & López-Zafra, E. (2006a). Congruencia de rol de género y liderazgo: El papel de las atribuciones causales sobre el éxito y el fracaso. *Revista Latinoamericana de Psicologia, 38,* 245–257.

García-Retamero, R., & López-Zafra, E. (2006b). Prejudice against women in male-congenial environments: Perceptions of gender role congruity in leadership. *Sex and Roles, 55,* 51–61.

García-Retamero, R., Takezawa, M., & **Gigerenzer, G.** (2006). How to learn good cue orders: When social learning benefits simple heuristics. *Proceedings of the 28th Annual Conference of the Cognitive Science Society,* 1352–1357.

García-Retamero, R., Wallin, A., & **Dieckmann, A.** (in press). Does causal knowledge help us be faster and more frugal in our decisions? *Memory & Cognition.*

Gigerenzer, G. (in press-a). Bounded rationality. In D. Sander & K. Scherer (Eds.), *Oxford companion to the affective sciences.* New York: Oxford University Press.

Gigerenzer, G. (in press-b). Moral intuition = fast and frugal heuristics? In W. Sinnott-Armstrong (Ed.), *The cognitive science of morality.*

Gigerenzer, G. (in press-c). *Rationality for mortals.* New York: Oxford University Press.

Gigerenzer, G. (in press-d). Reply to comments. In W. Sinnott-Armstrong (Ed.), *The cognitive science of morality.*

Gigerenzer, G. (in press-e). The role of representation in Bayesian reasoning: Correcting common misconceptions. *Behavioral and Brain Sciences.*

Gigerenzer, G. (in press-f). What is bounded rationality? *Supreme Court Economic Review.*

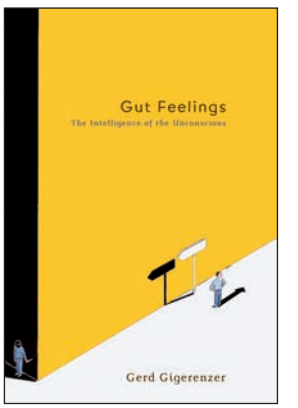
Gigerenzer, G. (in press-g). Why heuristics work. *Perspectives on Psychological Science.*

Gigerenzer, G. (in press-h). Wissenschaftler an einem Max-Planck-Institut. In K. Weis & M. Amelang (Eds.), *Psychologen im Beruf: Anforderungen, Chancen, Perspektiven.* Stuttgart: Kohlhammer.

Gigerenzer, G., Hoffrage, U., & Goldstein, D. G. (in press). Fast and frugal heuristics are plausible models of cognition: Reply to Dougherty, Franco-Watkins, and Thomas. *Psychological Review.*

Gigerenzer, G. (2007a). *Bauchentscheidungen: Die Intelligenz des Unbewussten und die Macht der Intuition.* München: Bertelsmann.

Gigerenzer, G. (2007b). *Gut feelings: The intelligence of the unconscious.* New York: Viking Press.



Gigerenzer, G. (2007c). *Short cuts: The intelligence of the unconscious.* London: Penguin Books.

Gigerenzer, G. (2006a). Bounded and rational. In R. J. Stainton (Ed.), *Contemporary debates in cognitive science* (pp. 115–133). Oxford, UK: Blackwell (Contemporary Debates in Philosophy 7).

Gigerenzer, G. (2006b). Einfache Heuristiken für komplexe Entscheidungen. In Berlin-Brandenburgische Akademie der Wissenschaften (Ed.), *Mathema-*

tisierung der Natur (pp. 37–44). Berlin (Debatte No. 4).

Gigerenzer, G. (2006c). Einfache Heuristiken für komplexe Entscheidungen. *Jahrbuch 2005 der Deutschen Akademie der Naturforscher Leopoldina, 51,* 337–343.

Gigerenzer, G. (2006d). Follow the leader. *Harvard Business Review, 84,* 58–59.

Gigerenzer, G. (2006e). Heuristics. In G. Gigerenzer & C. Engel (Eds.), *Heuristics and the law* (pp. 17–44). Cambridge, MA: MIT Press.

Gigerenzer, G. (2006f). Out of the frying pan into the fire: Behavioral reactions to terrorist attacks. *Risk Analysis, 26,* 347–351.

Gigerenzer, G. (2006g). What's in a sample? A manual for building cognitive theories. In K. Fiedler & P. Juslin (Eds.), *Information sampling and adaptive cognition* (pp. 239–260). New York: Cambridge University Press.

Gigerenzer, G. (2005a). *Calcular o risco: Aprender a lidar com a incerteza [Calculated risks: How to know when numbers deceive you].* Lisbon: Gradiva.

Gigerenzer, G. (2005b). Is the mind irrational or ecologically rational? In F. Parisi & V. L. Smith (Eds.), *The law and economics of irrational behavior* (pp. 37–67). Stanford, CA: Stanford University Press.

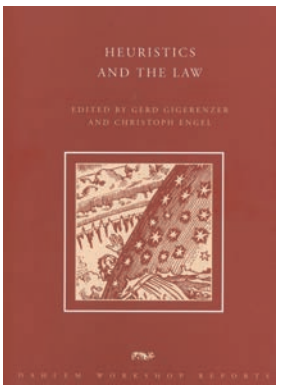
Gigerenzer, G. (2005c). I think, therefore I err. *Social Research, 72,* 195–218.

Gigerenzer, G. (2005d). Wie versteht man Risiken und Unsicherheiten? *HNO Informationen, 4,* 287–294.

Gigerenzer, G., & **Brighton, H. J.** (in press). Can hunches be rational? In C. S. Lerner & D. Polsby (Eds.), *Mere hunches: Policing in the age of terror.*

Gigerenzer, G., & **Dieckmann, A.** (2006). Oblivious confusion. In R. Rapp, P. Sedlmeier, & G. Zunker-Rapp (Eds.), *Perspectives on cognition: A Festschrift for Manfred Wettler* (pp. 19–29). Lengerich: Pabst Science Publishers.

Gigerenzer, G., & Engel, C. (Eds.). (2006). *Heuristics and the law: Report of the 94th Dahlem Workshop on heuristics and law, Berlin, June 6–11, 2004.* Cambridge, MA: MIT Press.



Gigerenzer, G., & **Gaissmaier, W.** (2006a). Denken und Urteilen unter Unsicherheit: Kognitive Heuristiken. In J. Funke (Ed.), *Enzyklopädie der Psychologie: Vol. C, II, 8. Denken und Problemlösen* (pp. 329–374). Göttingen: Hogrefe.

Gigerenzer, G., & **Gaissmaier, W.** (2006b). Ironie des Terrors. *Gehirn & Geist, 9,* 14–16.

Gigerenzer, G., & Gigerenzer, T. (2005). Is the ultimatum game a three-body affair? *Behavioral and Brain Sciences, 28,* 823–824.

Gigerenzer G., Hertwig R., Hoffrage U., & Sedlmeier P. (in press). Cognitive illusions reconsidered. In C. R. Plott & V. L. Smith (Eds.), *Handbook of results in experimental economics.* Amsterdam: Elsevier/North-Holland.

Gigerenzer, G., Hertwig, R., van den Broek, E., Fasolo, B., **Katsikopoulos, K. V.** (2005). A 30 % chance of rain tomorrow: How does the public understand probabilistic weather forecasts? *Risk Analysis, 25,* 623–629.

Gigerenzer, G., & Hoffrage, U. (in press). The role of representation in Bayesian reasoning: Correcting common misconceptions. *Behavioral and Brain Sciences.*

Gigerenzer, G., & Kurzenhäuser, S. (2005). Fast and frugal heuristics in medical decision making. In R. Bibace, J. D. Laird, K. L. Noller, & J. Valsiner (Eds.), *Science and medicine in dialogue: Thinking through particulars and universals* (pp. 3–15). Westport, CT: Praeger.

Gigerenzer, G., Martignon, L., Hoffrage, U., **Rieskamp, J.,** Czerlinski, J., & Goldstein, D. G. (in press). One-reason decision making. In C. R. Plott & V. L. Smith (Eds.), *Handbook of results in experimental economics.* Amsterdam: Elsevier.

Gigerenzer, G., & Sturm, T. (2007). Tools = theories = data? On some circular dynamics in cognitive science. In M. G. Ash & T. Sturm (Eds.), *Psychology's territories: Historical and contemporary perspectives form different disciplines* (pp. 305–342). Mahwah, NJ: Erlbaum.

Gigerenzer, G., & **Todd, P. M.** (in press). Rationality the fast and frugal way: Introduction. In C. R. Plott & V. L. Smith (Eds.), *Handbook of results in experimental economics.* Amsterdam: Elsevier.

Goldstein, D. G., & **Gigerenzer, G.** (in press). Ignorance-based decision making and the less-is-more paradox. In C. R. Plott & V. L. Smith (Eds.), *Handbooks of experimental economics results.* Amsterdam: Elsevier/North Holland.

González-Vallejo, C., & Bohnham, A. (2007). Aligning confidence with accuracy: Revisiting the role of feedback. *Acta Psychologica, 125,* 221–239.

González-Vallejo, C., & Reid, A. A. (2006). Quantifying persuasion effects on choice with the decision threshold of the stochastic choice model. *Organizational Behavior and Human Decision Processes, 100,* 250–267.

Gummerum, M., & **Keller, M.** (in press). Affection, virtue, pleasure, and profit: Developing an understanding of friendship closeness and intimacy in Western and Asian societies. *International Journal of Behavioral Development.*

Gummerum, M., Keller, M., Takezawa, M., & **Mata, J.** (in press). To give or not to give: Children's and adolescents' sharing and negotiations in economic decision situations. *Child Development.*

Hagen, E. H., Barrett, H. C., & Price, M. E. (2006). Do human parents face a quantity-quality tradeoff? Evidence from a Shuar community. *American Journal of Physical Anthropology, 130,* 405–418.

Hanoch, Y. (2005). One theory to fit them all: The search hypothesis of emotion revisited. *The British Journal for the Philosophy of Science, 56,* 135–145.

Hanoch, Y., Johnson, J. G., & **Wilke, A.** (2006). Domain specificity in experimental measures and participant recruitment: An application to risk-taking behavior. *Psychological Science, 17,* 300–304.

Hanoch, Y., **Katsikopoulos, K. V., Gummerum, M.,** & Brass, E. P. (in press). German and American students' knowledge, percepetion, and behavior with respect to over-the-counter pain relievers. *Health Psychology.*

von Helversen, B., & **Rieskamp, J.** (in press). The mapping model: A cognitive theory of quantitative estimation. *Journal of Experimental Psychology: General.*

Hertwig, R., **Pachur, T.,** & Kurzenhäuser, S. (2005). Judgments of risk frequencies: Tests of possible cognitive mechanisms. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31,* 621–642.

Hess, N. H., & Hagen, E. H. (2006). Psychological adaptations for assessing gossip veracity. *Human Nature, 17,* 337–354.

Hill, H., & Raab, M. (2005). Analyzing a complex visuomotor tracking task with brain-electrical event related potentials. *Human Movement Science, 24,* 1–30.

Hoffrage, U. (2006). Achtung Statistik! *Wissenschaftsjournalist,* 18–19.

Hoffrage, U., **García-Retamero, R.,** & **Czienskowski, U.** (in press). Compound cue preocessing in linearly and nonlinearly separable environments. *The Psychological Record.*

Hoffrage, U., **García-Retamero, R.,** & **Czienskowski, U.** (2005a). The robustness of the Take the Best configural heuristic in linearly and nonlinearly separable environments. In B. G. Bara, L. Barsalou, & M. Bucciarelli (Eds.), *Proceedings of the 27th Annual Conference of the Cognitive Science Society* (pp. 971–976). Mahwah, NJ: Erlbaum.

Hoffrage, U., **García-Retamero, R.,** & **Czienskowski, U.** (2005b). The robustness of the Take the Best configural heuristic in linearly and nonlinearly separable environments. In K. Opwis & I.-K. Penner (Eds.), *Proceedings of KogWis05: The German Cognitive Science Conference 2005* (pp. 83–88). Basel: Schwabe.

Hoffrage, U., & Hertwig, R. (2006). Which world should be represented in representative design? In K. Fiedler & P. Juslin (Eds.), *Information sampling and adaptive cognition* (pp. 381–408). New York: Cambridge University Press.

Hoffrage, U., Hertwig, R., & **Gigerenzer, G.** (2005). Die ökologische Rationalität einfacher Entscheidungs- und Urteilsheuristiken. In H. Siegenthaler (Ed.), *Rationalität im Prozess kultureller Evolution: Rationalitätsunterstellungen als eine Bedingung der Möglichkeit substantieller Rationalität des Handelns* (pp. 65–89). Tübingen: Mohr/Siebeck.

Hoffrage, U., Kurzenhäuser, S., & **Gigerenzer, G.** (2005). Understanding the results of medical tests: Why the representation of statistical information matters. In R. Bibace, J. D. Laird, K. L. Noller, & J. Valsiner (Eds.), *Science and medicine in dialogue: Thinking through particulars and universals* (pp. 83–98). Westport, CT: Praeger.

Hoffrage, U., & Vitouch, O. (in press). Evolutionäre Psychologie des Denkens und Problemlösens. In J. Müsseler (Ed.), *Allgemeine Psychologie.* Heidelberg: Spektrum.

Hutchinson, J. M. C., & Griffith, S. C. (in press). Extra-pair paternity in the skylark alauda arvensis. *Ibis.*

Hutchinson, J. M. C. (2005). Is more choice always desirable? Evidence and arguments from leks, food selection, and environmental enrichment. *Biological Reviews, 80,* 73–92.

Hutchinson, J. M. C., & **Gigerenzer, G.** (2005a). Connecting behavioural biologists and psychologists: Clarifying distinctions and suggestions for further work. *Behavioural Processes, 69,* 159–163.

Hutchinson, J. M. C., & **Gigerenzer, G.** (2005b). Simple heuristics and rules of thumb: Where psychologists and behavioural biologists might meet. *Behavioural Processes, 69,* 97–124.

Hutchinson, J. M. C., & Waser, P. (in press). Use, misuse and extensions of "ideal gas" models of animal encounter. *Biological Reviews.*

Johnson, T., Myagkov, M., & Orbell, J. (2005). Sociality as a defensive response to the threat of loss. *Politics and the Life Sciences, 23,* 13–19.

Kameda, T., **Takezawa, M.,** & Hastie, R. (2005). Where do social norms come from? The example of communal sharing. *Current Directions in Psychological Science, 14,* 331–334.

Katsikopoulos, K. V. (in press). (P, p) retraining policies. *IEEE Transactions on Systems, Man & Cybernetics: Systems & Humans.*

Katsikopoulos, K. V. (2005, Autumn). [Review of the book Thinking: Psychological perspectives on reasoning, judgment, and decision making]. Retrieved November 20, 2006, from http://www.psylone.com/eadm-bulletin.html

Katsikopoulos, K. V., & Fasolo, B. (2006). New tools for decision analysts. *IEEE Transactions on Systems, Man, and Cybernetics, Part A: Systems and Humans,* 36, 960–967.

Katsikopoulos, K. V., & Hanoch, Y. (2005). *European Journal of Cognitive Psychology, 17,* 155–158 [Review of the book Preference, belief, and similarity: Selected writings of Amos Tversky].

Katsikopoulos, K. V., & Martignon, L. (2006). Naive heuristics for paired comparisons: Some results on their relative accuracy. *Journal of Mathematical Psychology, 50,* 488–494.

Katsikopoulos, K. V., & Simsek, Ö. (2005). Optimal doubling strategy against a suboptimal opponent. *Journal of Applied Probability, 42,* 867–872.

Keller, M., & Becker, G. (in press). Ein handlungstheoretischer Ansatz zur Entwicklung und Förderung sozio-moralischer Kompetenz. In T. Malti & S. Perren (Eds.), *Entwicklung und Förderung sozialer Kompetenzen in Kindheit und Adoleszenz.* Stuttgart: Kohlhammer.

Keller, M., Brandt, A. & Sigurdardottir, G. (in press). Happy victimizers and unhappy moralists: The development of moral emotions in a cross-cultural perspective. In W. Koops & A. Sanders (Eds.), *The development and structure of conscience.* Hove, UK: Psychology Press.

Keller, M., & Malti, T. (in press). Sozialisation sozio-moralischer Kompetenzen: Eine kognitiv-entwicklungspsychologische Perspektive. In K. Hurrelmann, M. Grundmann & S. Walper (Eds.), *Handbuch der Sozialisationsforschung.* Weinheim: Beltz.

Keller, M., Malti, T., & Dravenau, D. (in press). Bindung, Sozialisation und die Entwicklung des sozio-moralischen Denkens von der Kindheit bis zum Jugendalter: Befunde einer Längsschnittuntersuchung. In C. Hopf & G. Nunner-Winkler (Eds.), *Bindung und moralische Entwicklung.* Weinheim: Juventa.

Keller, M., & Canz, T. (2007) Zwischen Fairness und Interesse: Eine entwicklungspsychologische Studie zu Verhandlungen in Gruppen. In A. A. Bucher (Ed.), *Moral, Religion, Politik: Psychologisch-pädagogische Zugänge: Festschrift für Fritz Oser* (pp. 113–139). Wien: LIT Verlag.

Keller, M., & Krettenauer, T. (2007). Moralentwicklung im Kulturvergleich. In G. Trommsdorf & H. J. Kornadt (Eds.), *Enzyklopädie der Psychologie: Vol. C, VII, 2. Erleben und Handeln im kulturellen Kontext* (pp. 521–555). Göttingen: Hogrefe.

Keller, M. (2006). The development of obligations and responsibilities in cultural context. In L. Smith & J. Vonèche (Eds.), *Norms in human development* (pp. 169–188). Cambridge, UK: Cambridge University Press.

Keller, M. (2005). Moralentwicklung und moralische Sozialisation. In D. Horster & J. Oelkers (Eds.), *Pädagogik und Ethik* (pp. 149–172). Wiesbaden: VS Verlag für Sozialwissenschaften.

Keller, M., Edelstein, W., Krettenauer, T., Fang, F.-X., & Fang, G. (2005). Reasoning about moral obligations and interpersonal responsibilities in different cultural contexts. In W. Edelstein & G. Nunner-Winkler (Eds.), *Morality in context* (pp. 17–337). Amsterdam: Elsevier (Advances in psychology 137).

Krämer, W., & **Gigerenzer, G.** (2005). How to confuse with statistics or: The use and misuse of conditional probabilities. *Statistical Science, 20,* 223–230.

Krappmann, L. (2005a). Is community compatible with autonomy? Some comments to Joan Miller's research on differing moralities in India and the United States. In W. Edelstein & G. Nunner-Winkler (Eds.), *Morality in context* (pp. 313–316). Amsterdam: Elsevier (Advances in psychology 137).

Krappmann, L. (2005b). *Soziologische Dimensionen der Identität: Strukturelle Bedingungen für die Teilnahme an Inter-*

aktionsprozessen (10th ed.). Stuttgart: Klett-Cotta.

Kurz-Milcke, E., & **Gigerenzer, G.** (2007). Heuristic decision making. *Marketing, 3,* 48–56.

Kysar, D. A., Ayton, P., Frank, R. H., Frey, B. S., **Gigerenzer, G.,** Glimcher, P. W., et al. (2006). Group report: Are heuristics a problem or a solution? In G. Gigerenzer & C. Engel (Eds.), *Heuristics and the law* (pp. 102–140). Cambridge, MA: MIT Press.

Machery, E. (2005). You don't know how you think: Introspection and language of thought. *The British Journal for the Philosophy of Science, 56,* 469–485.

Malti, T., & **Keller, M.** (in press). Observed aggressive behaviour in elementaryschool children: Its relations with moral cognitions and moral emotions in close relationships. *European Journal of Developmental Psychology.*

Marewski, J. N., Gaissmaier, W., Dieckmann, A., Schooler, L. J., & **Gigerenzer, G.** (in press). *Applying the recognition heuristic to politics: Antialpha as an analytical tool. In Proceedings of the 27th Annual Conference of the Cognitive Science Society.* Mahwah, NJ: Erlbaum.

Marewski, J. N., Gaissmaier, W., Dieckmann, A., Schooler, L. J., & **Gigerenzer, G.** (2005). Don't vote against the recognition heuristic. In B. G. Bara, L. Barsalou, & M. Bucciarelli (Eds.), *Proceedings of the 27th Annual Conference of the Cognitive Science Society* (p. 2524). Mahwah, NJ: Erlbaum.

Mata, R. (in press). How the central system works? It uses fast and frugal heuristics. In K. Forbus, D. Gentner, & T. Regier (Eds.), *Proceedings of the 26th Annual Conference of the Cognitive Science Society* (p. 1597). Mahwah, NJ: Erlbaum.

Mata, R. (2005). A neurocomputational approach to decision making and aging. In W. Dutch, J. Kacprzyk, E. Oja, & S. Zadrozny (Eds.), *Proceedings of the 15th International Conference on Artificial Neural Networks* (Vol. II, pp. 411–416).

Mata, J., Dieckmann, A., & **Gigerenzer, G.** (2005). Verständliche Risikokommunikation, leicht gemacht – oder: Wie man verwirrende Wahrscheinlichkeitsangaben vermeidet. *Zeitschrift für Allgemeinmedizin, 81,* 537–541.

Mata, R., Schooler, L. J., & **Rieskamp, J.** (in press). The aging decision maker: Cognitive aging and the adaptive selection of decision strategies. *Psychology and Aging.*

Mata, R., Wilke, A., & **Todd, P. M.** (2005). Adding the missing link back into mate choice research. *Behavioral and Brain Sciences, 28,* 289.

Muramatsu, R., & Hanoch, Y. (2005). Emotions as a mechanism for boundedly rational agents: The fast and frugal way. *Journal of Economic Psychology, 26,* 201–221.

Ortmann, A., **Gigerenzer, G.,** Borges, B., & Goldstein, D. G. (in press). Recognition heuristic: A fast and frugal way to investment choice? In C. R. Plott & V. L. Smith (Eds.), *Handbook of results in experimental economics.* Amsterdam: Elsevier/North Holland.

Pachur, T., & **Biele, G.** (2007). Forecasting from ignorance: The use and usefulness of recognition in lay predictions of sports events. *Acta Psychologica, 125,* 99–116.

Pachur, T., & Hertwig, R. (2006) On the psychology of the recognition heuristic: Retrieval primacy as a key determinant of its use. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32,* 983–1002.

Pachur, T., Rieskamp, J., & Hertwig, R. (2005). The social circle heuristic: Fast and frugal decisions based on small samples. In K. Forbus, D. Gentner, & T. Regier (Eds.), *Proceedings of the 26th Annual Conference of the Cognitive Science Society* (pp. 1077–1082). Mahwah, NJ: Erlbaum.

Pachur, T., Wittig, J., Dieckmann, A., & **Todd, P.** (2005). Kognitive Mechanismen bei der Partnerwahl. In Max-Planck-Gesellschaft (Ed.), *Jahrbuch 2005* (pp. 33–37). München: Selbstverlag.

Penke, L., **Todd, P. M.,** Lenton, A. P., & Fasolo, B. (in press). How self-assessments can guide human mating decisions. In G. Geher & G. F. Miller (Eds.), *Mating intelligence: Sex, raltionships, and the mind's reproductive system.* Mahwah, NJ: Erlbaum

Raab, M., & **Gigerenzer, G.** (2005). Intelligence as smart heuristics. In R. J. Sternberg & J. E. Pretz (Eds.), *Cognition and intelligence: Identifying the mechanisms of the mind* (pp. 188–207). Cambridge, UK: Cambridge University Press.

Raab, M., & Green, N. (2005). Motion as input: A functional explanation of movement effects on cognitive processes. *Perceptual and Motor Skills, 100,* 333–348.

Raab, M., & **Reimer, T.** (2007). Expertise in Sport: Intuitive und deliberative Entscheidungen im Sport. In N. Hagemann, M. Tietjens, & B. Strauß (Eds.), *Psychologie der sportlichen Höchstleistung: Grundlagen und Anwendungen der Expertiseforschung im Sport* (pp. 93–117). Göttingen: Hogrefe.

Reimer, T., Bornstein, A.-L., & Opwis, K. (2005). Positive and negative transfer effects in groups. In T. Betsch & S. Haberstroh (Eds.), *The routines of decision making* (pp. 175–192). Mahwah, NJ: Erlbaum.

Reimer, T., & Hoffrage, U. (2006). The ecological rationality of simple group heuristics: Effects of group member strategies on decision accuracy. *Theory and Decision, 60,* 403–438.

Reimer, T., & Hoffrage, U. (2005). Can simple group heuristics detect hidden profiles in randomly generated environments? *Swiss Journal of Psychology, 64,* 21–37.

Reimer, T., Hoffrage, U., & **Katsikopoulos, K. V.** (2007). Entscheidungsheuristiken in Gruppen. *NeuroPsycho-Economics, 2,* 7–29.

Reimer, T., Kuendig, S., Hoffrage, U., Park, E., & Hinsz, V. B. (2007). Effects of the information environment on group discussions and decisions in the hidden-profile paradigm. *Communication Monographs, 74,* 1–28.

Reimer, T., Mata, R., Katsikopoulos, K. V., & Opwis, K. (2005). On the interplay between heuristics and systematic processes in persuasion. In B. G. Bara, L. Barsalou, & M. Bucciarelli (Eds.), *Proceedings of the 27th Annual Conference of the Cognitive Science Society* (pp. 1833–1838). Mahwah, NJ: Erlbaum.

Reimer, T., Park, E., & Hinsz, V. B. (2006). Shared and coordinated cognition in competitive and dynamic task environments: An information-processing perspective for team sports. *International Journal of Sport and Exercise Psychology, 4,* 376–400.

Reimer, T., & **Rieskamp, J.** (in press). Fast and frugal heuristics. In R. F. Baumeister & K. D. Vohs (Eds.), *Encyclopedia of social psychology.* Thousand Oaks, CA: Sage.

Reise, H., **Hutchinson, J. M. C.,** Forsyth, R. G., & Forsyth, T. J. (2005). First records of the terrestrial slug Deroceras turcicum (Simroth, 1894) in Poland. *Folia Malacologica, 13,* 177–179.

Reise, H., **Hutchinson, J. M. C.,** & Robinson, D. G. (2006). Two introduced pest slugs: Tandonia budapestensis new to the Americas, and Deroceras panormitanum new to the Eastern USA. *The Veliger, 48,* 110–115.

Reise, H., Visse, S., & **Hutchinson, J. M. C.** (2007). Mating behaviour in the terrestrial slug Deroceras gorgonium: Is extreme morphology associated with extreme behaviour? *Animal Biology, 57,* 197–215.

Rieskamp, J., & Hoffrage, U. (in press). Inferences under time pressure: How opportunity costs affect strategy selection. *Acta Psychologica.*

Rieskamp, J., & **Reimer, T.** (in press). Ecological rationality. In R. F. Baumeister & K. D. Vohs (Eds.), *Encyclopedia of social psychology.* Thousand Oaks, CA: Sage.

Rieskamp, J. (2006a). Perspectives of probalistic inference: Reinforcement learning and an adaptive network compared. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32,* 1355–1370.

Rieskamp, J. (2006b). Positive and negative recency effects in retirement savings decisions. *Journal of Experimental Psychology: Applied, 12,* 233–250.

Rieskamp, J., Busemeyer, J. R., & Mellers, B. A. (2006). Extending the bounds of rationality: Evidence and theories of preferential choice. *Journal of Economic Literature, XLIV,* 631–661.

Rieskamp, J., Hertwig, R., & **Todd, P. M.** (2006). Bounded rationality: Two interpretations from psychology. In M. Altman (Ed.), *Handbook of contemporary behavioral economics: Foundations and developments* (pp. 218–236). Armonk, NY: Sharpe.

Rieskamp, J., & Otto, P. E. (2006). SSL: A theory of how people learn to select strategies. *Journal of Experimental Psychology: General, 135,* 207–236

Rieskamp, J., & **Todd, P. M.** (2006). The evolution of cooperative strategies for asymmetric social interactions. *Theory and Decision, 60,* 69–111.

Schlegelberger, B., & Hoffrage, U. (2005). Implikationen der genetischen Beratung bei Hochrisiko-Familien für erblichen Brust- und Eierstockkrebs. In A. Gerhardus, H. Schleberger, B. Schlegelberger, & F. W. Schwartz (Eds.), *BRCA: Erblicher Brust- und Eierstockkrebs. Beratung – Testverfahren – Kosten* (pp. 33–58). Heidelberg: Springer.

Schooler, L. J., & Hertwig, R. (2005). How forgetting Aids heuristic inference. *Psychological Review, 112,* 610–628.

Schooler, L. J., & Shiffrin, R. M. (2005). Efficiently measuring recognition performance with sparse data. *Behavior Research Methods, 37,* 3–10.

Schwenk, G., & **Reimer, T.** (in press). Social influence and bounded rationality: Heuristic decision making in complex networks. In D. S. McNamara & G. Trafton (Eds.), *Proceedings of the 29th Annual Meeting of the Cognitive Science Society.* Mahwah, NJ: Erlbaum.

Sturm, T., & **Gigerenzer, G.** (2006). How can we use the distinction between discovery and justification? On the weaknesses of the strong programme in the sociology of science. In J. Schickore & F. Steinle (Eds.), *Revisiting discovery and justification: Historical and philosophical perspectives on the context distinction* (pp. 133–158). Dordrecht: Springer (Archimedes 14).

Takezawa, M., Gummerum, M., & **Keller, M.** (2006). A stage for the rational tail of the emotional dog: Roles of moral reasoning in group decision making. *Journal of Economic Psychology, 27,* 117–139.

Todd, P. M. (2007a). Coevolved cognitive mechanisms in mate search: Making decisions in a decisionshaped world. In J. P. Forgas, M. Haselton, & W. von Hippel (Eds.), *Evolution and the social mind: Evolutionary psychology and social cognition.* New York: Psychology Press.

Todd, P. M. (2007b). How much information do we need? *European Journal of Operational Research, 177,* 1317–1332.

Todd, P. M., Billari, F. C., & Simao, J. (2005). Aggregate age-at-marriage patterns from individual mate-search heuristics. *Demography, 42,* 559–574.

Todd, P. M., & **Dieckmann, A.** (2005). Heuristics for ordering cue search in decision making. In L. K. Saul, Y. Weiss, & L. Bottou (Eds.), *Advances in neural information processing systems* (Vol. 17, pp. 1393–1400). Cambridge, MA: MIT Press.

Todd, P. M., Gigerenzer, G., & the ABC Research Group (in press). *Ecological rationality: Intelligence in the world.* Oxford: Oxford University Press.

Todd, P. M., & **Gigerenzer, G.** (in press-a). Environments that make us smart: Ecological rationality. *Current Directions in Psychological Science.*

Todd, P. M., & **Gigerenzer, G.** (in press-b). Social rationality. In C. R. Plott & V. L. Smith (Eds.), *Handbook of results in experimental economics.* Amsterdam: Elsevier/North Holland.

Todd, P. M., & **Gigerenzer, G.** (2007). Mechanisms of ecological rationality: Heuristics and environments that make us smart. In R. I. M. Dunbar & L. Barrett (Eds.), The *Oxford handbook of evolutionary psychology* (pp. 197–210). Oxford: Oxford University Press.

Todd, P. M., Hertwig, R., & Hoffrage, U. (2005). Evolutionary cognitive psychology. In D. M. Buss (Ed.), *The handbook of evolutionary psychology* (pp. 776–802). Hoboken, NJ: Wiley.

Todd, P. M., & Heuvelink, A. (2006). Shaping social environments with simple recognition heuristics. In P. Carruthers, S. Laurence, & S. Stich (Eds.) *The innate mind: Vol. 2. Culture and cognition* (pp. 165–180). Oxford: Oxford University Press.

Todd, P. M., & Miranda, E. R. (2006). Putting some (artificial) life into models of musical creativity. In I. Deliège & G. A. Wiggins (Eds.), *Musical creativity: Multidisciplinary research in theory and practice* (pp. 376–395). Hove: Psychology Press.

Todd, P. M., Rieskamp, J., & **Gigerenzer, G.** (in press). Social heuristics. In C. R. Plott & V. L. Smith (Eds.), *Handbook of results in experimental economics.* Amsterdam: Elsevier/North Holland.

Todd, P. M., & **Schooler, L. J.** (in press). From disintegrated architectures of cogniton to an integrated heuristic toolbox. In W. D. Gray (Ed.), *Integrated modles of cognitive systems.* Oxford: Oxford University Press.

Vitouch, O. (2005a). Absolutes Gehör. In N. Birbaumer, et al. (Series Eds.), T. H. Stoffer & R. Oerter (Vol. Eds.), *Enzyklopädie der Psychologie: Vol. D, VII, 1. Allgemeine Musikpsychologie* (pp. 717–766). Göttingen: Hogrefe.

Vitouch, O. (2005b). Erwerb musikalischer Expertise. In N. Birbaumer, et al. (Series Eds.), T. H. Stoffer & R. Oerter (Vol. Eds.), *Enzyklopädie der Psychologie: Vol. D, VII, 1. Allgemeine Musikpsychologie* (pp. 657–715). Göttingen: Hogrefe.

Volz, K. G., **Schooler, L. J.,** Schubotz, R., Raab, M., **Gigerenzer, G.,** & von Crammon, D. Y. (2006). Why you think Milan is larger than Modena: Neural correlates of the recognition heuristic. *Journal of Cognitive Neuroscience, 18,* 1924–1936.

Wallin, A. (2007). Explanation and environment: The case of psychology. In J. Persson & P. Ylikoski (Eds.), *Rethinking explanation* (pp. 163–176). Berlin: Springer.

Wilke, A. (2005). [Review of the book Human evolution: An illustrated introduction]. *Human Ethology Bulletin, 20* (3), 6–8.

Wilke, A., Hutchinson, J. M. C., & **Todd, P. M.** (2005). Testing simple rules for human foraging in patchy environments. In K. Forbus, D. Gentner, & T. Regier (Eds.), *Proceedings of the 26th Annual Conference of the Cognitive Science Society* (p. 1656). Mahwah, NJ: Erlbaum.

Wilke, A., Hutchinson, J. M. C., Todd, P. M., & Kruger, D. J. (2006). Is risk taking used as a cue in mate choice? *Evolutionary Psychology, 4,* 367–393.

Wilke, A., Todd, P. M., Hutchinson, J. M. C., & **Mata, R.** (2006). Das adaptive Problem der Ressourcensuche. In H. Hecht, S. Berti, G. Meinhardt, & M. Gamer (Eds.), *Beiträge zur 48. Tagung experimentell arbeitender Psychologen* (p. 317). Lengerich: Pabst Science Publishers.

Zhu, L., & **Gigerenzer, G.** (2006). Children can solve Bayesian problems: The role of representation in mental computation. *Cognition, 98,* 287–308.

Center for Educational Research

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Introductory Overview

The specific concern of the Center for Educational Research is the study of development and learning from the perspective of institutionalized education. Educational settings such as schools provide a specific structure of opportunities and constraints for learning and development. This structure offers a variety of developmental opportunities, but, at the same time, excludes others. How do aspects of schooling affect learning within and across subject domains, how do they impact the intra- and interindividual differentiation of personality traits and guide career-forming processes? How strongly do students themselves actively influence their own academic development, for example, by selecting or changing learning environments? Which roles do students' familial backgrounds play in student development as well as in the selection of learning environments and the optimization of academic outcomes? These and other questions are explored by a multidisciplinary team including educational scientists, psychologists, mathematicians, and sociologists.

Conceptual Orientation: Knowledge Acquisition and Psychosocial Development in the Context of Institutional Learning Settings

Learning in institutional settings is a complex and multidetermined process. It is difficult to determine whether a school career and a student's learning outcomes can be described as successful. It is even more difficult to identify the causes for success or failure. Simple explanatory models relying on a single factor as a cause for successful or unsuccessful learning processes are usually insufficient, if not entirely misleading—despite their popularity with the public, the press, and policymakers.

Due to the complexity of learning in institutional contexts, multiple perspectives guide our Center's research program.

(1) The interactive nature of the characteristics of an individual student and of institutionalized learning settings has to be taken into account. In all of our research, learners are perceived as the coproducers of their own development. Special emphasis is placed on the question of how cognitive activation and self-regulation can be stimulated and supported by instructional environments. However, the role of individuals as coproducers of their own development is not restricted to the constructivist sense of active and idiosyncratic acquisition of knowledge; rather, individuals are also assumed to proactively select and shape their developmental environment.

(2) A comprehensive analysis of institutional opportunities and constraints requires researchers to consider several context levels, such as countries, schools, classrooms, and the family. Accordingly, our research is embedded in a multilevel perspective, both conceptually and methodologically, and addresses these different context levels.

(3) It is important to analyze the effects of various facets of these learning contexts simultaneously. For this reason, we incorporate conceptually different aspects, such as the curriculum, the quality of instruction, and the composition of the learning group in our research models.

(4) Remaining attuned to the historical time in which learning takes place is crucial because educational systems as well as society as a whole change. We therefore embed our research in historical analyses and conduct studies that are able to document the effects of changes in institutional settings.

(5) The way in which educational institutions have structured content areas into different academic subjects determines the domain-specificity of knowledge acquisition. Our research focuses on domains of knowledge such as mathematics, reading, English as a foreign language, and sciences. These domains represent basic cultural tools that are critical for individual development in modern societies.

(6) Although the acquisition of knowledge in core domains is the most central variable in learning settings, it is not the only aspect of interest. The work of our Center also includes students' motivation, personality, personal goals, and values as both an outcome of

Key References

Baumert, J., Carstensen, C. H., & Siegle, T. (2005). Wirtschaftliche, soziale und kulturelle Lebensverhältnisse und regionale Disparitäten des Kompetenzerwerbs. In M. Prenzel, J. Baumert, W. Blum, R. Lehmann, D. Leutner, M. Neubrand et al. (Eds.), *PISA 2003: Der zweite Vergleich der Länder in Deutschland – Was wissen und können Jugendliche?* (pp. 323–365). Münster: Waxmann.

Baumert, J., Blum, W., & Neubrand, M. (2004). Drawing the lessons from PISA 2000: Long-term research implications. Gaining a better understanding of the relationship between system inputs and learning outcomes by assessing instructional and learning processes as mediating factors. In D. Lenzen, J. Baumert, R. Watermann, & U. Trautwein (Eds.), *PISA und die Konsequenzen für die erziehungswissenschaftliche Forschung* (pp.143–157). Wiesbaden: VS Verlag für Sozialwissenschaften.

Key References

Trautwein, U., Köller, O., Lehmann, R., & **Lüdtke, O.** (Eds.). (2007a). *Schulleistungen von Abiturienten. Regionale, schulformbezogene und soziale Disparitäten.* Münster: Waxmann.

Baumert, J., Stanat, P., & **Watermann, R.** (Eds.). (2006a). *Herkunftsbedingte Disparitäten im Bildungswesen: Differenzielle Bildungsprozesse und Probleme der Verteilungsgerechtigkeit: Vertiefende Analysen im Rahmen von PISA 2000.* Wiesbaden: VS Verlag für Sozialwissenschaften.

Kunter, M., & **Baumert, J.** (2006). Linking TIMSS to research on learning and instruction: A reanalysis of the German TIMSS and TIMSS video data. In S. J. Howie & T. Plomp (Eds.), *Contexts of learning mathematics and science: Lessons learned from TIMSS* (pp. 335–351). London: Routledge.

Cortina, K. S., **Baumert, J.,** Leschinsky, A., **Mayer, K. U.,** & **Trommer, L.** (Eds.). (2003). *Das Bildungswesen in der Bundesrepublik Deutschland. Strukturen und Entwicklungen im Überblick.* Reinbek: Rowohlt.

institutional learning and a predictor of academic success and choices.
(7) Several methodological approaches contribute to the identification of powerful learning environments. In our Center, experiments and intervention studies complement large-scale longitudinal studies.

Summary Outline

Research Area I focuses on the relationship between the opportunity structure of schools and the optimization of individual development, in terms of cognitive competencies, motivational and social resources, value commitment, and successful transitions to university education, vocational training, and the labor market. Two longitudinal studies form the basis for this research program. The ongoing, multiwave, multiple-cohort study *Learning Processes, Educational Careers, and Psychosocial Development in Adolescence and Young Adulthood* (BIJU) was initiated in 1991 with a sample of more than 5,000 7th graders. Data from six measurement points are now available for the main cohort. The longitudinal *Transformation of the Upper Secondary School System and Academic Careers* (TOSCA) study began in 2002; additional measurements took place in 2002 and 2004. The *Homework as Academic Learning Opportunities* (HALO) project uses data from multiple sources (BIJU, PISA) and establishes a link between Research Areas I and IV.
Research Area II deals with institutional, individual, and familial factors in their relation to transitions in the education system. This is a new research area which emerged from the focusing and elaboration of research questions that were initially addressed primarily in the context of the longitudinal studies of Research Area I and in the PISA study. A main focus of the activities in this Research Area is the Center's participation in the *Trends in International Mathematics and Science Study* (TIMSS), which has involved the development of an additional module to examine the transition from elementary to secondary school. The research questions being addressed within **Research Area III** draw on a key finding of PISA 2000. In Germany, at least 25 % of the upcoming generation represent a potential at-risk group as far as reading literacy is concerned. The projects in Research Area III have been designed to investigate, from theoretical and empirical perspectives, the functional mechanisms underlying intervention programs aiming to foster metamemory and learning strategies in the domain of reading comprehension. The studies are longitudinal or use an experimental or quasi-experimental design. They include a longitudinal study on the development of reading competence, a study of a training program targeting metamemory and reading strategies within family contexts, and an examination of the role of phonological awareness in the language development of bilingual children. Finally, the *Jacobs Summer Camp Project* investigates the role of implicit and explicit language learning, with a particular focus on proficiency in school-related academic language.
Research Area IV investigates the processes of learning and instruction, and examines how successful learning environments can be created. The focus is on learning that occurs in authentic real-life classrooms, particularly in mathematics classrooms. The question of what actually determines good instructional practice is central to the success of education and the functioning of the educational system. In Research Area IV, we address this question by combining pedagogical concepts of instructional quality with the analysis of individual and collective processes of knowledge acquisition in mathematics. The COACTIV data set has become the most important database in this area over the last two years.
With Prof. Dr. Elsbeth Stern's move to the Swiss Federal Institute of Technology in Zurich at the end of 2006, our Center's work on the **ENTERPRISE** project that was part of Research Area IV has been concluded. Therefore, we give an interim report on this project's outcomes over the past years.

Research Area I
Opportunity Structures of School and Individual Development in Adolescence and Young Adulthood

The successful development of human beings across the entire life span is dependent both on their individual characteristics and on external socializers, such as significant others and social institutions. The social institution of school plays a major role during childhood and adolescence, particularly in the domain of academic learning and, more generally, cognitive development. Furthermore, schools have an impact on the formation and development of motivation, emotions, attitudes, and other personal characteristics. Major research topics of Research Area I include the opportunity structures open to students from different backgrounds, the development of school achievement across the secondary school level, the educational standards attained in German upper secondary schools, the comparability of the school-leaving qualifications awarded across Germany, and determinants and consequences of different academic biographies. In addition, we analyze the interrelationship between school context and expectancy and value beliefs, and focus on self-selection versus socialization processes during the transition from school to work or university.

The BIJU Study—Aims and Data Collection

BIJU has four guiding components:

(1) providing institutional and individual baseline data on the integration of the East and West German educational systems; since 1991;

(2) analyzing domain-specific learning as a function of personal resources and institutional opportunity structures;

(3) analyzing long-term trajectories of psychosocial development in adolescence and young adulthood;

(4) analyzing ways of coping with the transition from school to vocational training or university.

Data collection began with a survey of the main cohort (longitudinal cohort 1) in the 1991/92 school year (see Figure 1). Data was gathered from 7th graders 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 took place in Spring 1997, when participants were either in vocational education or in the academic track of upper secondary level. The sixth wave of data collection was conducted in 2001, and focused on how students had mastered the transition from school to university or from vocational education to the labor market.

The 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.

In Spring 1993, the sample was supplemented by a second longitudinal cohort of 1,330 students in the final grade of lower secondary schooling. In order to provide a baseline for an East-West comparison at the end of lower secondary education, a separate cross-sectional study of approximately 1,600 10th graders was also carried out. This study concentrated on issues of political socialization, and the transition to vocational training and working life.

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Key References

Stanat, P., & **Lüdtke, O.** (in press). Multilevel issues in international large-scale assessment studies on student performance. In F. J. R. van de Vijver, D. A. van Hemert, & Y. H. Poortinga (Eds.), *Individuals and cultures in multilevel analysis.* Hillsdale, NJ: Erlbaum.

Lüdtke, O., Robitzsch, A., **Trautwein, U.,** & Köller, O. (2007). Umgang mit fehlenden Werten in der psychologischen Forschung: Probleme und Lösungen. *Psychologische Rundschau, 58,* 103–117.

Becker, M., Trautwein, U., Lüdtke, O., Cortina, K. S., & **Baumert, J.** (2006). Bildungsexpansion und kognitive Mobilisierung. In A. Hadjar & R. Becker (Eds.), *Die Bildungsexpansion: Erwartete und unerwartete Folgen* (pp. 63–89). Wiesbaden: VS Verlag für Sozialwissenschaften.

Lüdtke, O., Trautwein, U., Kunter, M., & **Baumert, J.** (2006b). Reliability and agreement of student ratings of the classroom environment: A reanalysis of TIMSS data. *Learning Environments Research, 9,* 215–230.

Baumert, J., Trautwein, U., & **Artelt, C.** (2003). Schulumwelten. Institutionelle Bedingungen des Lehrens und Lernens. In J. Baumert, C. Artelt, E. Klieme, M. Neubrand, M. Prenzel, U. Schiefele, W. Schneider, K.-J. Tillmann, & M. Weiß (Eds.), *PISA 2000. Ein differenzierter Blick auf die Länder der Bundesrepublik Deutschland* (pp. 261–331). Opladen: Leske + Budrich.

The Empirical Database

Given its emphasis on institutional influences on human development, the research conducted within Research Area I entails longitudinal multilevel studies that collect data at the country, state, school, class, and individual levels, cover more than one knowledge domain, and allow both intraindividual change across domains and interindividual differences in patterns of intraindividual change to be investigated. The two flagship studies in Research Area I, *Learning Processes, Educational Careers, and Psychosocial Development in Adolescence and Young Adulthood* (BIJU; see Figure 1), and *Transformation of the Secondary School System and Academic Careers* (TOSCA; see Figure 2) were designed to investigate the effects of learning contexts in high school and college environments on human development, bearing in mind the requirements of multilevel longitudinal designs. In addition to BIJU and TOSCA, research conducted within Research Area I makes use of the PISA and TIMSS data sets as well as additional data sets collected at our Center. Because the longitudinal modeling of hierarchically structured data is methodologically difficult, data analysis requires specific and complex methods (cf. Lüdtke & Köller, 2006; Lüdtke, Robitzsch, Trautwein, & Köller, 2007).

Educational Institutions as Developmental Environments: An Overview of Recent Research

Research in Area I has yielded a multitude of theoretically and practically significant findings in recent years. We first give a brief overview of several central results before describing two domains (the interplay of vocational interests and school performance at the transition from school to university and the effects of assigning and completing homework) in more depth.

Student Performance and Learning Gains

One focus of research has been on student performance and learning gains. The assumption that schools and school types represent differential developmental environments leading to different student learning gains at different school types (fan-spread) is a main hypothesis of our Research Center.

There are three main explanatory approaches to these fan-spread effects (cf. Baumert, Stanat, & Watermann, 2006a, 2000b). The first explanation assumes that differential developmental trajectories in German secondary schools—vocational track *Hauptschule*, intermediate track *Realschule*, and academic track *Gymnasium*—are attributable to differences in students' performance and learning speed that existed before they entered secondary

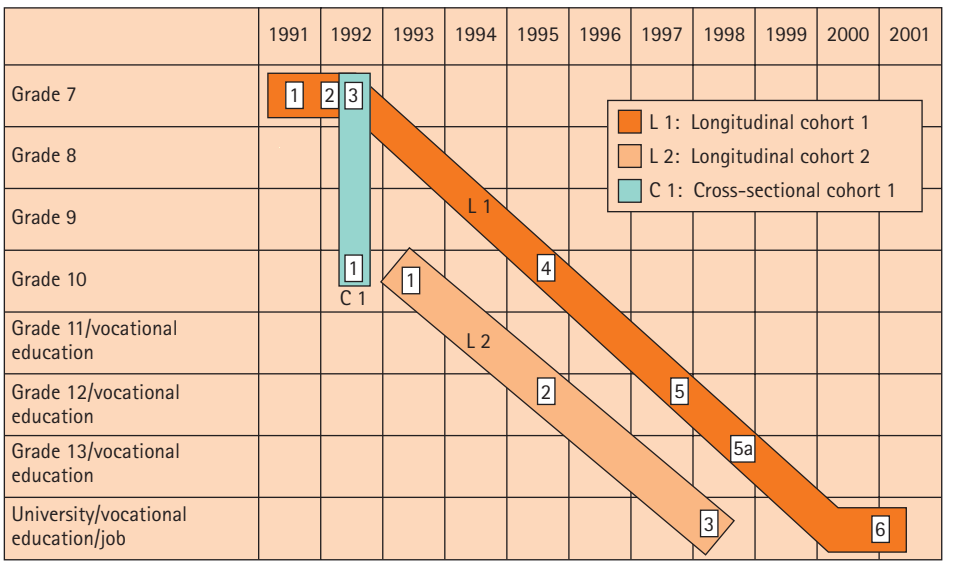

Figure 1. Study design of the BIJU project.

school (cf. Schneider & Stefanek, 2004). Differing developmental trajectories would thus be an expression of differential learning rates and, therefore, a function of entrance selectivity to the three school types. The second approach focuses on the differential effects of school types and school systems relying on differing timetables, curricula, and teaching cultures; these effects are "institutional" in nature (cf. Baumert et al., 2003). The third explanation for the effects of school types on student learning gains refers to composition effects arising from differing performance-related, social, cultural, and learning career groupings of students. According to this approach, differences in performance development are not, or are only partially, dependent on attending a certain school type. Rather, they are a consequence of the characteristics of the specific learning group.

Data Collection in TOSCA

At Time 1 of the TOSCA 2002 cohort, a representative sample of 4,730 students in their last year of upper secondary education (aged about 17 to 19 years) were sampled between March and May 2002. All students were attending either traditional *Gymnasium* schools or one of the five (now six) forms of vocational *Gymnasium* schools that have been established in the state of Baden-Wuerttemberg. More than 60 % of these students consented to be recontacted for follow-up studies. The second wave of data collection took place from February to May 2004. A total of 2,315 students participated in this follow-up. The third wave took place from February to May 2006 and a total of 1,912 students participated. At Time 4, in early 2007, a subsample of TOSCA participants were administered a set of mathematics and cognitive ability tests.

A second TOSCA cohort ("TOSCA-Repeat") began in 2006 with almost 5,000 students who were in their last year of upper secondary education at more than 150 schools in Baden-Wuerttemberg. TOSCA-Repeat assesses the effects of the structural reform of the upper secondary level (the last 3 years of schooling before the *Abitur*). The school system in Baden-Wuerttemberg has experienced major changes since 2002. The most important change to the upper secondary level has been the introduction of core competence subjects and the abolition of the traditional advanced courses *(Leistungskurse).* In 2005, instruments from the TOSCA study were administered to students in their final *Abitur* year participating in the LAU study on achievement at school entry and learning development. This is a longitudinal study that has already been running for several years (directed by Prof. Dr. Rainer Lehmann from Humboldt University Berlin), in which all of the students of a Hamburg cohort were assessed numerous times throughout their entire school careers. By using the TOSCA instruments in 2005, a detailed comparison of *Abitur* students in Baden-Wuerttemberg and Hamburg was possible for the first time.

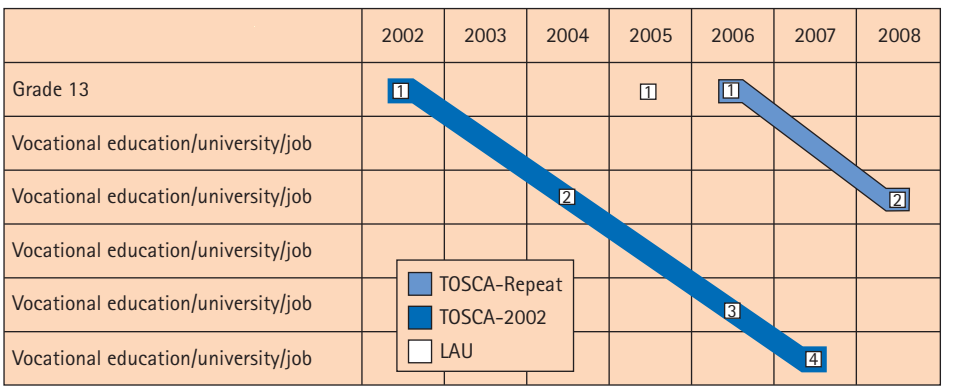

Figure 2. Study design of the TOSCA project.

Key References

Neumann, M., Schnyder, I., **Trautwein, U.,** Niggli, A., **Lüdtke, O.,** & Cathomas, R. (in press). Schulformen als differenzielle Lernmilieus: Institutionelle und kompositionelle Effekte auf die Leistungsentwicklung im Fach Französisch. *Zeitschrift für Erziehungswissenschaft.*

Becker, M., Lüdtke, O., Trautwein, U., & **Baumert, J.** (2006). Leistungszuwachs in Mathematik: Evidenz für einen Schereneffekt im mehrgliedrigen Schulsystem? *Zeitschrift für Pädagogische Psychologie, 20,* 233–242.

Baumert, J., Stanat, P., & **Watermann, R.** (2006b). Schulstruktur und die Enstehung differenzieller Lern- und Entwicklungsmilieus. In J. Baumert, P. Stanat, & R. Watermann (Eds.), *Herkunftsbedingte Disparitäten im Bildungswesen: Differenzielle Bildungsprozesse und Probleme der Verteilungsgerechtigkeit: Vertiefende Analysen im Rahmen von PISA 2000* (pp. 95–188). Wiesbaden: VS Verlag für Sozialwissenschaften.

Key References

Trautwein, U., Köller, O., Lehmann, R., & **Lüdtke, O.** (Eds.). (2007a). *Schulleistungen von Abiturienten. Regionale, schulformbezogene und soziale Disparitäten.* Münster: Waxmann.

Trautwein, U., Lüdtke, O., Köller, O., & **Baumert, J.** (2006). Self-esteem, academic self-concept, and achievement: How the learning environment moderates the dynamics of self-concept. *Journal of Personality and Social Psychology, 90,* 334–349.

Several recent articles from our Center indicate the importance of institutional and composition effects. Becker, Lüdtke, Trautwein, and Baumert (2006) were able to demonstrate the fan-spread effect on the basis of TIMSS: Within a school year, *Gymnasium* students learned more mathematics than *Realschule* or *Hauptschule* students. Baumert, Stanat, and Watermann (2006a, 2000b) drew on data from the PISA study to investigate students' mean performance and socioeconomic background characteristics within school types. In addition to school-type effects, the authors found evidence of composition effects: When controlling for individual background characteristics, a concentration of students with low average cognitive abilities or from disadvantaged family backgrounds had a negative effect on achievement.

A longitudinal study with students from two Swiss cantons learning French as a foreign language revealed similar effects (Neumann et al., in press): On the one hand, students in higher school types were shown to have particularly positive learning development; on the other hand, positive effects of favorable class composition were observed. However, composition effects decreased or became insignificant as soon as the school type was taken into account.

Our studies on standards of performance and the comparability of school-leaving certificates have been continued over the past two years (Köller, Watermann, Trautwein, & Lüdtke, 2004). In Germany, only those students who achieve the *Abitur* are eligible to study at universities. Therefore, the *Abitur* is a highly desirable school-leaving certificate that requires high standards of comparability. Together with Rainer Lehmann and Olaf Köller from the Humboldt University Berlin, we compared the mathematics, English, and science performance of *Abitur* students from different school types in the federal states of Hamburg (LAU) and Baden-Wuerttemberg (TOSCA) (Trautwein, Köller, Lehmann, & Lüdtke, 2007a). In mathematics, in particular, large differences were observed between school types within the two states. In addition, on average, students from Baden-Wuerttemberg performed significantly better than their peers in Hamburg. These findings have led to a renewed discussion of the quality of the *Abitur* in Germany.

Expectancy Beliefs, Value Beliefs, and Academic Choices

Beyond learning gains and performance standards, the examination of the relationship between performance and motivational variables (specifically expectancy and value beliefs) and the explanation of academic choices form a second focus of attention within Research Area I. Again, we are particularly interested in effects of different learning environments as differential developmental environments. We examine how school systems, school types, and the composition of school classes influence the development of noncognitive measures and student biographies.

Different school types can lead to different choice mechanisms. Nagy et al. (in press) compared the determinants of the selection of advanced courses in Germany and the USA. In order to increase the chance of obtaining a place at a renowned university in the USA, participation in a large number of advanced courses is recommended. In Germany, the number of advanced courses a student can take is restricted, and the choice of a certain course does not influence university entrance. As expected by the authors, the selection of advanced courses was especially dependent on students' school performance in the USA, but on students' domain-specific self-concept and interest in Germany. Trautwein, Lüdtke, Köller, and Baumert (2006) also identified effects of different school systems when comparing students from West and East Germany using the first waves of the BIJU study. The development of global self-esteem of students in East Germany was more strongly influenced by academic self-concepts than that of students in West Germany. The reasons for these differences are probably related to the different learning cultures existing just after reunification that were also reflected in the transparency of performance assessment in East Germany.

In a series of studies we continued our research program (see Köller, 2004; Trautwein, Köller, Lüdtke, & Baumert, 2005) examining frame-of-reference effects on self-concept. Herbert Marsh has coined the term *Big-Fish-Little-Pond Effect* (BFLPE) to describe the finding that students in high-achieving groups develop lower self-concepts than equally proficient students in low-achieving environments. Trautwein, Lüdtke, Marsh, Köller, and Baumert (2006) documented the powerful role of the BFLPE in the large student sample from the German extension to the PISA study. They found strong frame-of-reference effects on both mathematics self-concept and mathematics interest. Moreover, the study also showed that teachers' grading practices reflect frame-of-reference effects, and that grading standards that vary from school to school may partly explain the frame-of-reference effects on self-concept and interest. However, although grading practices may contribute to the BFLPE, they do not fully explain this phenomenon.
Lüdtke, Köller, Marsh, and Trautwein (2005) examined whether the BFLPE decreases if teachers use an individualized frame of reference instead of a social frame of reference. In accordance with their hypothesis, they found that an individualized frame of reference (as identified in a video study) was indeed associated with a more positive self-concept, but that the frame-of-reference effects were largely unaffected.
Frame-of-reference effects are pervasive and stable, even after educational transitions. Marsh, Trautwein, Lüdtke, Köller, and Baumert (in press) found persistent frame-of-reference effects from secondary school on academic self-concept in young adults 2 and 3 years after secondary school graduation.

Schooling as an Authentic Part of Life
It is a structural paradox of formal education that the experiences made available within institutions of formalized education are always vicarious—selected and prepared with the aim of facilitating learning processes which the learner must nevertheless perceive as personal and authentic. At the same time, however, the school or university context is a central part of the student's life, strongly affecting his or her cognitive activities, beliefs, and behavior outside of the educational institution. Educational institutions take up a large part of children's, adolescents', and young adults' time, and thus constitute social environments in their own right. The social rules and regulations of educational institutions not only create the conditions for systematic instruction and learning but also provide the setting for immediate everyday experiences.
Two current dissertation projects within Research Area I investigate the effects of school or university contexts on social behavior, life goals, and well-being. The dissertation project by Nicole Husemann sheds light on the development of life goal priorities in different environments and effects of person-environment fit in terms of goal congruence on well-being. The dissertation project by LIFE fellow Kathrin Jonkmann focuses on the relationship between peer status, achievement, and self-concept.

Interests and Achievement, and the Transition From School to University
In comparison to other countries, the coupling between education and occupational status is particularly strong in Germany, across the entire breadth of the professional hierarchy. Thus, the selection of a field of tertiary education is highly important because the ensuing occupational specialization shapes long stretches of each individual life path. What defines a good selection? What is regarded as a successful transition to tertiary education?
Psychological theories relate the success of the transition from school to tertiary education to the concept of person-environment fit (Holland, 1997). They hypothesize two aspects of person-environment fit to be central indicators of a transition's success: (1) the fit achieved between individual desires and the opportunities to realize them and (2) the fit achieved between individual competencies and the environmental requirements. A good fit secures high levels of individual performance and satisfaction in the context of tertiary education.

Key References

Marsh, H. W., **Trautwein, U., Lüdtke, O.,** Köller, O., & **Baumert, J.** (in press). Big Fish Little Pond Effect: Persistent negative effects of selective high schools on self-concept after graduation. *American Educational Research Journal.*

Trautwein, U., Lüdtke, O., Marsh, H. W., Köller, O., & **Baumert, J.** (2006). Tracking, grading, and student motivation: Using group composition and status to predict self-concept and interest in ninth-grade mathematics. *Journal of Educational Psychology, 98,* 788–806.

Lüdtke, O., Köller, O., Marsh, H. W., & **Trautwein, U.** (2005). Teacher frame of reference and the big-fish-little-pond effect. *Contemporary Educational Psychology, 30,* 263–285.

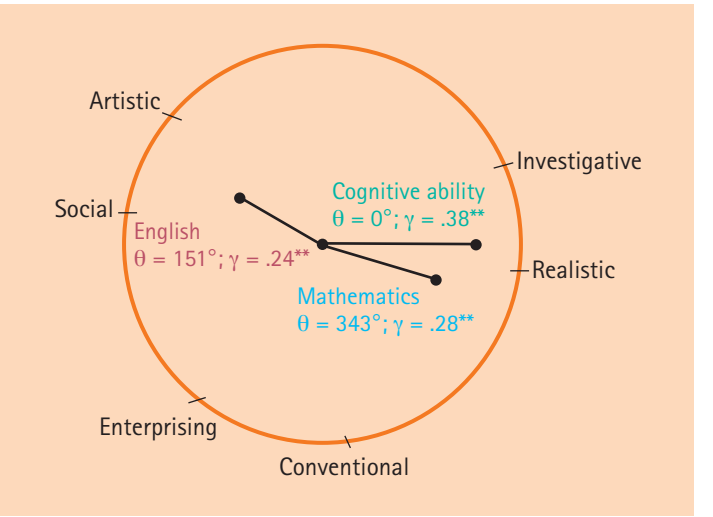

Figure 3. The relationship between interest profiles, basic cognitive abilities, and performance in mathematics and English.

Key Reference

Nagy, G. (2005). *Berufliche Interessen, kognitive und fachgebundene Kompetenzen: Ihre Bedeutung für die Studienfachwahl und die Bewährung im Studium.* Unpublished doctoral thesis, Free University Berlin.

Former LIFE fellow Gabriel Nagy's completed dissertation project examined person-environment fit during the transition from the *Gymnasium* to university using data from the TOSCA study (Nagy, 2005). The role of interests and competencies in the selection of a university degree program, along with subsequent success in the university context, were at the center of attention. This project drew on the concept of vocational interests developed by John Holland (1997), which identifies six broad content domains of vocational interests: (1) *realistic (R),* (2) *investigative (I),* (3) *artistic (A),* (4) *social (S),* (5) *enterprising (E),* and (6) *conventional (C)* interests. It is not the absolute level of interests, but the individual configuration of occupational interests that is important: Strong interests in a certain domain are usually accompanied by weak interests in other domains.

Development of Interests and Competencies

Various theories suggest that domain-specific competencies and vocational interests develop in a reciprocal process. The process of ability and interest differentiation is most clearly explicated in Ackerman's (1996) so-called PPIK theory, which examines the influences of intelligence-as-**P**rocess, **P**ersonality, **I**nterests, and intelligence-as-**K**nowledge. According to this theory, persons' interest leads them to engage often and intensely with the topic and content in question. In this way, they develop increased competencies in the domain of interest by investing their basic cognitive abilities in that domain. PPIK theory assumes this mechanism to explain the high correlations between domain-specific competencies and basic cognitive abilities. The predictions of PPIK theory were tested using the TOSCA data set. Examining whether specific competencies are associated with vocational interest profiles requires a series of complex analysis steps. The basic principle was to disentangle persons' general basic cognitive abilities from their domain-specific strengths and weaknesses.

The analyses showed clear associations between a person's basic cognitive ability profile and his or her interests: Those with particularly high basic cognitive abilities or mathematics ability usually had an interest focus within domains *I* and *R.* Specific competencies in the verbal domain were related to a profile orientation toward domains *A* and *S.* Thus, specific mathematical and verbal competencies were related to contrasting interest orientations. The results of these complex analyses are shown graphically in Figure 3.

Prediction of University Field of Study

Which characteristics are more important for the subject taken at university: interests or competencies? This question was also examined with the TOSCA data set. In this case, the analysis strategy focused on using students' knowledge and interests to predict their field of study. The relationship between correct and incorrect predictions was expressed as the "hit rate." Figure 4 shows the hit rates found by Nagy (2005) on the basics of ability measures or interest profiles alone as well as for the two aspects combined plus a number of additional predictors. Compari-

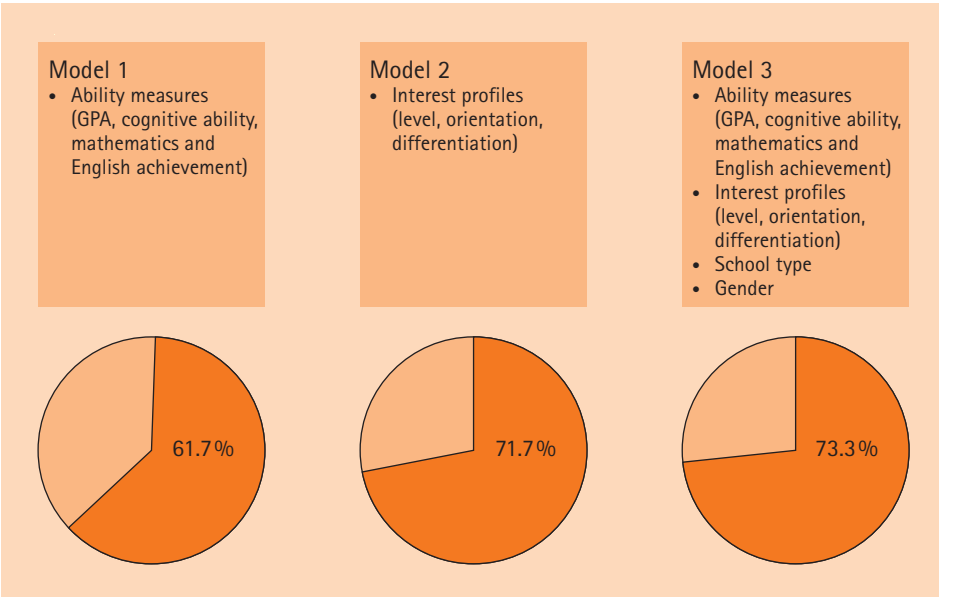

Figure 4. Hit rates from hierarchical multinomial logistic regressions predicting the selection of university courses based on average ability and interest profiles.

son of Models 2 and 3 shows that the hit rate of interest alone was barely improved by the inclusion of other predictors. This finding demonstrates the central importance of individual interest configurations for the selection of a university field of study.

University Success

The selection of a university field of study is often based on mistaken assessments of its demands and characteristics. Moreover, choices are often motivated by factors such as job market opportunities or chance experience rather than interest alone. These factors can lead to a decrease in the fit between the individual and the subject chosen.

What influences do individual interest configurations, on the one hand, and their fit to the university field of study, on the other, have for various aspects of success at univer-

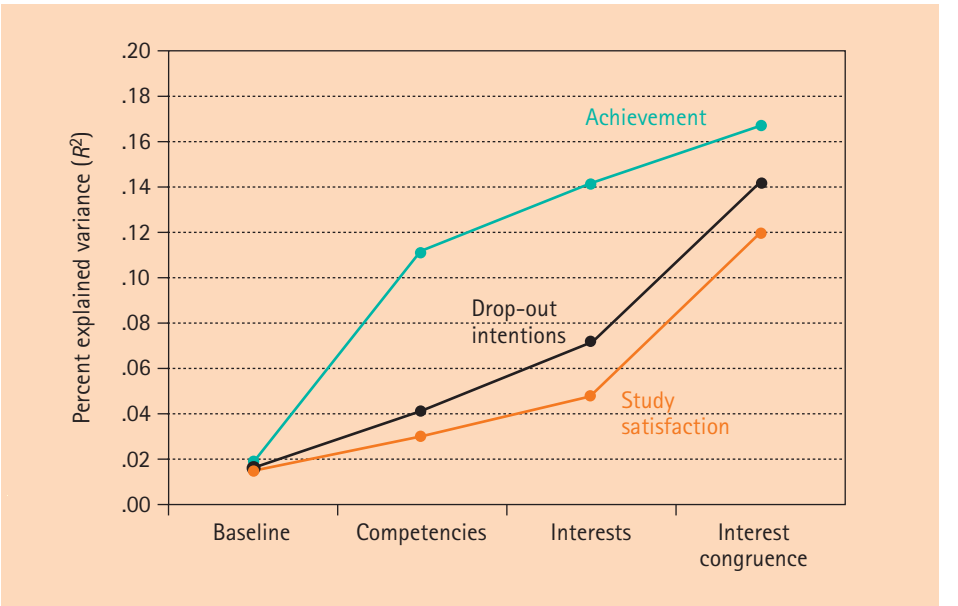

Figure 5. Variance explained by different aspects of success in hierarchical regression analyses.

sity? How important are cognitive competencies and those acquired at school? A theoretical framework model dealing with these questions was established by Lubinski and Benbow (2000). According to this model, the performance aspect of success at university depends mainly on the availability of the necessary abilities, whereas satisfaction with the university course depends on interest congruence.

The relationships between interests, competencies, and success at university were examined using data from the second wave of TOSCA. Two years after leaving school N = 1,756 young adults were studying at university. The assessment included a broad range of aspects of success: (1) self-reported university course achievement, (2) satisfaction with university course, and (3) the intention to drop out.

Figure 5 provides an overview of the central results of a series of sequential regression models. The prediction analyses showed that individual competencies (cognitive ability, mathematics and English achievement, and GPA), school grades, vocational interests, and interest congruence are associated with success at university. Furthermore, the different characteristics examined were related to differing aspects of success at university. University course achievement was mainly determined by measures of competency, whereas study satisfaction and intention to drop out were best predicted by interest congruence.

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Learning Opportunities Provided by Homework

There are few aspects of student development and learning whose practical significance for students, teachers, and parents stands in such stark contrast to the scarcity and arbitrariness of theoretical and empirical research as homework. Students, teachers, and parents invest millions of hours in homework every week, but the cost-benefit ratio remains a subject of intense debate. The available body of research findings on homework is complex, fragmented, and contradictory because of the wide variety of interacting factors that may influence the homework process, and because systematic research programs remain the exception to the rule. In fact, the recommendations that scientists and practitioners make about homework assignment and completion are often based on their own experience or on speculation rather than on sound scientific evidence (Trautwein & Köller, 2003).

Originating from analyses conducted within the BIJU study, the learning opportunities provided by homework assignments and completion have become an additional focus of Research Area I that forges a promising link to Research Area IV. The *Homework as Academic Learning Opportunities* (HALO) project draws on different data sources, such as PISA 2000, PISA 2003, and a study conducted in collaboration with the University of Teacher Education in Freiburg (Switzerland). Two questions are at its core: What is the relation between homework assignments and completion and student achievement? What are determinants of high homework morale?

The Homework-Achievement Relationship

Based on a review of prior research, Cooper and colleagues (2006) concluded that more time on homework is associated with higher achievement. Similarly, the OECD report on the PISA 2000 data suggests that the time spent on homework is positively associated with achievement in practically all participating countries. Our own research shows that definitive insights into the homework-achievement relationship are as yet precluded by a lack of suitable data sets and by methodological shortcomings in the analyses. There are at least three potential threats to the validity of typical correlational studies on the homework-achievement relationship (see Trautwein, 2007; Trautwein & Köller, 2003). First, homework can be related to achievement at two levels. One, a homework effect *at the class level* (or *homework assignment effect*) is found when students in classes with a higher quantity or quality of homework have more pronounced achievement gains than students in other classes. The other, a homework effect *at the student level* (or *homework completion effect*), is found when students in the same class who differ in their homework behavior (e. g., time spent on

homework) show differential outcomes. In this sense, homework is a classic example of the multilevel problem, and it is essential to differentiate between teacher- and student-level effects in all studies that relate homework to achievement. A second major issue in several homework studies is that they do not control for the role of confounding variables. For instance, more homework might be set in high-quality schools attended by students from privileged backgrounds. Given these relationships, the finding of a positive relationship between homework and achievement might be attributable to a common cause, and not to time on homework per se. In a related vein, the majority of studies are single-measurement studies. Questions pertaining to the directionality of homework effects cannot be readily answered on the basis of such designs. Third, research has concentrated almost exclusively on *time* spent on homework. Yet all sorts of distractions can have detrimental effects on students' homework behavior. If a student reports spending a lot of time on his or her homework, this is not necessarily a sign of great conscientiousness, but may reflect problems of motivation or concentration.

Our studies (Trautwein, 2007; Trautwein, Köller, Schmitz, & Baumert, 2002) indicate that frequent homework assignments in mathematics are positively associated with achievement gains at the class level, but that time-consuming assignments do not show positive effects. Focusing on individual students, those who put a lot of effort into their homework (but do not necessarily report long study times) fare better than those who invest less effort.

Determinants of Homework Effort

Trautwein and colleagues (Lüdtke, Trautwein, Schnyder, & Niggli, 2007; Trautwein & Köller, 2003; Trautwein, Lüdtke, Kastens, & Köller, 2006; Trautwein, Lüdtke, Schnyder, & Niggli, 2006) proposed a multilevel homework model as a general framework for studying homework effort (see Figure 6).

According to this model, students' homework effort impacts their achievement. Moreover, in line with the predictions of expectancy-value theory, as described in the work of Jacquelynne Eccles, homework behavior is believed to be heavily influenced by motivational predictors (e. g., belief in being able to solve homework problems, perceived utility of homework tasks). The effects of cognitive abilities and personality as well as the impact of the family context and parental behavior are seen as (partially) mediated by motivational predictors. Likewise, effects of the instructional environment (e. g., homework quality and control) are expected to be partially mediated by homework motivation. Several studies provide support for the central assumptions of the model (e. g., Trautwein, Lüdtke, Kastens, & Köller, 2006; Trautwein, Lüdtke, Schnyder, & Niggli, 2006). For instance, expectancy and value beliefs predict homework effort in different school subjects. In addition, students' perceptions of homework quality are closely associated with perceived homework value and homework effort. Moreover, classmates show comparably high agreement in their perceptions of homework quality, indicating that these perceptions are not completely idiosyncratic. At the same time, we also found substantial associations between students' homework behavior across domains, and a meaningful predictive effect of students' conscientiousness. This indicates that students' homework behavior is not only dependent on the quality of homework assignments and domain-specific expectancy and value beliefs, but also on stable personality characteristics.

In a recent study (Trautwein & Lüdtke, in press-b), we tested predictions derived from the homework model by taking an intraindividual approach. Whereas the interindividual perspective helps to explain why some students put more effort into their homework than others, the intraindividual approach focuses on within-student variability in homework effort across different subjects. We tested whether the homework model developed by Trautwein and colleagues can also account for intraindividual variation in homework effort. Our findings show that homework effort is primarily a function of between-student differences in conscientiousness, within-student differences in the

Key References

Trautwein, U. (in press). Hausaufgaben. In W. Schneider & M. Hasselhorn (Eds.), *Handbuch der Pädagogischen Psychologie*. Göttingen: Hogrefe.

Lüdtke, O., Trautwein, U., Schnyder, I., & Niggli, A. (2007). Simultane Analysen auf Schüler- und Klassenebene: Eine Demonstration der konfirmatorischen Mehrebenen-Faktorenanalyse zur Analyse der Schülerwahrnehmungen am Beispiel der Hausaufgabenvergabe. *Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie, 39,* 1–11.

Trautwein, U. (2007). The homework-achievement relation reconsidered: Differentiating homework time, homework frequency, and homework effort. *Learning and Instruction, 17,* 372–388.

Trautwein, U., Lüdtke, O., Kastens, C., & Köller, O. (2006). Effort on homework in grades 5–9: Development, motivational antecedents, and the association with effort on classwork. *Child Development, 77,* 1094–1111.

Trautwein, U., Lüdtke, O., Schnyder, I., & Niggli, A. (2006). Predicting homework effort: Support for a domain-specific, multilevel homework model. *Journal of Educational Psychology, 98,* 438–456.

Trautwein, U., & Köller, O. (2003). The relationship between homework and achievement: Still much of a mystery. *Educational Psychology Review, 15,* 115–145.

perceived learning environment (subject-specific homework quality and control), and within-student differences in motivation (subject-specific expectancy and value beliefs). Furthermore, a significant cross-level interaction was found, with perceived homework control by teachers having a stronger effect on less conscientious students than on their more conscientious peers.

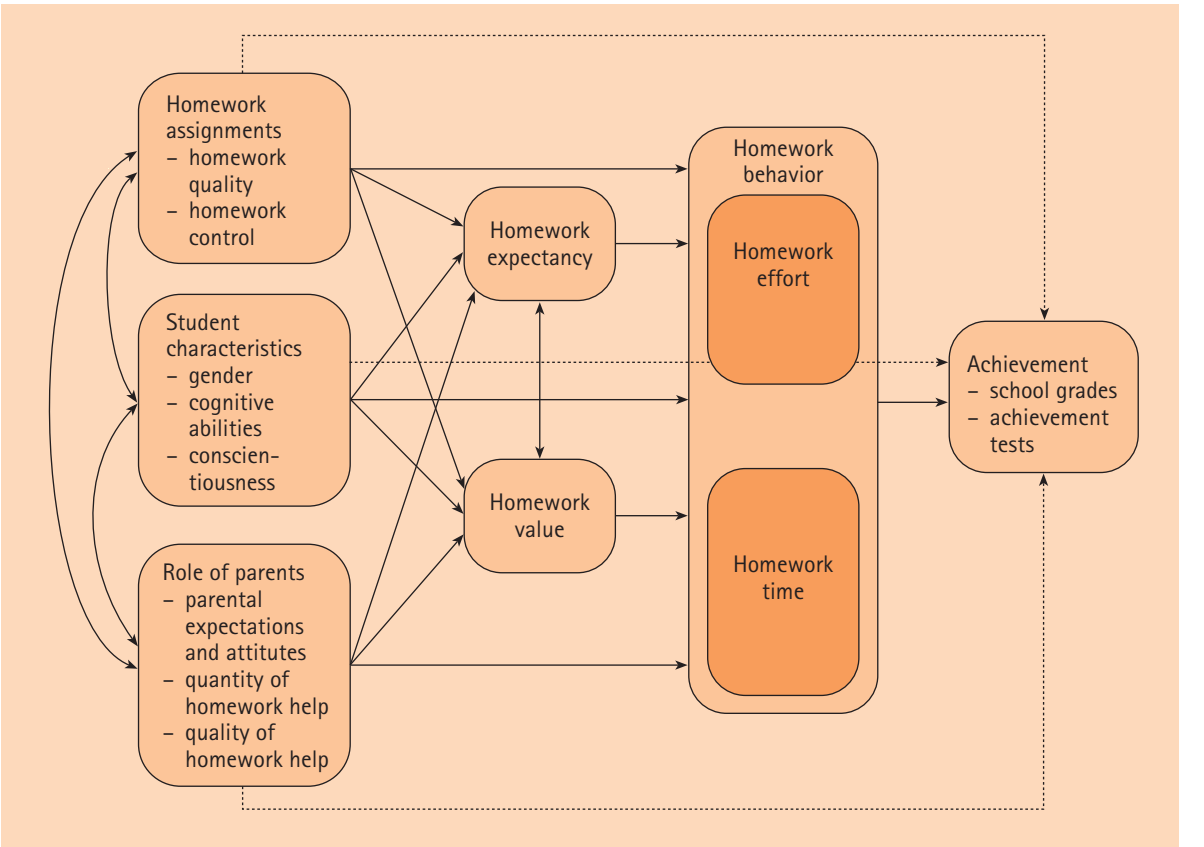
Moving beyond studies that rely on self-report from one source only (typically students), our homework research is currently focusing on what teachers do and think about homework, and the consequences for students' homework motivation and behavior.

Key References

Trautwein, U., & **Lüdtke, O.** (2007). Students' self-reported effort and time on homework in six school subjects: Between-student differences and within-student variation. *Journal of Educational Psychology, 99,* 432–444.

Trautwein, U., Köller, O., Schmitz, B., & **Baumert, J.** (2002). Do homework assignments enhance achievement? A multilevel analysis in 7th grade mathematics. *Contemporary Educational Psychology, 27,* 26–50.

Figure 6. Condensed version of the homework model (see Trautwein, Lüdtke, Schnyder, & Niggli, 2006).



Research Area II
Transitions in the Educational System

The biographies of young people are characterized by a host of transitions. Beyond the biological changes and psychological transitions from childhood to adolescence and adulthood that each individual needs to negotiate, there are several transitions in the context of the educational system that are governed by specific legal and societal regulations. These necessitate complex decisions that are not independent of societal and institutional conditions and, in a differentiated educational system, have a far-reaching influence on students' educational and vocational biographies. The analysis of transitions has a long tradition within the Center for Educational Research; transitions were not only examined in the context of Research Area I but also in former Research Areas II and III. The new Research Area II integrates all of the Center's projects and subprojects that deal explicitly with the analysis of transitions at various stages of educational careers, with a focus on familial background.

The importance of educational transitions is a result of the German educational system's structural features.
(1) Both children and parents are confronted with various decisions from the very beginning of the educational career: from the choice of kindergarten and elementary school, to the move to a secondary school, the transfer to upper secondary level or vocational training, and, finally, to the choice of a university course.
(2) The educational system is characterized by a high degree of standardization and stratification in terms of the points within an educational biography at which transitions take place, with specific regulations varying across federal states. The decisions taken at various stages of educational trajectories are thus taken in the context of institutional structures and administrative rules and regulations.
(3) Despite various reform endeavors, there is still a strong link between the educational track attended and the school-leaving certificate acquired. Although this link has become weaker over the past 10 years, 80 % of *Abitur* qualifications, the certificate qualifying for entrance to university, are attained at general *Gymnasium* schools. Relative to other countries, the association between the educational system and the occupational system is particularly strong in Germany, across the entire occupational spectrum. The first job is thus largely determined by the educational system (in terms of the qualifications acquired).

Our scientific interest in the analysis of transitions in educational biographies centers on two aspects: (1) On the one hand, we focus on the transitions themselves. The starting points are the social disparities in educational participation identified in contexts such as the PISA studies (Baumert & Schümer, 2001; Baumert, Stanat, & Watermann, 2006a). These social disparities are assumed to emerge primarily at transitional points in the educational career at which decisions must be taken. In this sense, transitions are analyzed as transition decisions.
(2) On the other hand, we concentrate on the period before the transition, examining the ways in which those involved (usually students) approach the transition from various theoretical perspectives.

Transitions From Elementary School to Lower Secondary Level

In order to analyze the transition from primary to lower secondary level, a new project named TRANSITION *(Übergang)* was initiated. This study examines performance-based distributive justice and regional, social, and cultural or ethnic disparities. Data are currently being collected (see Figure 1 below).

Description of the Problem and Its Theoretical Context

Over the past decades, the German school system has become more permeable and flexible. This is mainly due to the new routes to the *Abitur* that have been introduced in the vocational and general sectors of upper

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Key Reference

Baumert, J., & **Schümer, G.** (2001). Familiäre Lebensverhältnisse, Bildungsbeteiligung und Kompetenzerwerb. In J. Baumert, E. Klieme, M. Neubrand, M. Prenzel, U. Schiefele, W. Schneider, P. Stanat, K.-J. Tillmann, & M. Weiß (Eds.), *PISA 2000: Basiskompetenzen von Schülerinnen und Schülern im internationalen Vergleich* (pp. 323–407). Opladen: Leske + Budrich.

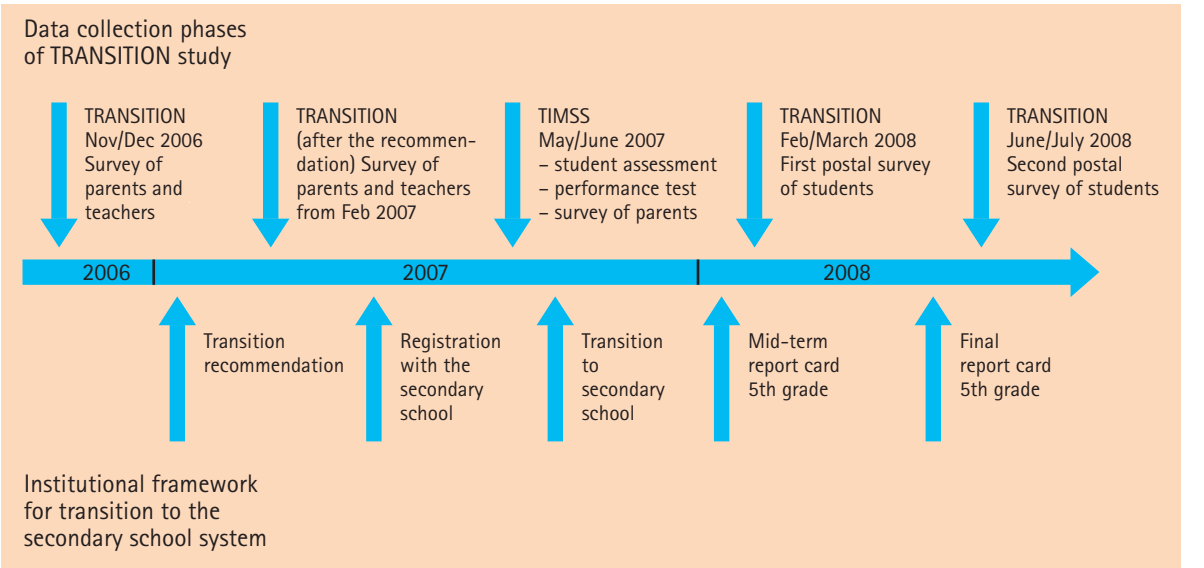


Figure 1. Schedule of the TRANSITION study following children, parents, and teachers through the transition from elementary to secondary school.

secondary schooling. Despite these opportunities to correct previous decisions, the transition from elementary to secondary school remains one of the most important changes of status in young people's lives, with long-term consequences for their future education and life chances. The allocation of students to different secondary school types highlights differences in performance that developed in elementary school or were already present at school entry. These performance differences are not independent of the students' social, ethnic, and cultural background, however. In fact, the assignment of students to different secondary tracks on the basis of their achievement is always associated with social, ethnic, and cultural disparities. These social and ethnic differences in educational participation, which are attributable to differences in student ability and performance, are called *primary* disparities. They are congruent with the principles of performance-based distributive justice—although they may well be considered too large from a normative perspective. Additionally, however, parents from different social and ethnic backgrounds may differ systematically in the secondary track they choose for their children. These differential choices produce new disparities in educational participation at the transition to secondary schooling. These disparities are independent of ability and attainment, and are called *secondary* disparities. They violate the principles of distributive justice.

In taking into account primary and secondary effects of social class, we follow Boudon's microsociological approach, according to which educational decisions result from an internal connection between students' school performance, selection mechanisms of the educational system, and familial decision processes. The selection mechanisms are determined by transition rules (e.g., whether or not recommendations made by elementary schools are binding) as well as by the institutional structure of the educational system. Familial or parental selection behavior is determined by the individual decisions of students or their parents, who have several options. Social-class-specific educational decisions are mainly due to differences in educational aspirations and students' school achievement. Thus, educational disparities result from background-dependent educational decisions and social-class-related achievement differences. Selection of an educational option can be regarded as the result of a combination of primary and secondary effects of social class. Whereas the primary effects mainly determine the likelihood of success of an educational investment via students' performance, the secondary effects

Key References

Maaz, K., Gresch, C., Köller, O., & **Trautwein, U.** (2007). Schullaufbahnen, soziokulturelle Merkmale und kognitive Grundfähigkeiten. In U. Trautwein, O. Köller, R. Lehmann, & O. Lüdtke (Eds.), *Schulleistungen von Abiturienten: Regionale, schulformbezogene und soziale Disparitäten* (pp. 43–70). Münster: Waxmann.

Baumert, J., Stanat, P., & **Watermann, R.** (Eds.). (2006a). *Herkunftsbedingte Disparitäten im Bildungswesen: Differenzielle Bildungsprozesse und Probleme der Verteilungsgerechtigkeit: Vertiefende Analysen im Rahmen von PISA 2000.* Wiesbaden: VS Verlag für Sozialwissenschaften.

additionally lead to differing cost-benefit calculations among the different social classes. We therefore take an expanded value-expectation approach that allows sociological *rational choice theory* to be tested against more psychological value-expectation models. Moreover, the model makes it possible to include institutional and administrative conditions as well as the norms of the respective social and ethnic reference group. These have tended to be disregarded theoretically so far.

Comparison of the proportions of students from different elementary schools or administrative districts enrolling in the different secondary tracks indicates the possible magnitude of these secondary disparities. For example, the proportion of students attending an academic-track *Gymnasium* can range from 10 % to 80 % depending on the district. Likewise, the probability that a student from a certain background will be enrolled in a mid-track *Realschule* or an academic-track *Gymnasium* varies considerably from school to school and from region to region, irrespective of the permeability of the secondary sector.

How do these kinds of differences develop? Is it possible to reduce them, and, if so, how? Any attempts to answer these questions highlight just how little we know about the transition from elementary to secondary school. We can only speculate that performance differences and secondary social and ethnic disparities in educational participation emerge from the interaction of the cultural background and social status of the parental home, the students' actual performance, teachers' recommendations, institutional regulations, and not least the cultural, social, and economic environment. Very little is known about the decision-making process itself, however.

Insights into this process are needed if we are to understand the logic and social dynamics of the German school system as a whole. For example, we know that the low *Gymnasium* attendance of certain student groups at middle school level can be compensated by establishing alternative college-bound paths at upper secondary level. Opening up the secondary system in this way also leads to a reduction of social disparities. However, it remains unclear whether it can compensate for secondary disparities arising at the transition from elementary to secondary school because little is known about the extent of these early inequalities. Corresponding knowledge of the other educational paths is even less satisfactory.

Main Aims of the TRANSITION Study and Its Design

Germany's participation in the TIMSS 2007 study of 4th graders has provided an ideal opportunity to considerably extend scientific knowledge of how parental intentions, cultural, social, and economic backgrounds, teachers' recommendations, and institutional regulations interact at the transition from elementary to secondary school. The main objective of the TRANSITION study is to analyze parental decisions on the transition from elementary to secondary school against the background of the following factors:

- students' achievement and attitudes at elementary school;
- the parental decision-making process as a function of the social, ethnic, and cultural background;
- the secondary track recommended by the elementary school teacher;
- the process of parent-teacher consultation;
- institutional regulations;
- the regional structure of the secondary system and the regional provision of secondary schools;
- the cultural environment of the school's catchment area; and
- the regional economic and labor market structure.

The objectives of the study are to find the critical variables regarding both the parental decision process and the recommendations made by elementary school teachers using specifically developed scales, and then to model the interactions of these indicators.

Key References

Trautwein, U., & Baeriswyl, F. (in press). Wenn leistungsstarke Klassenkameraden ein Nachteil sind: Referenzgruppeneffekte bei Übergangsentscheidungen. *Zeitschrift für Pädagogische Psychologie.*

Baeriswyl, F., Wandeler, C., **Trautwein, U.,** & Oswald, K. (2006). Leistungstest, Offenheit von Bildungsgängen und obligatorische Beratung der Eltern: Reduziert das Deutschfreiburger Übergangsmodell die Effekte des sozialen Hintergrunds bei Übergangsentscheidungen? *Zeitschrift für Erziehungswissenschaft, 9,* 373–392.

Maaz, K., Hausen, C., **McElvany, N.,** & **Baumert, J.** (2006). Stichwort: Übergänge im Bildungssystem. *Zeitschrift für Erziehungswissenschaft, 9,* 299–327.

Key Reference

Nagy, G., Köller, O., & Heckhausen, J. (2005). Der Übergang von der Schule in die berufliche Erstausbildung: Wer die Sorgen scheut, wird von ihnen ereilt. *Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie, 37,* 156–167.

This would replace the frequently applied, but unsatisfactory, approach of using a single question to indicate central dimensions of decision and recommendation behavior. The analysis follows four main lines of research:

(1) modeling the decision process in the children's parental home;
(2) examining the situation of children from immigrant families separately;
(3) reconstructing elementary school teachers' recommendation behavior and determining their diagnostic competence; and
(4) analyzing the importance of differing institutional regulations.

A further objective of the study is to analyze how the students and their parents cope with the process of transition. Therefore, there are two further phases of data collection after the transition to secondary school: The first covers the first 6 months after the transition up to the first mid-term report card in 5th grade. The second phase continues until the final 5th grade report card in the new school. The study is taking place in cooperation between the Berlin Max Planck Institute for Human Development and the Department of Education of the Georg August University Göttingen, with Professor Rainer Watermann from Göttingen in charge.
The TRANSITION study is coordinated with the design of TIMSS 2007 (cf. Figure 1). The sample is made up of the majority of classes taking part in TIMSS. The federal states of Berlin, Brandenburg, and Mecklenburg-Western Pomerania are excluded because the transition from elementary to secondary school takes place after 6th rather than 4th grade in these states. The sample is extended by an additional 26 classes with a higher rate of students from immigrant families. The entire sample is made up of 253 classes with 5,819 students. Parents, students, and teachers will be interviewed. Moreover, institutional and regional context factors will be taken into account.

Transition From Lower to Upper Secondary Level Schooling or to Vocational Training

At the end of lower secondary level, students and parents are again confronted with a difficult decision. Students can either finish school and acquire an educational qualification to move into vocational training or they can continue school by entering upper secondary level education.

Transition From Lower Secondary Level to the Vocational Training System

The transition from school to vocational training is a developmental task whose accomplishment is decisive for the ensuing professional career. The role of emotions during the search for an apprenticeship has hardly been examined so far. Based on the *Action Phase Model of Developmental Regulation* and *Control Process Theory,* predictions were drawn up in a study by Nagy, Köller, and Heckhausen (2005) regarding affective reactions during the search for an apprenticeship. These were tested in the longitudinal study *Developmental Regulation and Mastering the Transition from School to Work* (DRAMA) with $N = 363$ students in 10th grade of intermediate-track secondary school.
Structural equation models showed that the students' experience in the course of the application process is related to their negative vocation-specific affect. In contrast to unspecific mood measures, goal-specific affect mediates between the timing of the first positive response and subsequent commitment to the application process. After controlling for gender, mathematics achievement, and the social class of the area served by the school, negative affect remains predictive of the increase of application activity in the second half of the 10th grade.

Transition From Lower to Upper Secondary Level Schooling

Whereas social disparities have often been shown for the transition from elementary school, there have been relatively few studies discriminating primary and secondary effects for the transition at the end of lower secondary school. The TIMSS data were used to examine whether the transition to the upper

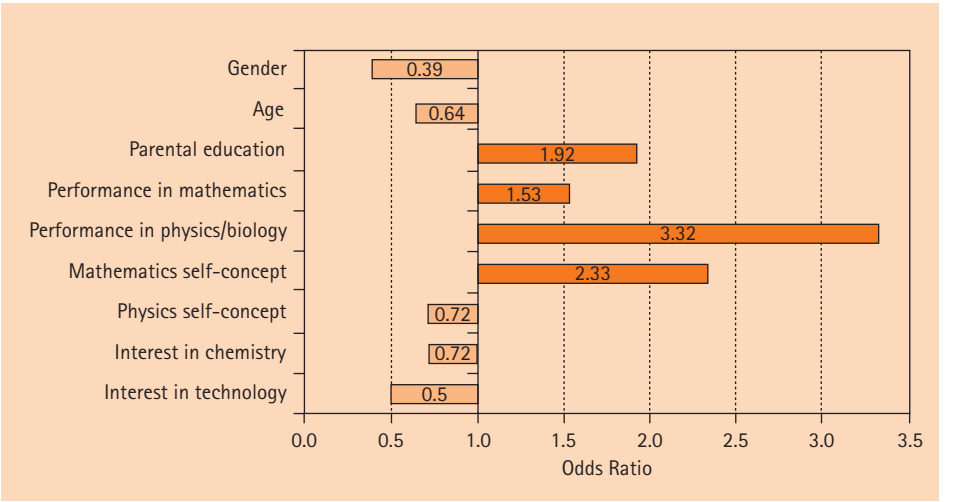


Figure 2. Logistical regression predicting entry to upper secondary level.

secondary level is socially selective. First of all, significant effects of performance in mathematics and physics/biology were found. An increase of one standard deviation in physics/biology performance was associated with a more than threefold increase in the chances of entering upper secondary level (cf. Figure 2). Moreover, controlling for mathematics and physics/biology performance revealed that cultural capital and parents' educational qualifications had a significant influence on the transition. For students with similar achievement, the likelihood of entering upper secondary track increased if their parents had high cultural capital. These effects can be interpreted as secondary disparities because the same performances led to differing transition decisions (Schnabel & Schwippert, 2000).

The TOSCA study showed that students in different secondary tracks differ in terms of social background. Students at vocational *Gymnasium* schools have a weaker social background than those at higher track *Gymnasium* schools (Chang, 2005; Maaz, 2006). In order to see whether additional systematic social selection occurs at the transition from lower to upper secondary level, that is, whether secondary social disparities play a role at this transition, TOSCA data were compared with PISA data. Figure 3 shows that attendance of certain school types is related to the parents' *Socio-Economic Status* (SES) as assessed by the *International Socio-Economic Index of Occupational Status* (ISEI). Parents of *Gymnasium* students had the highest ISEI scores and parents of *Hauptschule* students had the lowest.

A comparison of SES means for the 9th and 13th grades revealed two differences. Parents whose children attended the 13th grade of a general-education *Gymnasium* had a higher mean SES than those whose children went to the 9th grade of a *Gymnasium.* At the same time the parental SES of students attending vocational *Gymnasium* schools who went to a *Haupt-* or *Realschule* at lower secondary level was higher than the parental SES of students who attended a *Realschule* in the 9th grade. These findings indicate that social selection processes also occur at the transition to upper secondary level.

One must assume that most students with low achievement do not manage the transition to upper secondary level. Thus, the higher parental ISEI scores of students attending general-education *Gymnasium* schools could be due to an interaction between parents' SES and school performance. Comparison of the mean ISEI scores in relation to the students' average grades in the three main subjects, namely, German, mathematics, and English, confirms this assumption. In Figure 3 it is plain that the overlap of ISEI distributions among 9th-grade *Realschule* students with good or very good school grades and students of vocational *Gymnasium* schools who have transferred

Key References

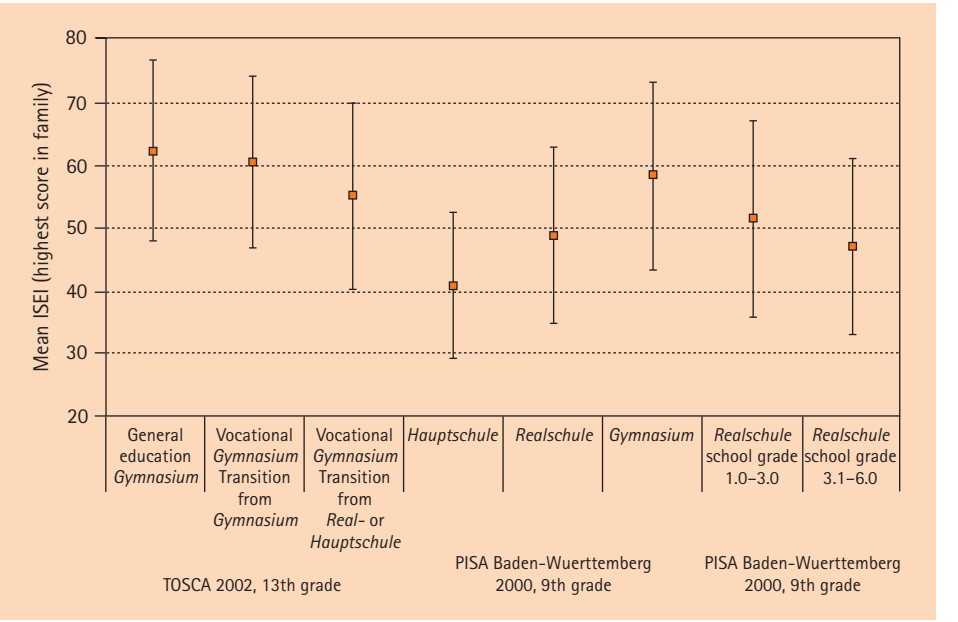
Maaz, K. (2006). *Soziale Herkunft und Hochschulzugang: Effekte institutioneller Öffnung im Bildungssystem.* Wiesbaden: VS Verlag für Sozialwissenschaften.

Chang, P.-H. (2005). *Transformation of vocational secondary schools: A study of the vocational Gymnasium in Germany.* Opladen: Barbara Budrich.

Maaz, K., Chang, P.-H., & Köller, O. (2004). Führt institutionelle Vielfalt zur Öffnung im Bildungssystem? Sozialer Hintergrund und kognitive Grundfähigkeit der Schülerschaft an allgemein bildenden und beruflichen Gymnasien. In O. Köller, R. Watermann, U. Trautwein, & O. Lüdtke (Eds.), *Wege zur Hochschulreife in Baden-Württemberg: TOSCA — Eine Untersuchung an allgemein bildenden und beruflichen Gymnasien* (pp. 153–203). Opladen: Leske + Budrich.

Schnabel, K. U., & Schwippert, K. (2000). Einflüsse sozialer und ethnischer Herkunft beim Übergang in die Sekundarstufe II und den Beruf. In J. Baumert, W. Bos, & R. Lehmann (Eds.), *TIMSS/III: Dritte Internationale Mathematik- und Naturwissenschaftsstudie: Mathematische und naturwissenschaftliche Bildung am Ende der Schullaufbahn* (Vol. 1, pp. 261–281). Opladen: Leske + Budrich.

Figure 3. Highest socio-economic status (ISEI score) in the family by school type in the 9th and 13th grades.



from a *Real-* or *Hauptschule* (13th grade) is greatest. Therefore, vocational *Gymnasium* schools attracted students from socially weaker families who did not attend general-education *Gymnasium* despite good school grades. At the same time, the results also show that *Realschule* students from families with high ISEI scores were more likely to risk the step to vocational *Gymnasium* than students with the same school grades, but from families with lower ISEI scores. Thus, social selection also occurs at the transition to vocational *Gymnasium* schools.

Educational Careers of Students With Intermediate-Level Certificates (Realschule)
So far, there are no reliable data in Germany to examine the transition from *Realschule* to the various types of upper secondary level school. Therefore, the project entitled *Educational Careers of Students with Intermediate-Level Certificates: The Role of School Achievement, Interest Profiles, and Familial Background for the Transition to Vocational* Gymnasium *or Vocational Training* was initiated to systematically analyze the transition behavior of students graduating from *Realschule*. Two questions are asked: Which characteristics predict successful integration into vocational training tracks? Which factors influence the decision of successful *Realschule* students to continue their school education by transferring to a vocational *Gymnasium* and what determines their subsequent success at that school? Particular emphasis will be placed on aspects to be measured in an extensive standardized assessment: (a) school competencies in the domains of mathematics, language, technology, and economics, (b) students' interest profiles, and (c) familial background. In addition, we will examine the extent to which the decision about further education is influenced by the regional structure of schools and vocational training on offer.

Transition to University
The effect of secondary social disparities at university entrance is mainly studied by examining the university aspirations of students with *Abitur.* Based on BIJU data, the longitudinal study carried out at the Max Planck Institute for Human Development, Schnabel, Alfeld, Eccles, Köller, and Baumert (2002) showed that the intention to enter university increases 1.5-fold if one parent holds the *Abitur* rather than a lower school certificate. The surprising aspect of this finding is that the authors controlled for academic performance in various domains,

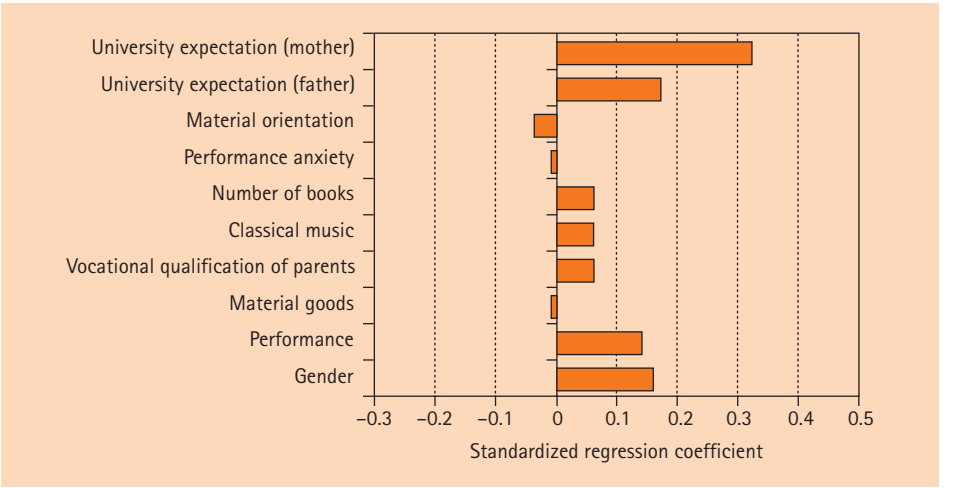


Figure 4. Results of logistical regression of university intentions by gender, school performance, as well as economic, social, and personal characteristics.

school grades, and domain-specific self-concepts.

Similar observations were made when analyzing TIMSS data. The parents' highest educational qualification had a positive effect on university intentions after control of students' school performance (see Figure 4). However, the effect of the educational milieu at home clearly decreased after controlling for the perception of parents' university expectations (Schnabel & Gruehn, 2000). This shows that the university aspirations of young adults develop in the context of their parents' hopes which differ by social status of the family.

Using the TOSCA data set, it was possible to analyze the transition to university longitudinally. Maaz (2006) showed that, in the case of students with *Abitur* from Baden-Wuerttemberg, social class only had a small effect (see also Watermann & Maaz, 2006b). However, there were differences in the type of university selected by students from different familial backgrounds. Students with Abitur from a privileged familial background were more likely than their peers with less favorable backgrounds to select university (rather than a lower track polytechnic *[Fachhochschule],* college of education *[Pädagogische Hochschule],* or vocational academy *[Berufsakademie];* Maaz, 2006; Trautwein, Maaz, Lüdtke et al., 2006; Watermann & Maaz, 2004). In addition, the selection of the degree to be taken is associated with sociocultural characteristics of the family of origin.

In many studies on the transition to university, it is not possible to consider different facets of social background or to distinguish between primary and secondary background effects. Maaz and Watermann (in press) have explicitly taken up the concept of primary and secondary effects of social background, and examine the effect of familial structure (e. g., SES, educational level) and process characteristics (e. g., familial book ownership, cultural participation) on university aspirations at the end of the upper secondary level of school. With TOSCA data, they were able to show that primary and secondary disparities take effect, even at this late juncture, and also that the exclusive consideration of familial structure in the context of disparity analysis provides an incomplete image of the effects of familial background characteristics. A communality analysis was carried out allowing a separation of the explained variance into predictor-specific and confounded variance components in order to study the respective influence of familial process and structure characteristics. Whereas the predictor-specific variance component symbolizes the proportion of explained variance that can be regarded as representing structure, respectively process characteristics, the confounded variance component represents the proportion of explained variance resulting from combinations of both characteristics.

Key References

Maaz, K., & **Watermann, R.** (in press). Reproduktion oder Mobilität? Zur Wirkung familiärer Prozessmerkmale auf die Studienintention am Ende der gymnasialen Oberstufe. *Zeitschrift für Soziologie der Erziehung und Sozialisation.*

Trautwein, U., Maaz, K., Lüdtke, O., Nagy, G., Husemann, N., Watermann, R., et al. (2006). Studieren an der Berufsakademie oder an der Universität, Fachhochschule oder Pädagogischen Hochschule: Ein Vergleich des Leistungsstands, familären Hintergrunds, beruflicher Interessen und der Studienwahlmotive von (künftigen) Studierenden aus Baden-Württemberg. *Zeitschrift für Erziehungswissenschaft, 9,* 393–412.

Watermann, R., & **Maaz, K.** (2004). Studierneigung bei Absolventen allgemein bildender und beruflicher Gymnasien. In O. Köller, R. Watermann, U. Trautwein, & O. Lüdtke (Eds.), *Wege zur Hochschulreife in Baden-Württemberg: TOSCA – eine Untersuchung an allgemein bildenden und beruflichen Gymnasien* (pp. 403–450). Opladen: Leske + Budrich.

Figure 5 shows the results of the communality analysis. Taken together, the proportion of variance explained by structure and process characteristics is rather low, but there is a proportion of specific process-related variance that contributes to the explanation of the total variance independently of structure characteristics. This shows that process characteristics are highly confounded with structure characteristics, but that they have their own independent effect on university aspirations.

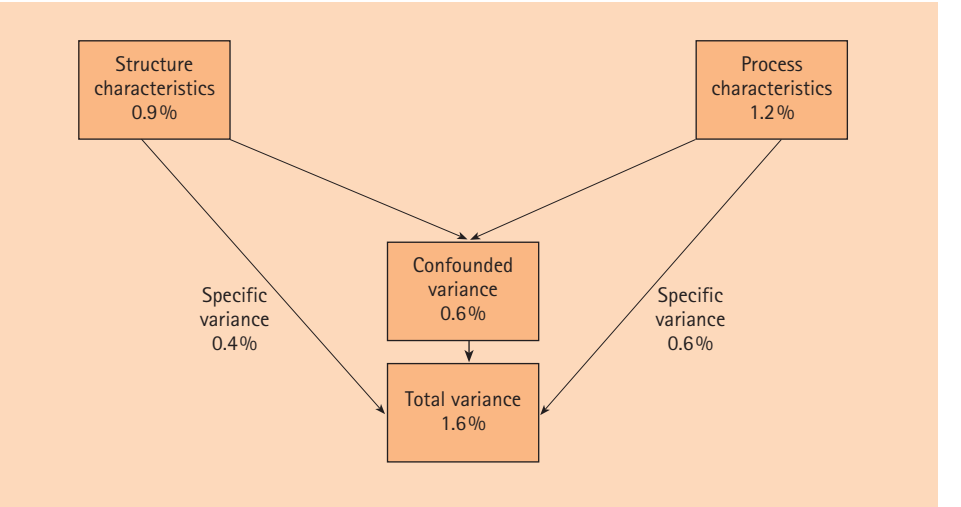


Figure 5. Communality analysis: Separation of the variance explained by structure and process characteristics in university aspirations after controlling for the grade attained in the *Abitur.*

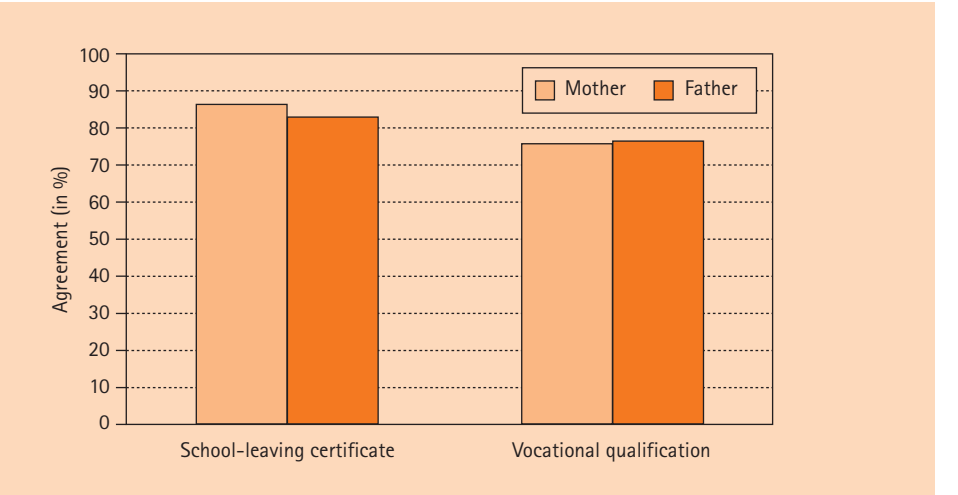


Figure 6. Percentual agreement of parents' and students' responses when asked about parents' educational and vocational level.

Validity of Students' Responses

Students usually provide the information on their parents' socioeconomic status (SES) and educational level in educational research. Validity of this information thus depends strongly on students' knowledge of their parents' educational and vocational achievements. Even if such information is never free of measurement error, it is expected that parents themselves should give more reliable information about their educational and vocational characteristics than their children, particularly when the children asked are very young. Analyses of PISA data were able to show that, in general, there is good agreement between parents' and students' responses about central features of their social background (Maaz, Kreuter, & Watermann, 2006). The analyses revealed that responses on general educational qualifications are less error-prone than responses on vocational training (see Figure 6). Students were also better able to give responses on their parents' profession than on their vocational qualification level.

In further studies, Kreuter, Maaz, and Watermann (2005, 2006) examined the consequences of various types of measurement error for analyses of interactions. Collecting data on parents' educational and vocational characteristics from students is associated with cognitive performance that additionally demands a certain degree of abstraction from them. The arising measurement error and its correlation with the dependent variable can lead to a systematic distortion of results. For example, the effect of a measurement error can be shown by bivariate regression of performance in a mathematics test on various measures of a father's vocational training. The coefficients were lower when the students' responses about their parents' educational background were used. This simplified bivariate regression clarifies the effect of measurement errors and of potential bias. The resulting underestimation is low, but statistically significant. It can be assumed that the underestimation of the effect of parents' vocational training can be offset in multivariate models when several indicators are linked in order to measure social background.

Key References

Kreuter, F., **Maaz, K.,** & **Watermann, R.** (2006). Der Zusammenhang zwischen der Qualität von Schülerangaben zur sozialen Herkunft und den Schulleistungen. In K.-S. Rehberg (Ed.), *Soziale Ungleichheit, kulturelle Unterschiede* (pp. 3465–3478). Frankfurt a. M.: Campus.

Maaz, K., Kreuter, F., & **Watermann, R.** (2006). Schüler als Informanten? Die Qualität von Schülerangaben zum sozialen Hintergrund. In J. Baumert, P. Stanat, & R. Watermann (Eds.), *Herkunftsbedingte Disparitäten im Bildungswesen: Differenzielle Bildungsprozesse und Probleme der Verteilungsgerechtigkeit: Vertiefende Analysen im Rahmen von PISA 2000* (pp. 31–59). Wiesbaden: VS Verlag für Sozialwissenschaften.

Kreuter, F., **Maaz, K.,** & **Watermann, R.** (2005). Messung sozialer Herkunft in Schulleistungsuntersuchungen: Der Zusammenhang zwischen der Qualität von Schülerangaben und den Leistungen. In U. Engel (Ed.), *Bildung und soziale Ungleichheit: Methodologische und strukturelle Analysen* (pp. 9–35). Bonn: Informationszentrum Sozialwissenschaften.

The Research Team

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Research Area III
Language Skills and Reading Literacy

Introduction and Project Overview

The examination of the development and effective promotion of students' language skills and reading literacy using longitudinal and several (quasi-)experimental intervention studies is at the heart of Research Area III. This research program was initiated partly in response to the national and international PISA 2000 and 2003 results, which revealed that students' reading literacy and motivation in Germany is well below the average in international comparison (Baumert et al., 2001; Schiefele, Artelt, Schneider, & Stanat, 2004). The situation in the lower performance range is particularly problematic: almost 25% of the 15-year-old students did not even reach the second of five proficiency levels defined by the OECD. With reading abilities that allow the decoding of letters and words or the retrieval of simple information from a written text at most, considerable difficulties are to be expected for these students, not only in school education but also in vocational training and working life. In-depth analyses show that familial background plays a crucial role in competence acquisition and educational participation. In Germany, the coupling of families' social background and students' educational success is particularly strong in international comparison. Students with a weak socioeconomic background are more often found on the low-proficiency levels. Students from immigrant families, that is, about one fifth of students in Germany, proved to be disadvantaged both in proficiency acquisition and in educational participation. The determinants of performance development in these children and opportunities for their in- and out-of-school promotion are a topic of particular interest to this Research Area.

The foundation for proficiency acquisition at higher level schools is laid at elementary school. At the same time, the transition from elementary to secondary schools is one of the key junctures in the German educational system that influences an individual's further educational and vocational career considerably (cf. Research Area II). Therefore, the projects on the acquisition and promotion of language skills and reading literacy focus on elementary school.

Reading proficiency was at the center of attention for three central projects within this Research Area in 2005 and 2006:

(1) A wide-ranging and interdisciplinary expertise on *Promotion of Reading Literacy* was commissioned by the German Federal Education and Research Ministry (Artelt et al., 2005).

(2) The development of reading proficiency and central individual and social influence factors from 3rd to 6th grade were examined in a new longitudinal study, the *Berliner Leselängsschnittstudie (Berlin Longitudinal Reading Study).*

(3) In response to research questions on promotion possibilities, a quasi-experimental intervention study on the implementation and efficacy of a newly developed reading support program, the *Berliner Eltern-Kind Leseprogramm (Berlin Parent-Child Reading Program),* was analyzed in an in-depth evaluation study.

All three projects focused on reading proficiency and included the special situation of children with a migration background. Three further central projects of the Research Area concentrated explicitly on the development and promotion of language skills and reading literacy of children with a migration background:

(1) *Phonological Processing, Verbal Abilities, and Second Language Literacy Development Among Bilingual Turkish Children in Germany:* In this study, central dimensions in second language acquisition were examined as prerequisites for the acquisition of reading literacy.

(2) *Barriers to Reaching Proficiency in School-Related Language Among Second Language Learners:* In this experimental study, systematically selected language aspects (vocabulary, grammar, contextual embeddedness, content related to everyday life) were empiri-

Key Reference

Artelt, C., McElvany, N., Christmann, N., Richter, T., Groeben, N., Köster, J., Schneider, W., **Stanat, P.,** Ostermeier, C., Schiefele, U., Valtin, R., & Ring, K. (2005). *Förderung von Lesekompetenz – Eine Expertise. Bonn: Bundesministerium für Bildung und Forschung* (BMBF).

cally analyzed to see whether those can be identified that create particular difficulties for children with migration backgrounds and that should be taken into account when designing promotion concepts.

(3) The *Jacobs Summer Camp:* In this experimental intervention study, a newly developed promotion concept was tested to see whether it was possible to improve the language skills of children from immigrant families in the summer vacation.

The research focus on children with a migration background was also intensified in an internationally comparative perspective on the PISA 2003 data. The results of the analyses were made available to the scientific community and the general public in the OECD report entitled: *Where immigrant students succeed—A comparative review of performance and engagement* (Stanat & Christensen, 2006).

Key Reference

Stanat, P., & **Christensen, G.** (2006). *Where immigrant students succeed: A comparative review of performance and engagement in PISA 2003.* Paris: OECD.

Reading Proficiency

Expertise "Promotion of Reading Proficiency"

Which approaches are there to promote reading literacy in Germany? How can support measures in the German states be supplemented in a useful way? These are the questions to which *Promotion of Reading Literacy,* the expertise commissioned by the *Bundesministerium für Bildung und Forschung,* responds. Since being published, it has been distributed widely and has elicited much interest. The expertise is based both on an extensive viewing of the scientific literature on the promotion of reading proficiency and on a detailed online survey of all 16 states in Germany about existing in- and out-of-school support offers. The expertise intentionally takes an interdisciplinary perspective, and was put together under the leadership of the Max Planck Institute for Human Development (Cordula Artelt, Nele McElvany, Petra Stanat) with reading research experts from various universities and institutions (Prof. U. Christmann, University of Heidelberg; Dr. T. Richter and Prof. N. Groeben, University of Cologne; Prof. J. Köster, University of Jena; Prof. W. Schneider, University of Würzburg; Dr. C. Ostermeier, Leibniz Institute for Science Education, Kiel; Prof. U. Schiefele, University of Bielefeld; Prof. R. Valtin, Humboldt University Berlin; Prof. K. Ring, Stiftung Lesen, a foundation sponsoring reading). After an extensive overview of the current state of research and of theoretical models available in the domain of reading literacy, a scientific perspective examines which insights can be gained from the viewpoints of different disciplines and where measures promoting reading literacy seem productive. The review of existing state activities showed that most projects' main aim is to promote reading motivation (see Figure 1).

The expertise arrived at three central recommendations regarding content, processes, and cooperation for further and sustained promotion of reading literacy from a statewide perspective:

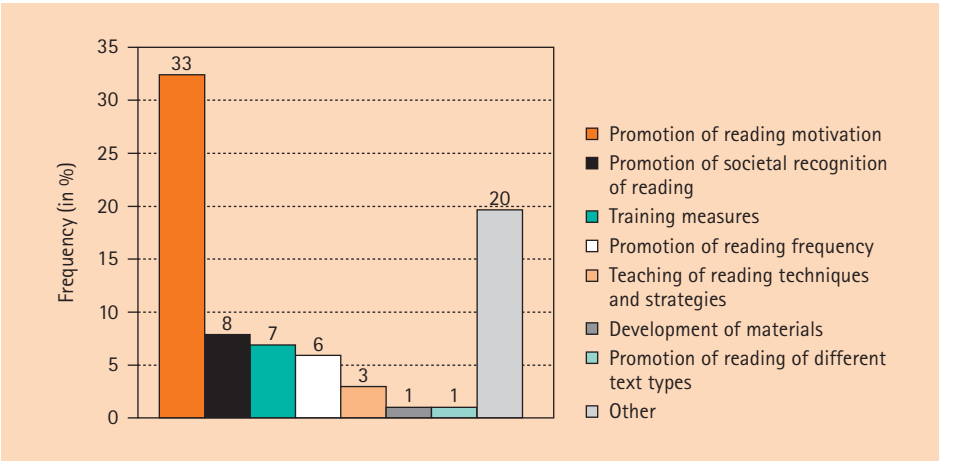


Figure 1. Main aims of the projects in German states (single nominations).

(1) Emphasizing subcompetencies and prerequisites of reading literacy as goal dimensions of promotion;
(2) placing communication about demands and competency expectations regarding students' reading literacy at the center of professional exchange between teachers and reading promoters; and
(3) forms of structured cooperation: making interfaces and transitions in the educational system points of departure for reading promotion and guaranteeing content transfer and coordination via structured in- and out-of-school cooperation.
Clear promotion potentials are seen in the stronger content alignment of promotion measures toward the construction of meaning in reading and the reading process, in the focusing on the needs of individual target groups, and in the expansion of promotion-related collaboration between in- and out-of-school support agencies.

Berliner Leselängsschnittstudie—Berlin Longitudinal Reading Study

The ability to read and understand texts is not only important in the school context, it is foremost a crucial precondition for participation in social, political, cultural, and economic life in our society. The results of international comparison, such as PISA, are all the more dramatic because they reveal considerable deficiencies in students' reading abilities in Germany (e.g., Baumert et al., 2001; Bos et al., 2003). In the context of a longitudinal study, Nele McElvany examined individual and social factors influencing the development of reading literacy, reading motivation, and reading behavior from 3rd to 6th grade.

In all, 33 elementary school classes in Berlin took part. The assessment began at the end of 3rd grade because basic reading techniques have usually been acquired by this time and more complex reading und comprehension processes play an increasing role. These provide the basis for continued in- and out-of-school learning and everyday life. The development and complex interaction of reading motivation, reading self-concept, reading practice, reading-related metacognitive knowledge, vocabulary, and decoding ability were examined. Vocabulary was particularly important for reading level and literacy development.
The longitudinal design of the reading study provides information on development before and after the tracking in secondary schools. This made it possible for Michael Becker to estimate, as part of his doctoral thesis, how developmental trajectories are influenced by the tracked school system. Moreover, in view of the tight coupling between familial background and school performance, we examine how school developments in reading literacy can be related to specific familial factors, such as cultural capital (e.g., reading together, parental attempts to motivate reading, or parents as reading models). The analysis of the use of cognitive and metacognitive reading strategies in this age group, the assessment of school support environments by surveying teaching staff on teaching practice and reading promotion activities, and the examination of the diagnostic competence of German teachers regarding reading literacy of their students are all areas of interest.
For the group of children with a familial migration background, the longitudinal data were used to determine whether the develop-

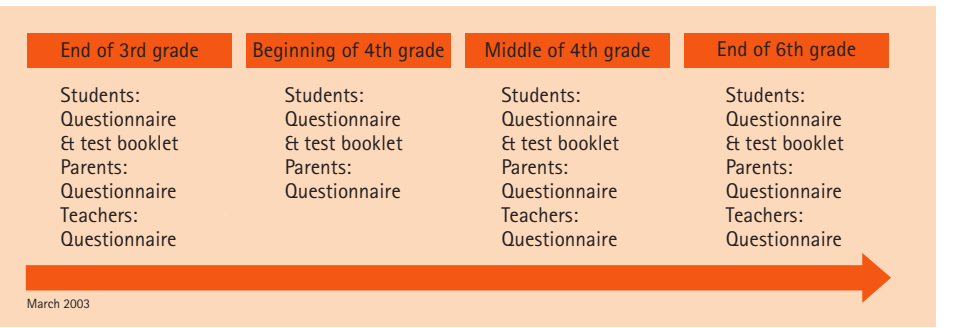


Figure 2. Design of the Berlin Longitudinal Reading Study.

ment of reading competency and important reading prerequisites, such as vocabulary, decoding abilities, and motivation, is comparable in the time period from 3rd to 6th grade with that of the group of children without a migration background and whether the examined factors play the same role for both groups. It became clear that competence differences favoring children without a migration background were mainly due to the better social status of these families. This had a significant effect on performance level at the end of 3rd grade, but not on further literacy development up to the end of 6th grade. For both groups, vocabulary had a greater influence on baseline literacy level and subsequent change than decoding ability.

Berlin Parent-Child Reading Program

Although the family is regarded as the most important out-of-school context for reading socialization of children (e. g., Hurrelmann & Hammer, 1994) and the PISA study in Germany and other large-scale studies have repeatedly demonstrated the tight link between school performance and familial background, pedagogical-psychological intervention approaches in the field of systematic promotion of reading literacy have mostly restricted themselves to small groups or the class context and have disregarded the promotion potential of the family. Within this Research Area, Nele McElvany developed the *Berliner Eltern-Kind Leseprogramm (Berlin Parent-Child Reading Program)* to promote reading literacy of students at elementary school age systematically within the context of their families (McElvany, 2007; McElvany, Artelt, & Holler, 2005). Based on findings on reading literacy promotion, reading socialization, and familial influence opportunities the program intends to promote the implicit understanding and habituation of text comprehension strategies and processes, with the long-term goal of reading literacy enhancement. To achieve this, the program makes use of parent-child interaction structured by questions and answers about individual texts. The program consists of 43 parent-child sessions and lasts 14 to 15 weeks, with 3 sessions per week. Each session takes about 30 minutes. At the beginning of the session, the parent and child decide whether they want to work on a longer or shorter text. These are very varied in topic and kind and aim at the interests of 4th graders. After the parent or child has read the text out loud, it is first established whether the child has had trouble understanding the content or individual words (cf. Figure 3). Simple or more complex comprehension questions follow and, on average, four follow-up questions or tasks stimulate an in-depth conversation that is supposed to lead to an elaborated understanding of text content. The final task usually requires an oral summary of the text, but can also be of a creative nature (e. g., draw a picture about the story).

Key Reference

McElvany, N. (in press). Die Bedeutung familiärer Merkmale für Lesekompetenz, Lesemotivation und Leseverhalten. *Psychologie in Erziehung und Unterricht.*

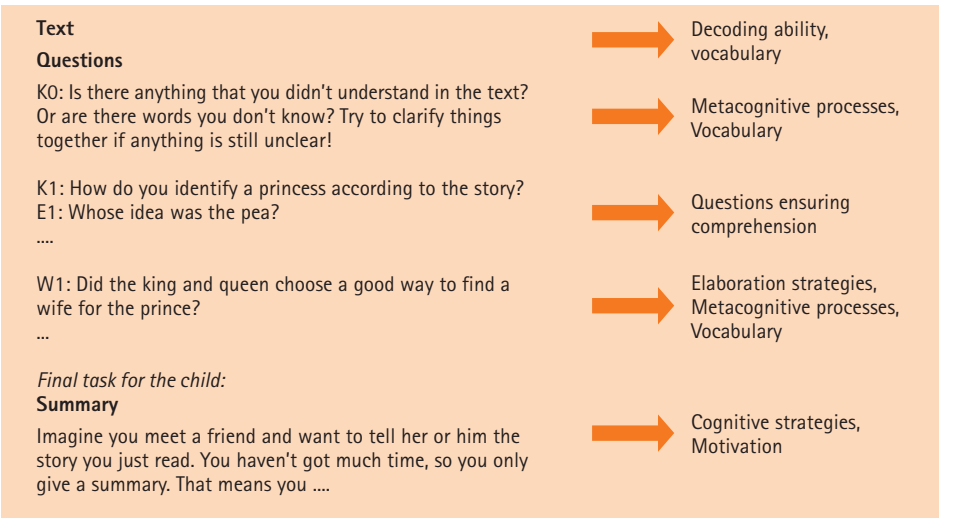


Figure 3. Conception of the reading program sessions.

Key References

McElvany, N., & **Artelt, C.** (in press-a). Das Berliner Eltern-Kind Leseprogramm: Konzeption und Effekte. *Psychologie in Erziehung und Unterricht.*

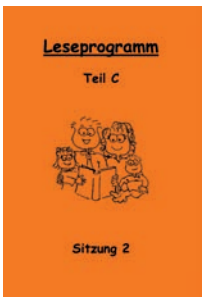
McElvany, N., & **Artelt, C.** (in press-b). Systematic reading training in the family: Development, implementation, and evaluation of the Berlin Parent-Child Reading Program. *Learning and Instruction.*

McElvany, N. (2007). *Förderung von Lesekompetenz im Kontext der Familie.* Münster: Waxmann.

McElvany, N., & **Artelt, C.** (2006). Das Berliner Eltern-Kind Leseprogramm. *Diskurs Kindheits- und Jugendforschung, 1,* 157–159.

McElvany, N., Artelt, C., & Holler, S. (2005). Leseförderung in der Familie. In A. Sasse & R. Valtin (Eds.), *Lesen lehren* (pp. 151–167). Berlin: Deutsche Gesellschaft für Lesen und Schreiben.

In contrast to typical homework supervision, the parent and child have equal rights throughout the session, carrying out all of the tasks in alternation or together and giving each other feedback. In this way, the program combines approaches of implicit strategy promotion and of "guided oral reading," complementing the role of the parental model and including scaffolding elements. The implementation and effectivity of the program were tested in an evaluation study (McElvany, 2007; McElvany & Artelt, 2006). Between September 2003 and January 2004, 509 4th graders from 15 Berlin elementary schools took part, with the nonparticipating peers (N = 393) representing the control group in the quasi-experimental pre-post-control group design. In the framework of this evaluation study, the effects of participation on prerequisites and subcompetencies of reading literacy could be observed. The vocabulary of the participants developed more strongly than that of the nonparticipants over the time of the study. A particular effectivity of the program for weak students was revealed regarding the development of text-related metacognition. However, there was no direct promotion effect on standard reading comprehension or decoding abilities. Beyond enhancement of concrete competencies, the findings show positive effects for familial reading culture. Further analyses of longer term effects are in planning. Longer term effects could be due to habituation of individual reading processes or to the general promotion of reading culture in the family. The analyses on implementation show that the structures and processes intended in the program worked well in the participating families but also that many families were not prepared to take part in this kind of voluntary supplementary reading promotion measure in their own home (cf. Figure 4).



There were clear differences between participants and nonparticipants. Participating children were more likely to come from more educated families, and were relatively good readers at baseline. This highlights the need for the development of additional strategies to counteract participation selectivity in terms of performance-related child characteristics and the social background of families.

With the *Berlin Parent-Child Reading Program,* the Research Area has provided a promising systematic intervention program supporting concrete reading competencies and familial reading culture.

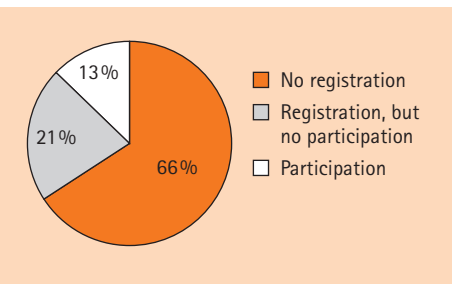


Figure 4. Distribution of families invited to register for, and participate in, the program.

Promoting Children With a Migration Background

Phonological Processing, Verbal Abilities, and Second Language Literacy Development Among Bilingual Turkish Children in Germany

Focusing on early reading skills, a doctoral thesis by LIFE fellow Christina Limbird used a longitudinal study to examine whether the same component processes are involved for both bilingual and monolingual children from the 1st to the 3rd grade. A sample of 169 children (69 monolingual, 100 Turkish-German bilingual) was investigated with regard to nonverbal cognitive abilities, phonological awareness, verbal abilities, short-term verbal memory, word decoding, and reading comprehension at multiple points of measurement over a 2-year period. International research in the realm of literacy acquisition repeatedly describes these skills as the building blocks of reading. Because both theoretical and empirical models of reading point to phonological awareness as an essential aspect of emerging reading skills and because a large body of literature indicates that phonological awareness may be influenced by diverse linguistic experiences, this study placed

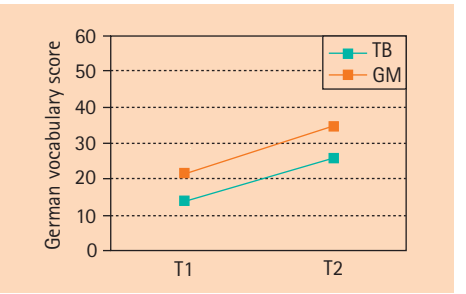


Figure 5. Number of German words identified by Turkish bilingual (TB) and German monolingual (GM) groups for German vocabulary in the middle and at the end of 2nd grade.

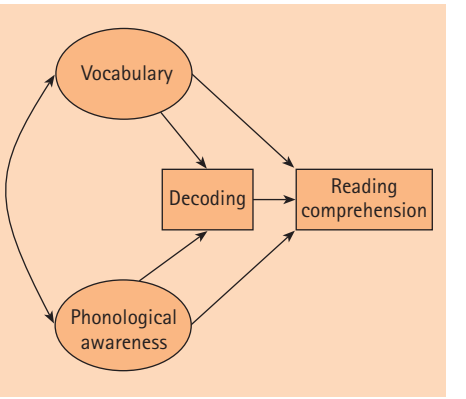


Figure 6. Model of reading tested for Turkish bilingual (TB) and German monolingual (GM) groups.

particular emphasis on bettering our understanding of the role of phonological awareness among the growing number of bilingual children in Germany.

Theories of bilingualism and empirical data led to the prediction that bilingual children would perform better on tasks involving phonological awareness than their monolingual peers. Monolingual children, on the other hand, were expected to outperform their bilingual counterparts on measures of German vocabulary. It was predicted that the factors involved in reading performance and reading development would differ between the groups, with vocabulary playing a more central role for bilingual children and phonological awareness demonstrating more importance for monolingual children. The common existing models of reading development were expected to function more poorly with a bilingual sample than with a monolingual sample.

Results indicated that while the bilingual children scored consistently higher on tasks of phonological awareness, the difference was not statistically significant. The data clearly showed though that the bilingual group performed much more poorly on measures of German vocabulary (see Figure 5).

On measures of word decoding and reading comprehension, no differences between the bilingual and monolingual children emerged. The two groups were then tested for goodness-of-fit on the selected model of reading. Analyses not only showed that phonological awareness played a significantly stronger role in developing reading comprehension for the monolingual group but also indicated that vocabulary may be more relevant for the bilingual group.

A series of analyses based on a typical model of reading for children (from Näslund & Schneider, 1991) showed poorer fit for the bilingual group. These findings indicate that the bulk of research on reading is not accounting for the unique characteristics of multilingual children in primary education, and that this deficit clearly needs to be addressed in future research. Practical implications of this study could include the implementation of vocabulary and phonological awareness training programs for multilingual preschoolers and young elementary school children in Germany.

Barriers to Reaching Proficiency in School-Related Language Among Second Language Learners

Despite the assumption that less knowledge of German contributes greatly to the differences in school performance between children with, and without, a migration background and to the increase of programs to promote language skills, information about the barriers preventing acquisition of German as a second language is limited. Specifically, little is known about the aspects of language that create particular difficulties for children with a non-German language background when learning school language. Everyday- and school-related types of communication appear to place differential demands on language competencies. Theoretical assumptions for such a differentiation were formulated by

Key References

Limbird, C. K. (2006). *Phonological processing, verbal abilities, and second language literacy development among bilingual Turkish children in Germany.* Unpublished doctoral thesis, Free University Berlin.

Limbird, C. K., & **Stanat, P.** (2006a). Prädiktoren von Leseverständnis bei Kindern deutscher und türkischer Herkunftssprache: Ergebnisse einer Längsschnittstudie. In A. Ittel & H. Mertens (Eds.), *Veränderungsmessung und Längsschnittstudien in der empirischen Erziehungswissenschaft* (pp. 93–123). Wiesbaden: VS Verlag für Sozialwissenschaften.

Limbird, C. K., & **Stanat, P.** (2006b). Sprachförderung bei Schülerinnen und Schülern mit Migrationshintergrund: Ansätze und ihre Wirksamkeit. In J. Baumert, P. Stanat, & R. Watermann (Eds.), *Herkunftsbedingte Disparitäten im Bildungswesen: Differenzielle Bildungsprozesse und Probleme der Verteilungsgerechtigkeit: Vertiefende Analysen im Rahmen von PISA 2000* (pp. 257–307). Wiesbaden: VS Verlag für Sozialwissenschaften.

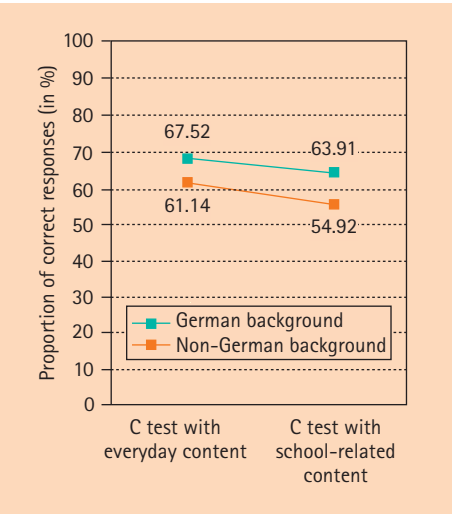


Figure 7. Interaction between written language performance and language background.

Cummins (1979, 1981) and Gogolin (2003), for example. However, there is a lack of empirical studies validating these assumptions. LIFE fellow Andrea G. Müller's dissertation project aimed to establish that everyday-related language is indeed easier than school-related language. Furthermore, the influence of selected aspects of language in the field of vocabulary and grammar as well as a contextualization of language on the auditory comprehension of children with a German and non-German language background was examined. Two (quasi-)experimental studies were carried out to answer these research questions. On the one hand, the analyses were based on data from a *Jacobs Summer Camp Project* subsample (N = 190; see below). On the other hand, data from Berlin elementary school children were analyzed (N = 529). In this quasi-experimental study that took place in February 2006, auditory comprehension performance of children with, and without, a migration background was tested.

Based on oral proficiency data from the elementary school children, the hypothesis of an additional performance disadvantage for children with a non-German versus German language background could not be confirmed regarding texts of school-related content. In the case of written work dealing with school-related texts, weaker performances were observed for children with a non-German language background (cf. Figure 7). However, this interaction effect disappeared when controlling for socioeconomic background. This shows that performance differences among students are related to their families' social background and language competencies. Thus, the significant interaction effect revealed in the initial analysis is not only due to lesser language competencies of children with a non-German language background. Rather, social background and the language spoken at home seem to combine and lead to worse performance, with texts related both to school and to everyday experience.

In a second step, the influence of selected aspects of language on auditory comprehension was examined. The interaction hypotheses that performance disadvantages are greater for children with a non-German language background than for those with a German language background when working on texts with a difficult vocabulary or complex grammar versus texts with easy vocabulary or simple grammar could not be confirmed. Furthermore, a greater performance disadvantage in conditions of language without contextualization than in conditions with contextualization were not observed when comparing children with, and without, a German language background.

Taken together, the results establish that children with a non-German language background do not perform as well as those with a German language background, but an additional performance disadvantage in the examined aspects of the German language was not confirmed. The results indicate the need for integrated promotion of German language competencies.

Promotion of Language Competencies in Children With Immigrant and Socially Disadvantaged Families: The Jacobs Summer Camp Project

Findings from international school achievement studies show that Germany is less successful in supporting students with a migration background in the acquisition of the school language than other countries. At the same time, little is known about the efficacy of measures that aim at promoting second

Key Reference

Müller, A. G. (2007). *Aspekte schulbezogener Sprache für schulischen Erfolg von Schülerinnen und Schülern deutscher und nichtdeutscher Herkunftssprache.* Unpublished doctoral thesis, Free University Berlin.

Figure 8. Participants in the *Jacobs Summer Camp Project.*

language acquisition. This was the *Jacobs Summer Camp Project's* starting point (Jürgen Baumert, Petra Stanat, Andrea G. Müller). A central aim was to obtain information on the effectiveness of different approaches to helping students acquire proficiency in German as a second language. The literature on foreign language teaching and learning distinguishes between implicit and explicit approaches (DeKeyser, 1995; Ellis, 1994, 2003; Gasparini, 2004; Hulstijn, 2005; Nunan, 1999). Implicit approaches create language-intensive situations in which learners are stimulated to use the target language. No measures are taken to steer their attention to linguistic rules. In contrast, explicit teaching strategies focus specifically on linguistic structures, for example, by explaining grammatical rules and following up with their use (explicit deduction) or by working on material revealing rules based on systematically structured language acquisition contexts (explicit induction).

The distinction between implicit and explicit teaching and learning of foreign languages has been examined both in class and under laboratory conditions. A meta-analysis of 49 studies indicates that explicit approaches lead to better learning achievements than implicit approaches (Norris & Ortega, 2000). However, almost 80 % of the studies included in the meta-analysis examined adult learners, and 65 % were carried out in the context of university teaching of foreign languages. In only one of the studies did the target population consist of primary school children. Moreover, it can be assumed that most participants in the programs already had a high proficiency level in their first language. Therefore, it is unclear whether the findings of the analyses can be transferred to children of primary school age who are learning a second language and whose knowledge of their first language is also often restricted.

The *Jacobs Summer Camp Project* explored this question by operationalizing the implicit strategy of second language support with a theater-pedagogical program and the explicit strategy with systematic classes in German as a second language. A field-experimental design with random assignment to the experimental conditions was applied in order to estimate the effects of these measures (Stanat, Baumert, & Müller, 2005; Stanat & Müller, 2005). Following up on the literature on evidence-based policy and reform (e. g., Feuer, Towne, & Shavelson, 2002; Mosteller & Boruch, 2002; National Research Council, 2002; Slavin, 2004), the study also intended to demonstrate how well-controlled field experiments can be implemented in educational science.

Children from the 3rd grade of schools in Bremen participated in the study. Of the children who had applied for participation, 150 were randomly selected for the summer camp (experimental group). The remaining 82 children formed the baseline group. Children in the experimental group were distributed between three camps. In one camp, only the theater and leisure components of the program (morning and afternoon) were implemented (implicit language support). In the other two camps, the children also took part in the theater and leisure program in the afternoons, but attended lessons for German as

Key References

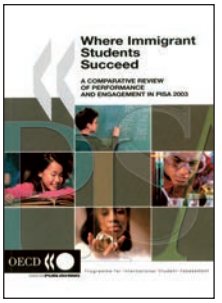
Stanat, P., Baumert, J., & **Müller, A. G.** (2005). Förderung von deutschen Sprachkompetenzen bei Kindern aus zugewanderten und sozial benachteiligten Familien: Evaluationskonzeption für das Jacobs-Sommercamp Projekt. *Zeitschrift für Pädagogik, 51,* 856–875.

Stanat, P., & **Müller, A. G.** (2005). Förderung von Schülerinnen und Schülern mit Migrationshintergrund. In H. Bartnitzky & A. Speck-Hamdan (Eds.), *Deutsch als Zweitsprache lernen* (pp. 20–32). Frankfurt a. M.: Grundschulverband.

Stanat, P., Müller, A. G., & **Baumert, J.** (2005). Die Kofferbande auf Reisen in das Land der Sprache und des Theaters: Das Jacobs-Sommercamp Projekt. *Pädagogik, 57*, 57–58.

Key Reference

Stanat, P., & **Christensen, G.** (2006). *Where immigrant students succeed: A comparative review of performance and engagement in PISA 2003.* Paris: OECD.



a second language in the mornings (implicit and explicit language support). To estimate the effects of the interventions, children completed tests of grammar, reading, and vocabulary shortly before and after the summer vacation (pretest, posttest) and again 3 months after the completion of the program (follow-up).

The results for the written tests show that the summer camp program improved children's language competencies despite the intervention's relatively brief duration. This was particularly the case for the combination of implicit and explicit language support. A multivariate analysis of variance revealed that students in this treatment group reached significantly higher performance levels in the posttest than students in the baseline group. The advantage was most pronounced for grammar (d = .86) and reading (d = .51). A similar tendency was observed for vocabulary (d = .37), yet the effect failed to reach significance (p = .095). Students in the implicit support condition also tended to perform better than the control group in grammar (d = .38) and reading (d = .49). However, none of these differences were significant.

A similar pattern emerged for the follow-up tests 3 months after the intervention, although the group differences tended to be smaller and only a few of them reached significance. The effect sizes, however, clearly indicate that students who had received both implicit and explicit language support reached higher scores in the tests of grammar (d = .38), reading (d = .49), and vocabulary (d = .41) than students in the baseline group. The somewhat weaker tendency for students in the implicit condition to perform better than students in the baseline condition was also apparent at the follow-up.

Overall, the findings of the *Jacobs Summer Camp Project* indicate that a combination of implicit and explicit language support is effective in helping elementary school children with an immigration background to improve their second-language skills. Implicit language support alone seems to yield similar, but weaker, effects.

OECD Report: "Where Immigrant Students Succeed—A Comparative Review of Performance and Engagement" (2006)

Successful integration of immigrant students into the education system presents a central concern to many countries worldwide. Therefore, as another core activity within this Research Area, Petra Stanat and Gayle Christensen analyzed data from PISA 2003 on outcomes of schooling for an OECD report. Measures were immigrant students' performance in key school subjects at the age of 15, their self-assessment as learners, and their feelings about school. Two groups of immigrant students were analyzed: *first-generation students* who were born outside the country of assessment and whose parents were also born in a different country; and *second-generation students* who were born in the country of assessment themselves but whose parents were born in a different country, that is, students who completed all of their schooling in the country of assessment. The report compares immigrant students to native students who were born in the country of assessment and who have at least one parent born in that country. The analyses include 17 countries with significant immigrant student populations: the OECD countries Australia, Austria, Belgium, Canada, Denmark, France, Germany, Luxembourg, the Netherlands, New Zealand, Norway, Sweden, Switzerland and the United States as well as the partner countries Hong Kong China, Macau China, and the Russian Federation. For the majority of these countries, as well as for the United Kingdom, Finland, and Spain, the report also presents information on policies and programs to help immigrant students attain proficiency in the language of instruction. Among others, the following seven important conclusions were drawn from the analyses:

(1) PISA results suggest that high levels of immigration do not necessarily impair integration.

(2) Immigrant students are motivated learners and have positive attitudes toward school. Such strong learning dispositions can be developed by schools to help these students succeed in the education system.

(3) Despite these strong learning dispositions, immigrant students often perform at levels significantly lower than their native peers. At the same time, however, their performance levels vary across countries.
(4) In the majority of countries, at least 25 % of immigrant students could face considerable challenges in their future professional and personal lives as they do not have basic mathematics skills according to the PISA 2003 assessment.
(5) Background characteristics of immigrant student populations and school characteristics only partially explain differences in mathematics performance.
(6) Similarly, performance differences in mathematics are not fully explained by the fact that some immigrant students do not speak the language of instruction at home. However, in several countries this relationship is quite strong, and may warrant stronger language support in schools.
(7) Policies to help immigrant students attain proficiency in the language of instruction have common characteristics, but vary in terms of explicit curricula and focus.

The Center for Educational Research in March 2007

Left to right: Gabriel Nagy, Thamar Dubberke, Stefan Krauss, Michael Becker, Nele McElvany, Uta Klusmann, Yi-Miau Tsai, Kai Maaz, Mareike Kunter, Oliver Lüdtke, Nicole Husemann, Kathrin Jonkmann, Marko Neumann, Cornelia Gresch, Ulrich Trautwein, Erin Furtak, Jürgen Baumert.

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Research Area IV
Cognitive Activation in the Classroom

Introduction to Research Area IV

Research Area IV investigates the processes of learning and instruction, and examines how powerful learning environments can be created. The focus is on learning that occurs in authentic real-life classrooms, particularly in mathematics classrooms. Classroom instruction is not the only factor that determines the learning outcomes of students. It is, however, the factor most likely to be affected by the institutions of the educational system and the professional activity of teachers. Recent findings emphasize that classroom instruction rather than the school environment or management structures has the main impact on school effectiveness in terms of learning outcomes. As such, the question of what actually determines good instructional practice is central to the success of education and the functioning of the educational system. In Research Area IV, we address this question by combining concepts of instructional quality with the analysis of individual and collective processes of knowledge acquisition in a specific domain, that is, in mathematics.

The research program builds on earlier work that was carried out in the context of our large-scale and longitudinal studies, such as BIJU, TIMSS, and PISA, which had provided first evidence about which features of classroom instruction are essential for students' learning. In addition, in our secondary analyses of the 1996 *TIMSS Videotape Classroom Study,* we have linked classroom observation data with student data and have been able to describe, for example, how the types of tasks set in lessons influence learning processes,

The aim of the COACTIV study is to investigate mathematics teachers' competence and the way this competence relates to instructional processes. By assessing the knowledge, beliefs, motivation, and self-regulatory skills of mathematics teachers, and then linking these aspects to features of their classroom instruction and to the development of their students' mathematical literacy, the study is intended to provide unique insights into the prerequisites for students' mathematical learning.
The COACTIV study is embedded in the longitudinal component of the PISA 2003 study. Both the students sampled for PISA and their mathematics teachers were assessed twice—once at the end of 9th grade, and once at the end of 10th grade. We are thus able to combine student achievement and questionnaire data with their teachers' data, and to observe changes over the course of a school year.
Measures on students' development are obtained from the students' PISA test scores and additional questionnaire data. Information on mathematics instruction comes from three sources: teacher reports, student reports (both standardized questionnaires), and analyses of the teaching material that was used in the given period. For this, teachers were asked to submit the tasks they actually employed in their PISA classes (homework assignments, exams, and tasks used in introductory lessons). These tasks were coded by trained raters using a newly developed classification scheme to tap the cognitive potential inherent in the tasks. To assess teachers' competence, we developed an array of new instruments, some of which are computer-based. In particular, we focused on developing a standardized test to assess teachers' content and pedagogical content knowledge.
Our teacher sample consists of 351 teachers and their mathematics classes in the first wave, and 240 teachers and their classes in the second wave (the reduction in sample size is due to students from vocational schools no longer being included in the assessment at the second wave). A total of 178 teachers participated in both waves of the assessment, and taught the PISA classes over the whole school year.

and ultimately impact on students' learning outcomes, including motivational development. In our current research program, we take the idea of learning environments one step further and put a new focus on the teacher as the prime agent in the teaching and learning process. One of our core objectives therefore is to investigate the prerequisites that teachers need to have in order to be able to create successful learning environments.

Methodologically, in Research Area IV, we build on correlational and quasi-experimental studies in which we often combine teacher and student data to gain valid insights into the instructional processes. The flagship of the research program of Area IV is the COACTIV study which is embedded in the PISA 2003 assessment and investigates mathematical teachers' competence and the way several aspects of competence relate to teachers' instruction in their mathematics classes. In our ongoing research program, we complement the findings from this study with new research projects that follow some of the questions that arose in more detail.

Insightful Learning in Powerful Learning Environments

The research in Area IV is guided by a theoretical framework that conceptualizes teachers, lessons, and students as the three cornerstones of teaching and learning processes in classroom instruction. The framework draws on aspects of teacher expertise, the process-mediation-product model, and the (social-)constructivist approach. The general approach that structures our framework is outlined in Figure 1.

Our theoretical framework is based on the notion that conceptual understanding is a central aim of mathematics instruction. It is now widely accepted that new concepts and insights are not acquired through passive knowledge transmission of the teachers' knowledge to the learner's mind, but rather that they are the result of the learner's active process of constructing increasingly complex and elaborated cognitive structures. This process of insightful learning is characterized by the learner's active mental engagement that occurs in interaction with the learning environment. The product of this process is a thorough understanding of domain-specific concepts comprising declarative knowledge, skills, and procedures. The process of insightful learning is supported by motivational variables, such as interest, and self-related cognitions, such as control beliefs. At the same time, insightful learning processes may also result in the development of functional motivational and self-related cognitions.

We see the classroom instruction as a structured learning opportunity that may, or may not, provide the occasion for insightful learning. Powerful classroom environments are those that stimulate students to apply themselves cognitively and that are structured in such a way that active and independent knowledge construction is possible. The most

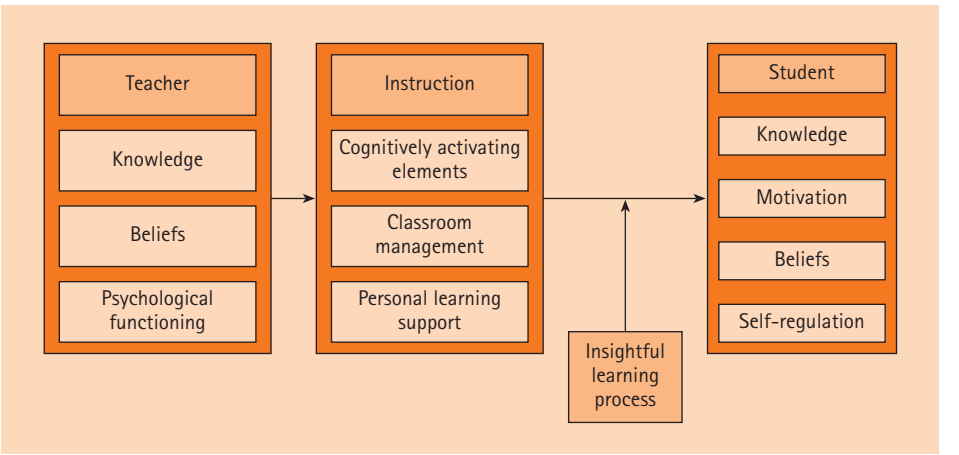


Figure 1. Teachers' competence, mathematics instruction lessons, and students' learning: The underlying structure of the theoretical framework in the COACTIV study.

Key References

Kunter, M., Klusmann, U., Dubberke, T., Blum, W., **Brunner, M.,** Jordan, A., **Krauss, S.,** Löwen, K., Neubrand, M., & **Tsai, Y.-M.** (in press). Linking aspects of teacher competence to their instruction: Results from the COACTIV project. In M. Prenzel (Ed.), *Studies on the educational quality of schools: The final report on the DFG priority program.* Münster: Waxmann.

Brunner, M., Kunter, M., Krauss, S., Klusmann, U., Baumert, J., Blum, W., et al. (2006). Die professionelle Kompetenz von Mathematiklehrkräften: Konzeptualisierung, Erfassung und Bedeutung für den Unterricht: Eine Zwischenbilanz des COACTIV-Projekts. In M. Prenzel & L. Allolio-Näcke (Eds.), *Untersuchungen zur Bildungsqualität von Schule: Abschlussbericht des DFG-Schwerpunktprogramms* (pp. 54–82). Münster: Waxmann.

Key References

Kunter, M., & **Baumert, J.** (2006a). Linking TIMSS to research on learning and instruction: A re-analysis of the German TIMSS and TIMSS video data. In S. J. Howie & T. Plomp (Eds.), *Contexts of learning mathematics and science: Lessons learned from TIMSS* (pp. 335–351). London: Routledge.

Kunter, M., & **Baumert, J.** (2006b). Who is the expert? Construct and criteria validity of student and teacher ratings of instruction. *Learning Environments Research, 9,* 231–251.

Kunter, M., Dubberke, T., Baumert, J., Blum, W., **Brunner, M.,** Jordan, A., et al. (2006). Mathematikunterricht in den PISA-Klassen 2004: Rahmenbedingungen, Formen und Lehr-Lernprozesse. In M. Prenzel, J. Baumert, W. Blum, R. Lehmann, D. Leutner, M. Neubrand et al. (Eds.), *PISA 2003: Untersuchungen zur Kompetenzentwicklung im Verlauf eines Schuljahres* (pp. 161–194). Münster: Waxmann.

Kunter, M. (2005). *Multiple Ziele im Mathematikunterricht.* Münster: Waxmann (Pädagogische Psychologie und Entwicklungspsychologie 51).

important key to trigger and uphold active knowledge construction is the attunement of the tasks to be mastered to the students' prior knowledge and understanding. In our work—which will be described in more detail in the next paragraph—we identified three general features of instruction that are crucial to enable insightful learning processes in secondary school mathematics, namely, cognitively activating elements, classroom management, and individual learning support.

It is important to note that the uptake of the learning opportunity depends both on the students themselves (according to their individual prerequisites) and on situational constraints (Baumert, Blum, & Neubrand, 2004; Helmke, 2003). Successful instruction thus hinges on the degree to which instructional strategies are suited to the needs of the situation *and* the students. Instructors therefore need to provide challenging tasks, monitor student learning, and need to adapt their teaching accordingly if they want to support active and independent knowledge construction for many learners (de Corte et al., 1996). For teachers in classroom situations, this is a demanding task—it is no easy matter to create challenging and suitable learning conditions for groups of students who may differ greatly in terms of motivation or prior knowledge. Such deliberate, but, at the same time, flexible and adaptive action, can only be achieved based on a solid knowledge base that is supported by adaptive beliefs and adequate psychological functioning. From this perspective, particular relevance is put on the person of the teacher as an important agent in the instructional process. Consequently, as one major part in our recent work, we investigate which aspects of teacher competence—such as knowledge, beliefs, and their psychological functioning—are relevant for educational outcomes. Before we turn to this issue, we will first describe our notion of high quality in more detail.

What Are the Features of High Quality Instruction?

Classroom instruction can be described in various ways. As a first approach, it is often useful to describe the organizational structure of the learning environment, for instance, the general lesson scripts or the use of particular learning settings, such as whole class discussion, group work, or partner work. However, instructional research has shown that these surface features alone do not decide whether students will engage in insightful learning processes, and thus do not necessarily predict learning outcomes. In order to describe strengths and weaknesses of instruction, it is fruitful to describe the interaction between teacher and students in the instructional process in more detail.

Prior research, for instance from the 1996 *TIMSS Videotape Classroom Study* (e. g., Baumert et al., 1997; Klieme et al., 2001; Kunter, 2005; Kunter & Baumert, 2006a), has shown that both formal organization and the instructional interactions of mathematics teaching in German secondary schools are not optimally suited to trigger insightful learning processes. Formally, the "monoculture of mathematics teaching" has often been noted, with lessons typically following a rather rigid script of teacher presentation with class discussion and ensuing seat work. In terms of the instructional process, the TIMSS Video study has shown that German mathematics lessons have typically focused on drilling routines rather than on developing conceptual knowledge. Teachers guided students through new topics step-by-step, presenting the new ideas themselves, and rarely making reference to students' conceptions. The tasks students worked on were very routine-oriented, and their solutions required the application of procedures rather than conceptual understanding.

The findings from the TIMSS Video study and the disappointing results of the PISA 2000 study have received much attention in Germany, leading to several programs in research and teacher education aiming to improve the quality of instruction, particularly in the domain of mathematics. One of the questions addressed by the COACTIV study was whether improvements in the current German mathematics instruction were observable. With our assessment being embedded in the PISA 2003 study, we can draw on a representative sample of mathematics

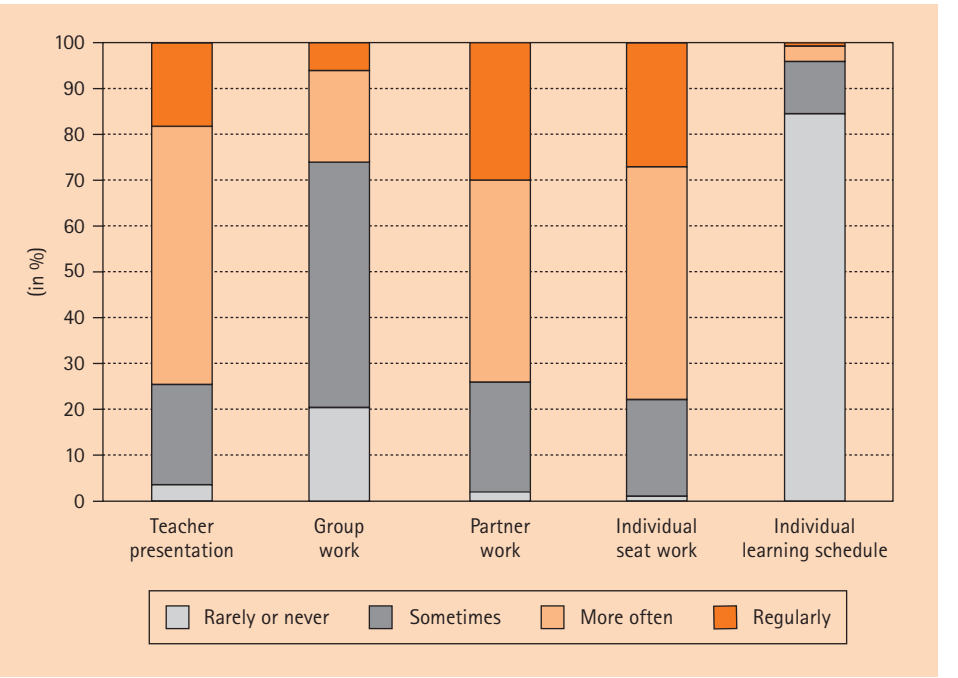


Figure 2. Usage of particular learning settings in mathematics lessons: Results from the teacher survey in COACTIV.

classes and their teachers. We used a multimethodological approach in which we combined teacher self-reports, student ratings of instruction, and analyses of the tasks that teachers employed in their lessons. We examined the formal arrangements of the lessons as well as the interaction between teacher and students in the instructional process.

Formal Arrangements of Mathematics Lessons

Our results indicate that the picture of the uniform organization has not changed much in secondary school mathematics classes since the results from TIMSS in the 1990s. Figure 2 presents results from the teacher survey in which teachers were asked how often they implement several learning settings, such as teacher presentation, partner or group work, or individual seat work.

As can be seen in Figure 2, the most frequent learning arrangements are teacher presentation and individual seat work, but collaborative learning settings are rarely used. Of particular interest is the last bar of the figure, which reports the implementation of individualized learning schedules. It shows that over 80 % of the teachers do not, or hardly ever, use this type of learning arrangement. These results indicate that formal learning arrangements in the mathematics lessons are still —10 years after the TIMSS Video study—very teacher-centered. Moreover, learning arrangements that allow for collaborative learning or explicitly cater to individual students' needs are rarely used.

Features of the Instructional Process

Within the COACTIV framework, we distinguish three aspects of the instructional interaction between teacher and students that theoretically seem crucial for initiating and sustaining insightful learning processes in mathematics lessons (see Figure 1). First, we consider the frequency of *cognitively activating elements* of instruction. Cognitively activating elements refers to all learning situations that may trigger students' conceptual involvement. In the mathematics classroom, it is determined primarily by the types of tasks and the way they are implemented. Tasks that draw on students' prior knowledge by challenging their beliefs is one example. While implementing tasks in class discussion, the teacher does not simply declare students' answers to be "right" or "wrong," but encour-

Table 1
Even Tasks on a Low Difficulty Level May Imply Conceptual Understanding:
Examples of Tasks With Diverse Levels of Curricular Knowledge and Cognitive Demands

	Low level of curricular knowledge	*High level of curricular knowledge*
Technical task	Consider the function $f(x) = 3x - 1$. Find the value of x when $f(x) = 11$.	Let f be the quadratic function $f(x) = 2x^2 + 5x - 3$. Write f(x) in vertex form.
Conceptual modeling task	How does the surface area of a square change when the side length is tripled? Show your reasoning.	Thomas' father wants to give him some money towards a motorbike. He makes Thomas two offers: (1) 15€ today, a further 20€ tomorrow, a further 25€ the next day, and so on for 2 weeks (i.e., increasing the sum by 5€ every day). (2) 5 cents today, a further 10 cents tomorrow, a further 20 cents the next day, and so on (i.e., doubling the sum every day), again for 14 days. Which offer should Thomas choose? Show your reasoning.

ages students to evaluate the validity of their solutions for themselves. The second important aspect is *classroom management.* Classrooms with less disruption and more efficiency in time use are a prerequisite for learning to occur. Third, we consider the *personal learning support* provided by the teacher. Motivational theories have shown that students engage in insightful learning processes and develop intrinsic motivation when they feel personally supported in their learning environments. Therefore, teachers need to be acutely aware of possible difficulties and offer assistance to stimulate individual learning processes.

Particularly with regard to cognitive potential inherent in lessons, our results also tend to replicate the TIMSS findings of routine-oriented rather than problem-solving-oriented instruction. In the COACTIV study, we asked the teachers to submit (among others) all the exams they set in the PISA classes during the whole school year. On average, each teacher submitted 53 exam tasks which were then coded by trained raters, using a newly developed classification scheme to tap the cognitive potential inherent in the tasks. Several categories of cognitive potential were evaluated. For instance, all tasks were classified as either technical tasks or modeling tasks, based on the cognitive processes that are required to solve them. Technical tasks require only factual knowledge or computational skills. Modeling tasks, on the other hand, require students first to construct a representation of the problem situation by interpreting the information given in the task statement. This situational model then has to be translated into a mathematical model, from which the mathematical solutions needed to solve the problem can be derived. These solution strategies then have to be implemented, interpreted, and validated. The match between the situational model and the mathematical model determines the quality of the task solution. Modeling tasks are further categorized as computational modeling tasks or conceptual modeling tasks. If the situational model is close to the mathematical model required to solve it, and the solution strategies primarily entail calculations and mathematical algorithms (even demanding ones), it is called a computational modeling task. If the mathematical model requires the students to link several concepts or strategies, or to draw inferences going beyond the information given in the task statement, the task is called a conceptual modeling task. It is important to note that this classification does not equate with problem difficulty in terms of the average student success rate on a problem. All three types of problems—technical tasks,

computational modeling tasks, and conceptual modeling tasks—can occur at all difficulty levels. Table 1 illustrates this point. Figure 3 shows that of all exam tasks, almost half were technical tasks, meaning that their solution required only factual knowledge or computational skills. The other half were modeling tasks. Of these, most were computational modeling tasks that required procedural thinking during the processing phase. Only 8 % of all tasks were conceptual modeling tasks in which conceptual thinking was needed during the processing phase, such as linking several concepts or strategies or drawing inferences beyond the information in the task statement. Considering the fact that exam tasks are meant to represent the accomplishment of learning goals at the end of a unit, this finding illustrates the computational orientation of German mathematics instruction in a very striking way.

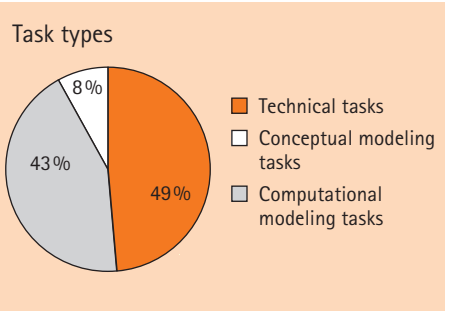


Figure 3. Cognitive potential of the exam tasks set by the teachers in the COACTIV mathematics.

Effects of Instructional Features on Educational Outcomes

Our results thus indicate that truly powerful mathematics instruction that supports independent and insightful student learning is a rather rare occurrence in German secondary school mathematics classes. However, despite this general tendency, the instructional quality varies between classes and teachers. Using the data from the longitudinal component of the PISA 2003/04 assessment, we therefore investigated whether higher instructional quality can systematically be linked to students' learning over the course of 1 school year. We found that classes in which tasks with high cognitive potential were set showed higher mathematics achievement than other classes. In addition to the cognitive potential, efficient classroom management was another factor that influenced the learning of students positively. In our future work, we will investigate the interplay between the three aspects of the instructional process in more detail. Moreover, in our work, we have, as a first step, concentrated on the learning gains of students as one of many desirable outcomes of instruction. However, taking the multifacetted nature of educational objectives into account, we also investigate the effects of instruction on students' motivational development. For instance, a reanalysis of the 1996 TIMSS data showed that students' interest development may be fostered if students perceive their mathematics instruction as transparent and feel monitored by their teacher. In another current research project, LIFE fellow Yi-Miau Tsai investigates instructional effects on student motivation in an intraindividual design. Nine classes including 261 students and 25 teachers participated in the study with a repeated-measurement design. For 3 consecutive weeks, students and teachers reported their lesson experience immediately after each lesson, particularly their interest and self-view. First analyses of the students' data showed that students' self-reported instructional quality predicts their interest experience and perceived competence during the lesson. Students enjoyed lessons more when teachers provided them with personal and cognitive autonomy support. In addition, such beneficial effects are not limited to mathematics lessons, they are also applicable in language lessons.

How Can Teachers Provide High Quality Instruction?

Educational research has recently seen a remarkable upsurge in interest in the person of the teacher as one of the main agents in the instructional process. Providing cognitively activating instruction, managing the classroom efficiently, and supporting students personally require high levels of attention and engagement of the teacher. Moreover, teachers need a broad knowledge of instructional methods and strategies to establish well-structured and cognitively activating

Key Reference

Kunter, M., Baumert, J., & Köller, O. (in press). Effective classroom management and the development of subject-related interest. *Learning and Instruction.*

learning situations, and need to implement them flexibly according to students' needs. For the pursuit of cognitively activating elements in particular, domain-specific background knowledge seems to be of high importance.

To date, empirical evidence on which teacher characteristics are particularly important to create high-quality learning situations is still scarce, one reason for this being the lack of adequate measurement instruments to tap teachers' knowledge and other characteristics. The COACTIV study is one of the first studies that succeeded in developing a comprehensive assessment instrument measuring several aspects of mathematics teachers' competence. Drawing on our framework of powerful mathematics instruction outlined above, we derived several prerequisites that seem crucial for teachers to successfully meet the demands of (mathematics) teaching. These include aspects of knowledge, beliefs, and variables of psychological functioning, and are seen as being at the core of mathematical teachers' competence. Figure 4 gives an overview of the competence aspects that we examined.

Knowledge

In order to create a challenging and adaptive learning environment in the mathematics classroom, teachers need to select mathematical tasks that meet the differing needs of individual students, that is, tasks that vary in terms of their difficulty and cognitive demands as well as in structural and contextual terms, thus helping learners gain transferable knowledge. These tasks must be presented in an order that allows students to gradually expand their knowledge and practice existing skills. This requires a profound base of knowledge on the teacher's part. In COACTIV, we therefore focus on teachers' domain-specific knowledge. Drawing on Shulman (1986, 1987), we differentiate between mathematics-related *content knowledge* (CK) and mathematics-related *pedagogical content knowledge* (PCK). CK concerns the content to be taught in school, whereas PCK is the awareness of how best to present this content to students. Important facets of PCK include knowledge of instructional strategies and knowledge of students' understanding as well as knowledge of the potential of mathematical tasks.

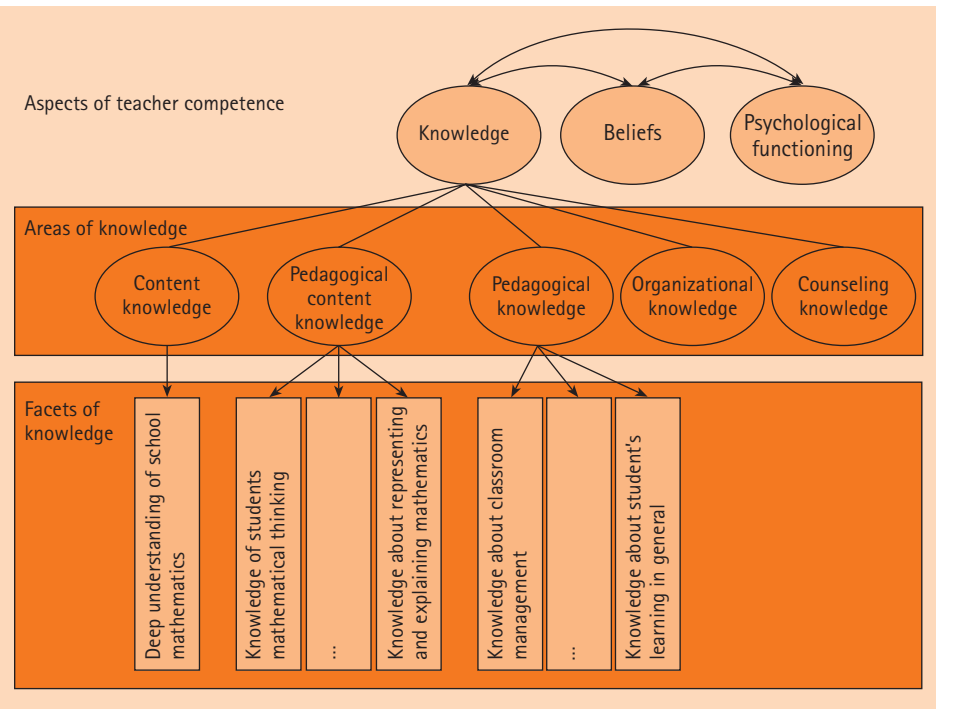


Figure 4. Teacher competence as conceptualized in the COACTIV study.

Beliefs

What teachers think about their subject, and—even more importantly—whether they feel responsible for their students and seek to support their personal growth, may determine whether or not their teaching serves to create powerful learning environments. In COACTIV, we consider teacher's beliefs about the nature of knowledge and knowing (epistemological beliefs), theories about the nature of learning and teaching, and teachers' instructional goals, all referring to the context of mathematics. We differentiate between a *transmission view* (drawing on traditional learning theories) and a *constructivist view* (e. g., Staub & Stern, 2002).

Psychological Functioning: Engaging and Coping

We assume that a combination of high engagement and a high capacity to deal with the pressures of school life is crucial for teachers' psychological functioning. On the one hand, teaching—perhaps more than many other professions—calls for continuous engagement, and requires teachers to apply themselves personally: Students demand teachers' attention, standardized curricula create time pressures, and the lack of external guidance and feedback necessitates high levels of self-motivation. At the same time, teachers work in a complex social environment that requires immediate responses to multiple social stimuli, always under the students' scrutiny (Doyle, 1986). To do well in this situation, teachers need to be able to distance themselves from these pressures, making themselves less vulnerable to criticism and failure. In COACTIV, we examine different *motivational variables* (i. e., their general professional engagement, such as career ambitions or the subjective significance of their work, and their mathematics-specific engagement, e. g., teachers' enthusiasm for mathematics) as one motor for their engagement. In terms of teachers' *ability to cope* with pressures and failures, we consider aspects of their resilience (e. g., emotional distancing and application of active coping strategies). The interplay between the two dimensions may constitute a specific *self-regulatory style*, particularly where general occupational engagement and coping are concerned.

Assessing Teacher Competence

Although notions of teacher competence are convincing from the theoretical perspective, empirical evidence to support them is as yet sporadic. An empirical approach to the question is complicated for both theoretical and methodological reasons. Theoretically, a conceptualization of teacher competence as a multidimensional construct needs to unite several theoretical approaches: domain-specific theories of student learning, general learning theories, and psychological theories of human functioning. Methodologically, an empirical assessment of competence requires reliable measures, which are scarce at present. There are few standardized instruments —particularly in the area of teacher knowledge but also in all other areas of interest— and most previous findings are based on qualitative and anecdotal data. Moreover, it is vital to ensure variability of the target variables in the teacher samples, for example, by drawing sufficiently large samples or using quasi-experimental approaches. Finally, cross-sectional data need to be supplemented by either longitudinal or experimental approaches if conclusions are to be drawn on the causal influences of teacher competence.

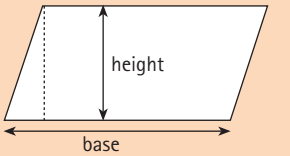
The COACTIV study was designed to address these questions by conceptualizing, assessing, and validating a model of teacher competence for mathematics instruction. The development of valid and reliable instruments that are suited to assess these aspects of teachers' competence was one of the major challenges of our study. This was particularly the case for the assessment of teachers' knowledge, as no standard instruments existed thus far. The theory-based construction of the tests of PCK and CK was a multidisciplinary and a multistep project. Researchers in mathematics education, psychology, and secondary mathematics teachers collaborated in writing, piloting, and analyzing items. The test on teachers' PCK included items that asked teachers to provide explanations for

Key References

Baumert, J., & **Kunter, M.** (2006). Stichwort: Professionelle Kompetenz von Lehrkräften. *Zeitschrift für Erziehungswissenschaft, 9,* 469–520.

Klusmann, U., Kunter, M., Trautwein, U., & **Baumert, J.** (2006). Lehrerbelastung und Unterrichtsqualität aus der Perspektive von Lehrenden und Lernenden. *Zeitschrift für Pädagogische Psychologie, 20* (3), 161–173.

Figure 5. Sample items from the test on mathematics teachers' CK and PCK.

"Square" ("Tasks" subfacet of PCK) How does the surface area of a square change when the side length is tripled? Show your reasoning. Please note down as many different ways of solving this problem (and different reasonings) as possible.	"Parallelogram" ("Students" subfacet of PCK) The area of a parallelogram can be calculated by multiplying the length of its base by its height.  Please sketch an example of a parallelogram to which students might fail to apply this formula.
"–1 times –1" ("Instruction" subfacet of PCK) A student says: I don't understand why $(-1)\cdot(-1)=1$ Please outline as many different ways as possible of explaining this mathematical fact to your student.	"Infinite decimal" (Test of CK) Is it true that $0.999999\ldots=1$? Please give detailed reasons for your answer.

mathematical problems, items that required teachers to detect typical student errors, and items in which teachers had to find multiple ways for solving tasks. The items in the CK task tapped conceptual and/or procedural mathematical skills. Although the items related to mathematical content that is typically taught at high school, they were essentially too difficult for students, but required a deep understanding of mathematics. Sample items of the test are displayed in Figure 5.
The successful construction of a set of valid and reliable measures tapping aspects of teacher competence was one of the most important milestones of the COACTIV study. These new measures now allow us to learn more about the relations between the different aspects of teacher competence, to compare different groups of teachers, and, most importantly, to investigate which of the competence aspects are particularly relevant for educational outcomes.

The First Results From COACTIV: Linking Teacher Competence and Instruction

Using our newly developed measures, we have started the systematic investigation of interindividual differences in teacher competence and in instruction, and have linked aspects of teacher competence to their teaching.
As a first step, it was important to learn more about the configuration of the various aspects of teacher competence. Is there someone resembling a "perfect teacher" who scores high on all our competence measures (and vice versa)—or is it, for instance, typical that some teachers have high knowledge scores, but show rather low engagement? A first answer to the question can be found in Figure 6 which shows the intercorrelations between selected aspects of teacher competence, namely, teachers' CK, PCK, their belief that mathematics is best taught in direct transmission mode, their enthusiasm for mathematics, and a coping style that is marked by high engagement and high resilience at the same time. The figure shows that both knowledge types and teachers'

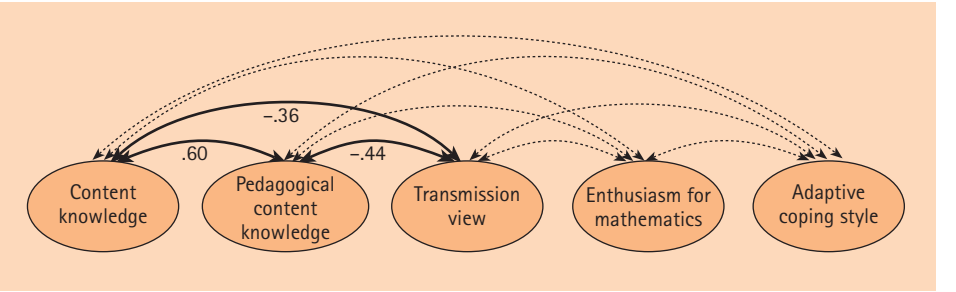


Figure 6. The relation between multiple aspects of teacher competence (latent correlation from a *Structural Equation Model* (SEM).

beliefs are related to each other, suggesting (a) that teachers with higher mathematics-specific CK usually also know better how mathematics content can be made accessible to students, and (b) that typically teachers with higher scores in the knowledge tests tend to reject the traditional transmission view of teaching. However, teachers' knowledge and beliefs are not directly linked with teachers' psychological functioning, as teacher's enthusiasm and coping style do not correlate with the other measures.

In terms of interindividual differences, we found that teachers vary substantially in all aspects of competence, and that these differences are especially pronounced in knowledge. These knowledge differences are at least partially dependent on the type of university education teachers received, as we found substantially higher levels of PCK and CK or those teachers who were trained to teach the academic track (see Figure 7). Interestingly, person variables, such as age or gender, were not significantly related to teachers' knowledge. With regard to psychological functioning, however, older teachers were less likely to be enthusiastic or to report effective coping skills.

The crucial question of course is whether teachers' competence is systematically linked to their mathematics instruction. The COACTIV design provides an excellent database to explore this question in detail, as we are able to tap information about the quality of instruction from various sources, such as task analysis and students' reports, thus going beyond teacher self-reports.

We found that teachers' PCK uniquely predicts the degree of cognitive activation in class, both measured by the task material and the student reports: The more teachers know about how to make mathematical content accessible to students, the more cognitively demanding tasks they set in class (e. g., in their exams), and the more their students feel challenged in the classroom. Teachers with higher PCK also show higher levels of individual learning support, indicating that a certain level of content-specific knowledge is needed to provide students with adequate guidance. Teachers' pure CK, however, does not directly contribute to teachers' instructional quality: Whether teachers have a deep understanding of their subject does not seem to be reflected directly in their teaching—at least not in a way that the students notice. Instead, CK seems to exert an indirect influence, as it predicts teachers' PCK. Concerning other variables, teachers' coping style seems to be the most significant predictor: Teachers who show high levels of commitment, but are able to distance themselves from problems at the same time, seem best equipped to provide students with patient and constructive support. Interestingly, there were no systematic associations between teachers' enthusiasm for the subject of mathematics and their instruction. Evidently, teachers' interest in, and enjoyment of, a subject is not necessarily reflected in specific classroom behaviors.

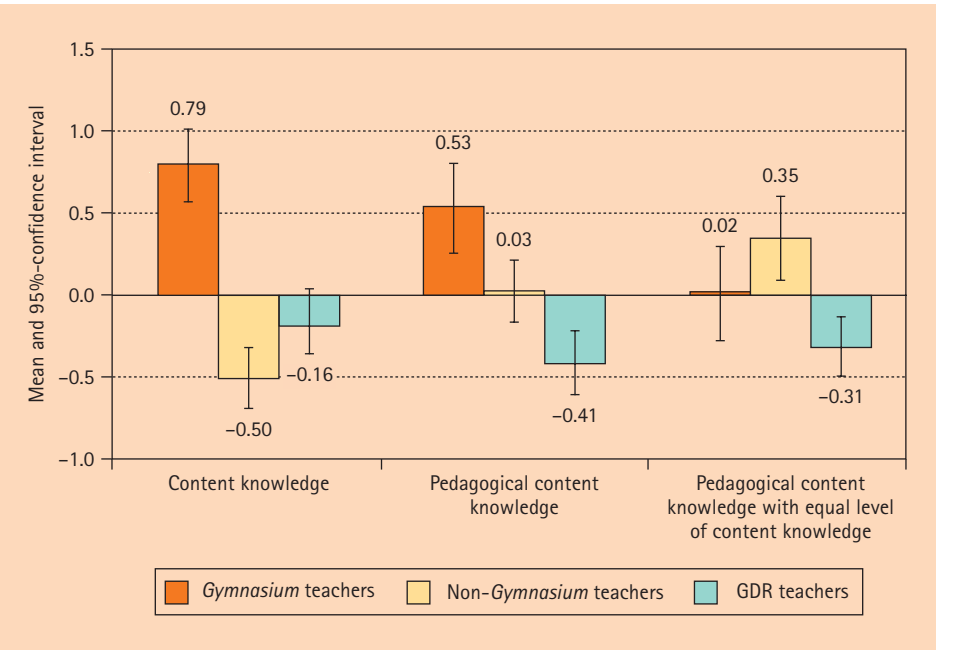
Figure 8 illustrates our findings by showing an SEM in which we specified the teachers' characteristics as predictors of their teaching behaviors, as rated by their students.

With the establishment of the link between teachers' characteristics and their instruction, we have a first indication that teacher competence is an array of different features, including cognitive, motivational and domain-specific as well as general person char-

Key Reference

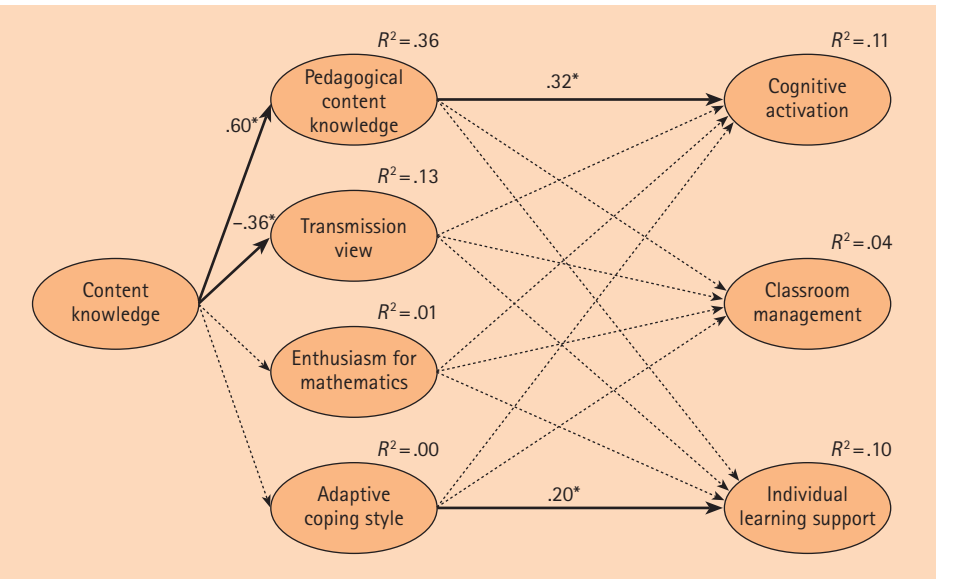
Brunner, M., Kunter, M., Krauss, S., Baumert, J., Blum, W., **Dubberke, T.,** et al. (2006). Welche Zusammenhänge bestehen zwischen dem fachspezifischen Professionswissen von Mathematiklehrkräften und ihrer Ausbildung sowie beruflichen Fortbildung? *Zeitschrift für Erziehungswissenschaft, 9,* 521–544.

Figure 7. Differences in teachers' pedagogical context knowledge and content knowledge depending on their university education.



acteristics. In our future analyses, we will now further examine the importance of these aspects for the creation of meaningful learning environments, and eventually for students' cognitive and motivational development. In order to learn more about the psychological functioning of teachers, we are currently running a quasi-experimental interview and questionnaire study in which we compare exhausted and nonexhausted teachers. Another direction of our research program is the extension of our framework over and above the domain of mathematics, investigating aspects of general pedagogical knowledge as well as knowledge in other domains, such as reading (see Research Area III).

Figure 8. Aspects of teacher competence as predictors of student-reported teaching behaviors (standardized regression coefficients and R^2 of the structural model).



Completed Project ENTERPRISE: Early Learning of Science and Mathematics

The ENTERPRISE project (**E**nhancing K**N**owledge **T**ransfer and **E**fficient **R**easoning by **P**racticing **R**epresentation **I**n **S**cience **E**ducation) aims to explore the conditions under which graphs and diagrams can serve as tools for structuring learning environments and, thus, foster conceptual understanding in science as well as other content areas.

In 1997, Elsbeth Stern was hired as a senior research scientist to establish a research project on science and mathematics learning for elementary school children.

The project was based on a domain-specific perspective of cognitive development, arguing that the difficulties experienced by younger children in coping with specific cognitive demands can be traced back to their lack of domain-specific conceptual and procedural knowledge. In this perspective, learning environments for young children should focus on laying the foundations for the kind of knowledge acquisition that is most relevant and challenging in the upper grades of school. Knowledge dealt with in all kinds of academic contexts is based on symbolic systems, such as script, formal mathematical language, pictures, and diagrammatic representations. Symbols can be understood as mental tools that support the construction of meaning in concepts, ideas, or plans.

The longitudinal studies Elsbeth Stern was involved in before she started her project at the MPIB clearly suggest a strong impact of early number understanding on later mathematical understanding (Stern, 2005; Stern & Felbrich, 2006). During the past decade, elementary school mathematics in German schools has considerably improved: Curricula focusing on the development of the number sense rather than on practicing numerical facts are on the advance. Early science education, in contrast, still had a lot of catching up to do in the 1990s. As a consequence, the major goal of the ENTERPRISE project was to foster science learning in elementary school children by providing students with reasoning tools that support an understanding of proportional concepts in a scientific context, that is, speed, density, or concentration. It was shown that with the help of tools, like balance beams or graphs, 3rd graders were already able to develop a deeper and transferable understanding of scientific concepts. In several PhD theses and in cooperation projects with the Department of Science Education in Elementary School of the University of Münster, evidence for the short-term as well as long-term effects of tool use on deeper conceptual understanding could be obtained (Hardy, Schneider, Jonen, Stern, & Möller, 2005; Hardy, Jonen, Stern, & Möller, 2006; see also the past three annual reports). The effects of cognitive tool use on the emergence of conceptual knowledge was addressed in two dissertations finished in 2006. Michael Schneider investigated how practice with number line games affects the relationship between procedural and conceptual knowledge. Henrik Saalbach ran cross-cultural studies in order to explore the impact of grammar as a cognitive tool on the conceptual development of young children (Saalbach & Stern, 2004).

Cognitive Tool Use and Its Effects on the Interaction Between Conceptual and Procedural Knowledge

Conceptual knowledge, as seen by cognitive theories of learning, provides an in-depth understanding of the principles of, and interrelations among, pieces of knowledge in a domain. Procedural knowledge allows for the efficient and goal-directed solution of routine problems, and is represented, on the cognitive level, by production rules with different degrees of automaticity.

In the literature addressing the interrelations between conceptual and procedural knowledge, three basic approaches can be distinguished: concepts-first approaches, which are based on the assumption that the acquisition of conceptual knowledge takes place, as a rule, prior to that of procedural knowledge and, subsequently, causes an increase in procedural knowledge; procedures-first approaches, which postulate the exact opposite with respect to the sequence of acquisition

The Research Team

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Henrik Saalbach
Michael Schneider
(predoctoral fellows)

Understanding comes from having a good representation
Novick & Hmleo

Key References

Hardy, I., Jonen, A., Möller, K., & **Stern, E.** (2006). Effects of instructional support in constructivist learning environments for elementary school students' understanding of "floating and sinking." *Journal of Educational Psychology, 98,* 307–325.

Hardy, I., Schneider, M., Jonen, A., **Stern, E.,** & Möller, K. (2005). Fostering diagrammatic reasoning in science education. *Swiss Journal of Psychology, 64,* 207–217.

Saalbach, H., & **Stern, E.** (2004). Differences between Chinese morpho-syllabic and German alphabetic readers in the Stroop interference effect. *Psychonomic Bulletin & Review, 11,* 709–715.

Key References

Stern, E., Felbrich, A., & **Schneider, M.** (2006). Mathematik lernen. In D. Rost (Ed.), *Handwörterbuch Pädagogische Psychologie* (3rd, rev. ed., pp. 461–469). Weinheim: Beltz.

Stern, E. (2005d). Knowledge restructuring as a powerful mechanism of cognitive development: How to lay an early foundation for conceptual understanding in formal domains. In P. D. Tomlinson, J. Dockrell, & P. Winne (Eds.), *Pedagogy—teaching for learning* (pp. 153–169). Leicester: British Psychological Society (British Journal of Educational Psychology Monograph Series II, 3).

and the direction of causation; and the *Iterative Model,* which holds that the sequence of acquisition depends on experience and that causal relations are bidirectional. In his thesis, Michael Schneider took up the challenge to find measures allowing for the separation of conceptual and procedural knowledge which, in actual behavior, are inextricably interwoven.

Predictions based on the *Iterative Model* were tested in the well-researched field of decimal fractions against predictions based on the concepts-first and the procedures-first approaches. Four measures of conceptual knowledge (evaluation of procedures, translation into diagrams, size comparison, and written explanations) and four measures of procedural knowledge (problem-solving accuracy, problem-solving duration, asymmetry of access, dual-task costs) were used, all of them adapted from published studies.

In a first study, knowledge types were modeled in structural equation models (SEM) as two latent factors underlying the eight manifest measures, thus permitting predictive relations between factor pairs to be examined across three points of measurement in a cross-lagged panel design. The sample consisted of 204 5th graders and 6th graders. The eight measures were shown to possess

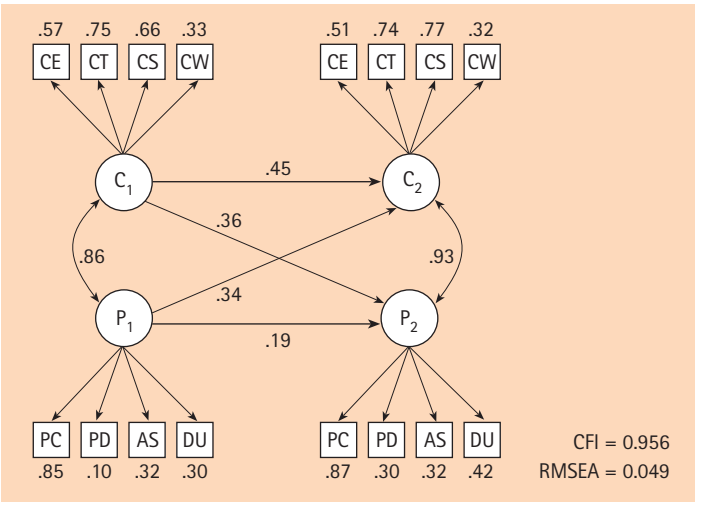


Figure 1. SEM on the relationship between the measures of conceptual knowledge (C) (evaluation of procedures [CE], translation into diagrams [CT], size comparison [CS], and written explanations [CW]) and four measures of procedural knowledge (problem-solving accuracy [PC], problem-solving duration [PD], asymmetry of access [AS], dual-task costs[DU]).

Figure 2. The catch-the-monster game.

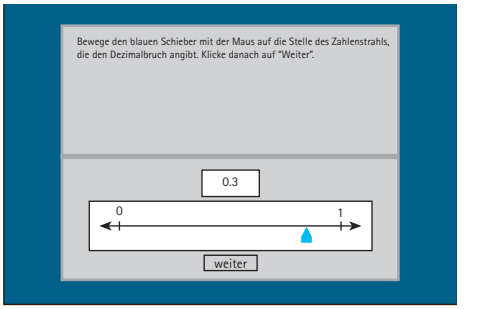


Figure 3. Practicing procedural knowledge: The task was: "Use the mouse to move the blue slide to the position of the number line which matches the decimal fraction."

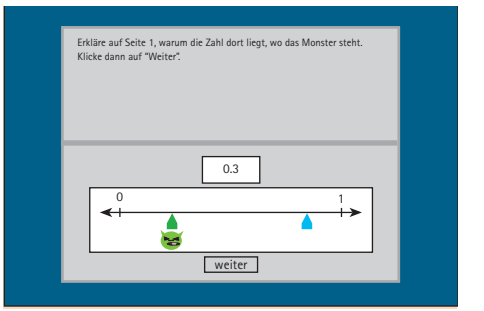


Figure 4. Practicing conceptual knowledge: The task was: "Explain briefly why the number is placed at the position of the monster."

high convergent validities, but low divergent validities. Intercorrelations between the latent factors were very high. This proved to be an obstacle to the analysis of predictive relations, which provided some clues, but no unambiguous evidence, for the validity of the *Iterative Model,* as can be seen in Figure 1.

In a consecutive study with 84 5th graders, it was investigated whether, nonetheless, procedural and conceptual knowledge can be

fostered independently of each other by practicing with cognitive tools either in a more procedural or in a more conceptual manner. Two learning environments based on the "catch-the-monster game" were realized, as shown in Figures 2 to 4. In a 2 x 3 experimental design with two independent treatment groups and three measurement points, no between-group differences were revealed. All in all, results show that conceptual and procedural knowledge are much more strongly interrelated than one would expect from all previous studies which, using only manifest measures, were more prone to measurement errors. Therefore, the *Iterative Model* could be neither validated nor invalidated. Although the distinction between both kinds of knowledge remains useful from a heuristic point of view, cognitive competence in a subject area like mathematics seems to rely on the integration of well-developed procedural as well as conceptual knowledge.

The Impact of Grammatical Language Tools on Conceptual Structures

From the very beginning, humans structure their complex environment by grouping stimuli according to their similarity by various criteria. In the case of concrete objects, shape is a very salient feature strongly calling for categorization. Another common way of classifying objects uses thematic relations which can be based on co-occurrence or interaction in space or time, or functional or causal relationships (e. g., carrot/rabbit, scissors/paper, cow/milk). Still another basis of conceptual structuring already found in younger children concerns nonobvious taxonomic relations. Taxonomic categories are differentiated into levels of varying specificity (e. g., animal, dog, collie) related by class inclusion (e. g., a collie is a dog, a dog is an animal, a collie is an animal).

Three kinds of tasks were used to find out whether objects are grouped on the basis of their form, or of their thematic or taxonomic relations, respectively:

(1) In the nonlexical classification task, participants were asked to select the item that best matched the standard object.

(2) In the word learning task, participants were asked to extend a novel label that was given to the standard ("This is called FEP. What else is called FEP?").

(3) In the property induction task, participants were taught a novel nonperceptual property of the standard object (e. g., "Look, this one has IDOFORM inside") and asked to select the item that would be most likely to have the same property.

According to the widely accepted linguistic relativity approach, the conceptual structure of children and of adults can be affected by the grammar of their mother tongue. Cross-language studies have revealed that certain grammar elements can affect cognitive development mainly by influencing the foci of children's habitual attention, thus leading them to engage in certain processes of categorization and conceptualization. A particularly strong impact of grammatical structures, such as count/mass syntax or gender grammar, has been shown by several studies. The grammatical structure that was the focus of Henrik Saalbach's research was the Chinese system of numeral classifiers by which nouns are grouped into linguistic categories, just as they are by the system of grammatical gender in German. Unlike gender systems, however, there are more than 20 classifier categories in Chinese that are actually used, organized around semantic features, such as shape, function, or animacy. For example, tiao, a common Chinese classifier for long and flexible things, includes many things from different taxonomic categories—fish, dogs, rivers, roads, pants, and more—and even crosses the animate/inanimate boundary (see Figure 5).

The core question was whether the classifier system affects children's concepts in any significant ways. According to the semantic nature of classifier categories (i. e., the fact that shape is an important semantic feature), it was hypothesized that both Chinese children and adults may have a stronger tendency than speakers of nonclassifier languages to organize objects on the basis of their shape rather than on taxonomic or thematic relations.

Figure 5. Objects for which the classifier "tiao" is used in the Chinese language.

"Words serve as invitation to form categories." Waxman

German and Chinese speakers of three age groups (3-year-olds, 5-year-olds, adults) were tested on a match-to-standard generalization paradigm in the three mentioned formats: nonlexical classification, word learning, and property inference. In all task contexts, a child was shown a picture of the standard object (e. g., banana), and was asked to choose one item out of three choice items: a taxonomic item from the same super-ordinate category (grape), a shape/classifier item (feather), and a thematic item (monkey). All objects were represented by colored line drawings (see Figure 6).

Differences between German and Chinese participants were only found in the nonlexical classification task (see Figure 7). Chinese speakers, especially children, pay more attention to shape similarity than German speakers, given that shape is a prominent semantic feature in classifier categories. In the property inference task, the majority of participants referred to taxonomy relations. In the word learning task, Chinese as well as German children judged on the basis of shape, while all adults considered taxonomy relations.

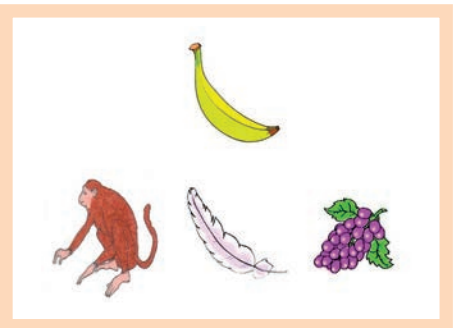


Figure 6. Type of relationships to banana: thematic (monkey), shape (feather), taxonomic (grape).

In sum, this research demonstrates that children are extremely flexible and adaptive learners who make use of various environmental cues which may help them to structure the complexity of the world. Grammatical language tools are among such cues and are particularly used in situations not constrained by any more salient information. The results suggest that deliberate language input is important for young children's environment. Long before the youngsters can actively use the correct grammar rules in language production, they make use of them when complex incoming information has to be handled to form useful conceptual structures.

Activities of the ENTERPRISE Group Continued at the ETH Zürich

Since 2004, Elsbeth Stern has become increasingly involved in discussions on whether neuroscience can inform educational reform (Stern, 2005a, 2005b). On the one hand, she felt responsible for scaling down unrealistic expectations about the educational implications of neuroscience and emphasizing the importance of more traditional empirical educational research. On the other hand, she acknowledged that collaboration between neuroscience and educational research provides unique opportunities to gain insight into the interaction between mind and brain in the cultural context. In 2005, Elsbeth Stern and Michael Schneider headed and coordinated the research program *Neuroscience, Instruction, and Learning* (NIL) which is funded by the German Federal Ministry of Education and Science. Meanwhile, NIL provides funding for six research projects in which neuroscientists and educational researchers address questions of brain functioning during school-related activities.

In 2006, the ENTERPRISE group moved to the Swiss Federal Institute of Technology Zurich (ETH Zürich), where Elsbeth Stern was appointed Professor for Research on Learning and Instruction, and where she heads the masters program for teacher students in secondary higher education. Despite this shift toward research in learning and instruction in the upper grades, the theoretical focus of

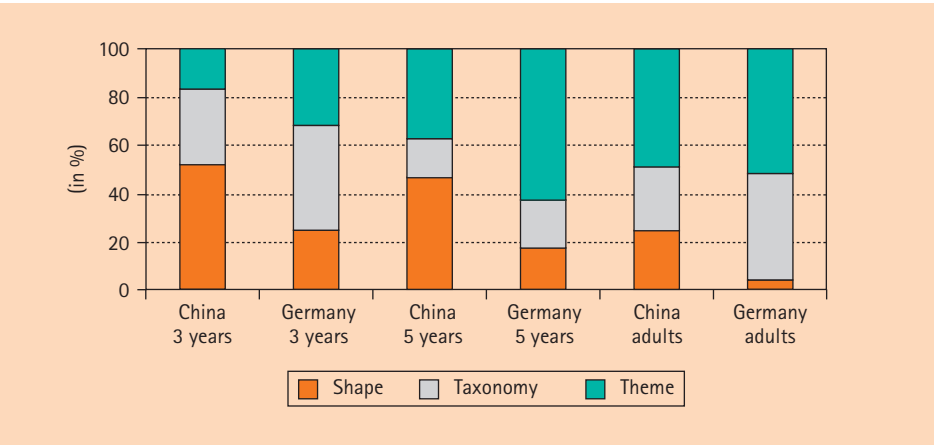


Figure 7. Percentage of German and Chinese speakers who chose the three kinds of relationships in the nonlexical classification task.

the ENTERPRISE project has been maintained. The major concern will be to explore how, in the field of science, learning with cognitive tools may optimize the way incoming information is connected with knowledge that already exists in the mind. In continuation of the research on the interaction between intelligence and knowledge (Grabner, Neubauer, & Stern, 2006), special emphasis will be placed on the question of how individual differences in cognitive resources affect learning in the area of science and engineering.

Key References

Grabner, R. H., Neubauer, A. C., & **Stern, E.** (2006). Superior performance and neural efficiency: The impact of intelligence and expertise. *Brain Research Bulletin, 69,* 422–439.

Stern, E. (2005a). Brain goes to school. [Review of the book The learning brain: Lessons for education]. *Trends in Cognitive Science, 9,* 563–565.

Stern, E. (2005b). Editorial: Pedagogy meets neuroscience. *Science, 310,* 745.

Projects of W. Edelstein, Director Emeritus

Learning and Living Democracy: A Program of Education for Democracy and Citzenship in 13 German States

Around the turn of the century, in the face of right-wing extremist acts of violence and xenophobic attacks on individuals and refugee asylums, the Freudenberg Foundation convened a group of social scientists, experts in youth development, and educators and community workers to discuss the problems of adolescent right-wing extremism in Germany as well as strategies to deal with it with some hope of success. It soon became clear that it was essential to distinguish between police *repression* of violent and criminal acts, social *intervention* in view of a regional response to the local situation—a type of action mostly to be entrusted to social workers—and, finally, general *prevention* defined as a task of education for democracy in the schools. For all three domains of action, the Freudenberg group was able to marshal a number of knowledgeable experts (Edelstein, 2005a, 2005b).

For the prevention aspect, Wolfgang Edelstein and Peter Fauser, professor of educational science at the University of Jena, undertook to develop a concept of educational action in schools. Their report served as a basis for deliberation in the Joint Federal and States' Commission on Educational Planning and Research (BLK), which decided to implement a program of democracy or citizenship education ultimately involving some 170 schools in 13 of the 16 German States. The report specified four modules or areas of action in the schools: instructional strategies and interaction processes (including feedback and assessment modalities), projects involving democratic concerns and procedures, democratic participation and governance in the schools, and opening the school to participation in community life. The report was published by the Commission in the year 2001 under the title "Demokratie lernen und leben" (Learning and Living Democracy), and became the basic document of reference in the program. (For the theoretical underpinnings of the report and, ultimately, of the program itself see the previous Research Report [2002–2004, pp. 142–143].)

The program has now been running for 5 years, coming to its close on March 31, 2007. It has been coordinated by a staff center at the Department of Education at the Free University Berlin and headed by professors Gerhard de Haan and Wolfgang Edelstein. The center coordinated 26 school networks in the participating States, produced a remarkably effective internet platform, and published 97 publications (mostly materials for practical use by teachers: "building blocks" for democratic schools; a set of "Contributions to Democracy Education" that provide the basis for a series to be published by Beltz starting in 2007; and three book publications, one of which was the starting volume of the above mentioned series. This volume is a major contribution to the development of a more substantial role of democracy education in German schools, defining standards, criteria and learning opportunities for citizenship education in secondary schools (de Haan, Edelstein, & Eikel, 2007).

On the face of it, the program has been effective and quite successful. In fact, we shall have to await the evaluation results for a realistic appraisal of effects. There has been an initial formative evaluation and a summative evaluation of outcomes as well as of processes (i. e., a longitudinal sequence of quantitative assessments). The data will be analyzed in the coming months. Moreover, some 30 qualitative case analyses have been completed. A group of some 120 transfer agents have been trained and certified as democracy counsellors in a 3-year sequence of courses involving, for each counsellor, a set of four selected modules (out of a total of 12 available modules) plus an obligatory module on managing democratic school development. Finally, an Association for Democratic Education has been founded. Its main goal is to maintain and extend the activities developed and orchestrated in the program,

www.blk-demokratie.de

Key References

de Haan, G., **Edelstein, W.,** & Eikel, A. (2007). *Qualitätsrahmen Demokratiepädagogik: Demokratische Handlungskompetenz fördern, demokratische Schulqualität entwickeln* (Vols. 1–7). Weinheim: Beltz.

Edelstein, W. (2005a). The rise of a right-wing culture among German youth. The effects of social transformation, identity construction, and context. In D. B. Pillemer & S. H. White (Eds.), *Developmental psychology and social change: Research, history and policy* (pp. 314–351). Cambridge, UK: Cambridge University Press.

www.degede.de

help to transfer these into the practice of schools, and to serve the development of a democratic school culture that is characterized by the spirit of recognition, the practice of participation, the fostering of self-efficacy, and the sharing of responsibility.

The basic principle leading to this construction is the maxim that an individual's experience of a democratic form of life is the fundamental condition for the development of democratic habits of the heart. Complex societies with highly abstract social and political organization and formal rules of representative government require a democratic culture of the school that provides all children and youth with the essential set of opportunities to acquire these habits. Such habits, it is believed, are essential in order to obviate the disaffection with democracy that is characteristic of right-wing extremism among adolescents but also, as many studies of political attitudes across Europe have shown, among an increasing number of adults.

When starting the program in 2002, the focus was on the situation and political perspectives of youth in Germany. Only in the course of the program's implementation did its coordinators realize that the European Union, the Council of Europe, and the OECD were all committed, each in a somewhat different manner, to the enhancement of the norms and values of citizenship in European schools: Human rights, democracy, social inclusion, and sustainable development were to become the maxims and normative criteria of education in European schools (Eurydice, 2005). The goals of the European Year of Citizenship through Education 2005 converge with the goals of the program "Learning and Living Democracy" and the policies of its successors in the Association for Democratic Education in Germany. The program shares with OECD's Defining and Selecting Competencies platform (DeSeCo; Rychen & Salganic 2001, 2003) the insistence on individual autonomy and social competence (Edelstein & de Haan, 2004). But it also shares with the Council of Europe the critical assessment of the compliance gap between the policy level and the level of practice and implementation (see Bîrcea, Kerr, Mikkelsen et al., 2004). Finally, however, the program described in these pages has been able to produce, and to provide to interested actors and agencies, a systematic set of criteria, standards, competencies, learning opportunities and evaluation concepts that will serve the development of democratic schools beyond the confines of the German States that participated in the program.

Key Reference

Edelstein, W., & de Haan, G. (2004). Empfehlung 5: Lernkonzepte für eine zukunftsfähige Schule – von Schlüsselkompetenzen zum Curriculum. In Heinrich-Böll-Stiftung und Bildungskommission der Heinrich-Böll-Stiftung (Ed.), *Selbstständig lernen: Bildung stärkt Zivilgesellschaft: Sechs Empfehlungen der Bildungskommission der Heinrich-Böll-Stiftung* (pp. 130–188). Weinheim: Beltz.

Publications 2005–2006

(last update: May 2007)

Artelt, C. (2006). Lernstrategien in der Schule. In H. Mandl & H. F. Friedrich (Eds.), *Handbuch Lernstrategien* (pp. 337–351). Göttingen: Hogrefe.

Artelt, C. (2005). Cross-cultural approaches to measuring motivation. *Educational Assessment, 10,* 231–255.

Artelt, C., McElvany, N., Christmann, N., Richter, T., Groeben, N., Köster, J., Schneider, W., **Stanat, P.,** Ostermeier, C., Schiefele, U., Valtin, R., & Ring, K. (2005). *Förderung von Lesekompetenz – Eine Expertise. Bonn: Bundesministerium für Bildung und Forschung* (BMBF).

Baeriswyl, F., Wandeler, C., **Trautwein, U.,** & Oswald, K. (2006). Leistungstest, Offenheit von Bildungsgängen und obligatorische Beratung der Eltern: Reduziert das Deutschfreiburger Übergangsmodell die Effekte des sozialen Hintergrunds bei Übergangsentscheidungen? *Zeitschrift für Erziehungswissenschaft, 9,* 373–392.

Baltes, P. B. (2007). Foreword. In M. G. Ash & T. Sturm (Eds.), *Psychology's territories: Historical and contemporary perspectives form different disciplines* (pp. IX–XIV). Mahwah, NJ: Erlbaum.

Baumert, J. (2006). Was wissen wir über die Entwicklung von Schulleistungen? *Pädagogik, 58* (4), 40–46.

Baumert, J. (2005). Schlussfolgerungen mit Blick auf Hochschulen, Bund und Länder: Akzentsetzungen für die Empirische Bildungsforschung. In H. Mandl & B. Kopp (Eds.), *Impulse für die Bildungsforschung: Stand und Perspektiven: Dokumentation eines Expertengesprächs* (pp. 127–137). Berlin: Akademie-Verlag.

Baumert, J., Brunner, M., Lüdtke, O., & **Trautwein, U.** (2007). Was messen internationale Schulleistungsstudien? Resultate kumulativer Wissenserwerbsprozesse: Eine Antwort auf Heiner Rindermann. *Psychologische Rundschau, 58,* 118–128.

Baumert, J., Carstensen, C. H., & Siegle, T. (2005). Wirtschaftliche, soziale und kulturelle Lebensverhältnisse und regionale Disparitäten des Kompetenzerwerbs. In M. Prenzel, J. Baumert, W. Blum, R. Lehmann, D. Leutner, M. Neubrand, et al. (Eds.), *PISA 2003: Der zweite Vergleich der Länder in Deutschland – Was wissen und können Jugendliche?* (pp. 323–365). Münster: Waxmann.

Baumert, J., & Köller, O. (2005). Sozialer Hintergrund, Bildungsbeteiligung und Bildungsverläufe im differenzierten Sekundarschulsystem. In V. Frederking, H. Heller, & A. Scheunpflug (Eds.), *Nach PISA: Konsequenzen für Schule und Lehrerbildung nach zwei Studien* (pp. 9–21). Wiesbaden: VS Verlag für Sozialwissenschaften.

Baumert, J., & **Kunter, M.** (2006). Stichwort: Professionelle Kompetenz von Lehrkräften. *Zeitschrift für Erziehungswissenschaft, 9,* 469–520.

Baumert, J., & **Maaz, K.** (2006). Das theoretische und methodische Konzept von PISA zur Erfassung sozialer und kultureller Ressourcen der Herkunftsfamilie: Internationale und nationale Rahmenkonzeption. In J. Baumert, P. Stanat, & R. Watermann (Eds.), *Herkunftsbedingte Disparitäten im Bildungswesen: Differenzielle Bildungsprozesse und Probleme der Verteilungsgerechtigkeit: Vertiefende Analysen im Rahmen von PISA 2000* (pp. 11–29). Wiesbaden: VS Verlag für Sozialwissenschaften.

Baumert, J., & **Stanat, P.** (2006). Internationale Schulleistungsvergleiche. In D. H. Rost (Ed.), *Handwörterbuch Pädagogische Psychologie* (3rd, rev. ed., pp. 291–302). Weinheim: Beltz.

Baumert, J., Stanat, P., & **Watermann, R.** (Eds.). (2006a). *Herkunftsbedingte Disparitäten im Bildungswesen: Differenzielle Bildungsprozesse und Probleme der Verteilungsgerechtigkeit: Vertiefende Analysen im Rahmen von PISA 2000.* Wiesbaden: VS Verlag für Sozialwissenschaften.

Baumert, J., Stanat, P., & **Watermann, R.** (2006b). Schulstruktur und die Enstehung differenzieller Lern- und Entwicklungsmilieus. In J. Baumert, P. Stanat, & R. Watermann (Eds.), *Herkunftsbedingte Disparitäten im Bildungswesen: Differenzielle Bildungsprozesse und Probleme der Verteilungsgerechtigkeit: Vertiefende Analysen im Rahmen von PISA 2000* (pp. 95–188). Wiesbaden: VS Verlag für Sozialwissenschaften.

Baumert, J., Stanat, P., & **Watermann, R.** (2006c). Vorwort. In J. Baumert, P. Stanat, & R. Watermann (Eds.), *Herkunftsbedingte Disparitäten im Bildungswesen: Differenzielle Bildungsprozesse und Probleme der Verteilungsgerechtigkeit: Vertiefende Analysen im Rahmen von PISA 2000* (pp. 9–10). Wiesbaden: VS Verlag für Sozialwissenschaften.

Baumert, J., & Tillmann, K.-J. (2005). Vorwort. In R. Watermann, S. Thurn, K.-J. Tillmann, & P. Stanat (Eds.), *Die Laborschule im Spiegel ihrer PISA-Ergebnisse: Pädagogisch-didaktische Konzepte und empirische Evaluation reformpädagogischer Praxis* (pp. 9–11). Weinheim: Juventa.

Becker, M., Lüdtke, O., Trautwein, U., & **Baumert, J.** (2006). Leistungszuwachs in Mathematik: Evidenz für einen Schereneffekt im mehrgliedrigen Schulsystem? *Zeitschrift für Pädagogische Psychologie, 20,* 233–242.

Becker, M., Trautwein, U., Lüdtke, O., Cortina, K. S., & **Baumert, J.** (2006). Bildungsexpansion und kognitive Mobilisierung. In A. Hadjar & R. Becker (Eds.), *Die Bildungsexpansion: Erwartete und unerwartete Folgen* (pp. 63–89). Wiesbaden: VS Verlag für Sozialwissenschaften.

Brunner, M., Artelt, C., Krauss, S., & **Baumert, J.** (2007). Coaching for the PISA test. *Learning and Instruction, 17,* 111–122.

Brunner, M., & **Krauss, S.** (2005). Der Mathematikunterricht an der Laborschule: Empirische Befunde zu den mathematischen Kompetenzen. In R. Watermann, S. Thurn, K.-J. Tillmann, & P. Stanat (Eds.), *Die Laborschule im Spiegel ihrer PISA-Ergebnisse: Pädagogisch-didaktische Konzepte und empirische Evaluation reformpädagogischer Praxis* (pp. 121–131). Weinheim: Juventa.

Brunner, M., Kunter, M., Krauss, S., Baumert, J., Blum, W., **Dubberke, T.,** Jordan, A., **Klusmann, U., Tsai, Y.-M.,** & Neubrand, M. (in press). Wie erwerben Mathematiklehrkräfte ihr Fachwissen und ihr fachdidaktisches Wissen? *Zeitschrift für Erziehungswissenschaft.*

Brunner, M., Kunter, M., Krauss, S., Baumert, J., Blum, W., **Dubberke, T.,** et al. (2006). Welche Zusammenhänge bestehen zwischen dem fachspezifischen Professionswissen von Mathematiklehrkräften und ihrer Ausbildung sowie beruf-

lichen Fortbildung? *Zeitschrift für Erziehungswissenschaft, 9,* 521–544.

Brunner, M., Kunter, M., Krauss, S., Klusmann, U., Baumert, J., Blum, W., et al. (2006). Die professionelle Kompetenz von Mathematiklehrkräften: Konzeptualisierung, Erfassung und Bedeutung für den Unterricht: Eine Zwischenbilanz des COACTIV-Projekts. In M. Prenzel & L. Allolio-Näcke (Eds.), *Untersuchungen zur Bildungsqualität von Schule: Abschlussbericht des DFG-Schwerpunktprogramms* (pp. 54–82). Münster: Waxmann.

Brunner, M., & Süß, H.-M. (2005). Analyzing the reliability of multidimensional measures: An example from intelligence research. *Educational and Psychological Measurement, 65,* 227–240.

Chang, P.–H. (2005). *Transformation of vocational secondary schools: A study of the vocational Gymnasium in Germany.* Opladen: Barbara Budrich.

Cortina, K. S., Alfeld, C., Köller, O., **Baumert, J.,** & Eccles, J. S. (2006). Zur Bedeutung innerer und äußerer Differenzierung für den Bildungsverlauf – eine vergleichende Längsschnittanalyse zum Hochschulübergang. In A. Ittel, L. Stecher, H. Merkens, & J. Zinnecker (Eds.), *Jahrbuch Jugendforschung* (Vol. 6, pp. 15–32). Wiesbaden: VS Verlag für Sozialwissenschaften.

Cortina, K. S., **Baumert, J.,** Leschinsky, A., Mayer, K. U., & Trommer, L. (Eds.). (in press). *Das Bildungswesen in der Bundesrepublik Deutschland.* Reinbek: Rowohlt.

Dieckmann, A., & **Krauss, S.** (2005). Wenn weniger Wissen mehr sein kann: Einfache Heuristiken zur psychologischen Entscheidungsfindung. *Zeitschrift für Erziehungswissenschaft, 8,* 187–201.

Edelstein, W. (in press). Demokratie als Praxis und Demokratie als Wert: Überlegungen zu einer demokratiepädagogisch aktiven Schule. *Pädagogische Führung.*

Edelstein, W. (in press). Zur Genese des rechtsextremen Potentials in Deutschland und mögliche Antworten seitens der Schule. In C. Petry & E. Welz (Eds.), *Demokratie lernen und leben* (Vol. 3). Weinheim: Beltz.

Edelstein, W. (2007). Schule als Armutsfalle – wie lange noch? *Schulmagazin, 5–10* (1), 53–56.

Edelstein, W. (2006a). Bildung und Armut: Der Beitrag des Bildungssystems zur Vererbung und zur Bekämpfung von Armut. *Zeitschrift für Soziologie der Erziehung und Sozialisation, 26,* 120–134.

Edelstein, W. (2006b). Demokratie lernen: Kompetenzen für die Zukunft und Lehren aus der Vergangenheit. In A. Rogoss, E. Hemmer, & E. Zimmer (Eds.), *Georg Elser – ein Attentäter als Vorbild* (pp. 133–140). Bremen: Edition Temmen.

Edelstein, W. (2006c). Entgegenkommmende Verhältnisse – Aufgaben der Ganztagsschule für die Zivilgesellschaft. In Arbeitsgemeinschaft für Kinder- und Jugendhilfe – AGJ (Ed.), *Zukunftsprojekt: Gemeinsame Gestaltung von Lern- und Lebenswelten. Zusammenspiel von Kinder- und Jugendhilfe & Schule im Sozialraum* (pp. 85–93). Berlin: Arbeitsgemeinschaft für Kinder- und Jugendhilfe.

Edelstein, W. (2006d). Extremist youth in Germany: The role of history, development, and cohort experience. In C. Daiute, Z. Beykont, C. Higson-Smith, & L. Nucci (Eds.), *International perspectives on youth conflict and development* (pp. 43–56). Oxford: Oxford University Press.

Edelstein, W. (2006e). Kompetenzen für die Zivilgesellschaft. In R. Boenicke, A. Hund, T. Rihm, & V. Strittmatter-Haubold (Eds.), *Innovativ Schule entwickeln: Kompetenzen, Praxis und Visionen. 7. Heidelberger Dienstagsseminar* (pp. 13–26). Heidelberg: Mattes (Schriftenreihe der Pädagogischen Hochschule Heidelberg 47).

Edelstein, W. (2006f). Zur Förderung der individuellen und sozialen Entwicklung in Ganztagsschulen. *Recht der Jugend und des Bildungswesens, 54,* 3–10.

Edelstein, W. (2005a). The rise of a right-wing culture among German youth: The effects of social transformation, identity construction, and context. In D. B. Pillemer & S. H. White (Eds.), *Developmental psychology and social change: Research, history and policy* (pp. 314–351). Cambridge, UK: Cambridge University Press.

Edelstein, W. (2005b). The rise of right-wing extremist youth culture in postunification Germany. In L. Nucci (Ed.), *Conflict, contradiction, and contrarian elements in moral development and education* (pp. 157–172). Mahwah, NJ: Erlbaum.

Edelstein, W. (2005c). Wissenschaftsdynamik und Gesellschaftsentwicklung: Skizze eines Forschungsprogramms. In R. M. Kiesow, R. Ogorek, & S. Simitis (Eds.), *Summa: Dieter Simon zum 70. Geburtstag* (pp. 133–140). Frankfurt a. M.: Klostermann (Studien zur europäischen Rechtsgeschichte 193).

Edelstein, W. (2005d). Zukunftsfeste Kompetenzen: Werte für eine nachhaltige Bildung. In A. Knauf, K. Liebers, & A. Prengel (Eds.), *Länderübergreifende Curricula für die Grundschule* (pp. 7–11). Bad Heilbrunn: Klinkhardt.

Edelstein, W., & Grundmann, M. (2006). The persistence of social class: A macro-micro analytical approach to educational performance and attainment in three generations. In M. Grundmann, D. Dravenau, U. H. Bittlingmayer, & W. Edelstein (Eds.), *Handlungsbefähigung und Milieu: Zur Analyse milieuspezifischer Alltagspraktiken und ihrer Ungleichheitsrelevanz* (pp. 96–153). Berlin: LIT-Verlag (Individuum und Gesellschaft 2).

Edelstein, W., & de Haan, G. (2006). Lernkonzepte für eine zukunftsfähige Schule. In K. Gerlof & A. Ulrich (Eds.), *Die Verfasstheit der Wissensgesellschaft* (pp. 238–249). Münster: Westfälisches Dampfboot.

Edelstein, W., & Nunner-Winkler, G. (Eds.). (2005). *Morality in context.* Amsterdam: Elsevier (Advances in psychology 137).

Felbrich, A., **Hardy, I.,** & **Stern, E.** (in press). Mathematische Kompetenz. In M. Hasselhorn & W. Schneider (Eds.), *Handbuch der Psychologie: Vol. Entwicklungspsychologie.* Göttingen: Hogrefe.

Gerlach, E., **Trautwein, U.,** & **Lüdtke, O.** (in press). Selbstkonzept und Effekte der sozialen Umwelt. In A. Conzelmann & F. Hänsel (Eds.), *Sport und Selbstkonzept.* Schorndorf: Hofmann.

Gerlach, E., **Trautwein, U.,** & **Lüdtke, O.** (2007). Referenzgruppeneffekte im Sportunterricht: Kurz- und langfristig negative Effekte von sportlichen Klassenkameraden auf das Selbstkonzept. *Zeitschrift für Sozialpsychologie, 38,* 73–83.

Grabner, R. H., Neubauer, A. C., & **Stern, E.** (2006). Superior performance and neural efficiency: The impact of intelligence and expertise. *Brain Research Bulletin, 69,* 422–439.

Grabner, R. H., **Stern, E.,** & Neubauer, A. C. (2007). Individual differences in chess expertise: A psychometric investigation. *Acta Psychologica, 124,* 398–420.

Grundmann, M., Bittlingmayer, U. H., Dravenau, D., & **Edelstein, W.** (2006). Bildungsstrukturen und sozialstrukturelle Sozialisation. In M. Grundmann, D. Dravenau, U. H. Bittlingmayer, & W. Edelstein (Eds.), *Handlungsbefähigung und Milieu: Zur Analyse milieuspezifischer Alltagspraktiken und ihrer Ungleichheitsrelevanz* (pp. 13–35). Berlin: LIT-Verlag (Individuum und Gesellschaft 2).

Grundmann, M., Dravenau, D., Bittlingmayer, U. H., & **Edelstein, W.** (Eds.). (2006). *Handlungsbefähigung und Milieu: Zur Analyse milieuspezifischer Alltagspraktiken und*

ihrer Ungleichheitsrelevanz. Münster: LIT-Verlag (Individuum und Gesellschaft 2).

de Haan, G., **Edelstein, W.,** & Eikel, A. (Eds.). (2007). *Qualitätsrahmen Demokratiepädagogik: Demokratische Handlungskompetenz fördern, demokratische Schulqualität entwickeln* (Vols. 1–7). Weinheim: Beltz.

Hardy, I., Jonen, A., Möller, K., & **Stern, E.** (2006). Effects of instructional support in constructivist learning environments for elementary school students' understanding of "floating and sinking". *Journal of Educational Psychology, 98,* 307–325.

Hardy, I., Schneider, M., Jonen, A., **Stern, E.,** & Möller, K. (2005). Fostering diagrammatic reasoning in science education. *Swiss Journal of Psychology, 64,* 207–217.

Hardy, I., & Stadelhofer, B. (2006). Concept maps wirkungsvoll als Strukturierungshilfen einsetzen: Welche Rolle spielt die Selbstkonstruktion? *Zeitschrift für Pädagogische Psychologie, 20,* 175–187.

Jonkmann, K., Köller, O., & **Trautwein, U.** (2007). Englischleistungen am Ende der Sekundarstufe II. In U. Trautwein, O. Köller, R. Lehmann, & O. Lüdtke (Eds.), *Schulleistungen von Abiturienten: Regionale, schulformbezogene und soziale Disparitäten* (pp. 113–142). Münster: Waxmann.

Jordan, A., Ross, N., **Krauss, S., Baumert, J.,** Blum, W., Neubrand, M., et al. (2006). *Klassifikationsschema für Mathematikaufgaben: Dokumentation der Aufgabenkategorisierung im COACTIV-Projekt.* Berlin: Max-Planck-Institut für Bildungsforschung (Materialien aus der Bildungsforschung 81).

Klusmann, U., Kunter, M., Trautwein, U., & **Baumert, J.** (2006). Lehrerbelastung und Unterrichtsqualität aus der Perspektive von Lehrenden und Lernenden. *Zeitschrift für Pädagogische Psychologie, 20* (3), 161–173.

Klusmann, U., Trautwein, U., & **Lüdtke, O.** (2005). Intrinsische und extrinsische Lebensziele: Reliabilität und Validität einer deutschen Fassung des Aspirations Index. *Diagnostica, 51,* 40–51.

Köller, O., **Trautwein, U.,** Cortina, K. S., & **Baumert, J.** (2006). Rezeptive Kompetenzen in Englisch am Ende der gymnasialen Oberstufe: Verankerung deutscher Abiturienten am Gemeinsamen Europäischen Referenzrahmen für die Sprachen. *Unterrichtswissenschaft, 34,* 239–255.

Köller, O., **Trautwein, U., Lüdtke, O.,** & **Baumert, J.** (2006). Zum Zusammenspiel von schulischer Leistung, Selbstkonzept und Interesse in der gymnasialen Oberstufe. *Zeitschrift für Pädagogische Psychologie, 20,* 27–39.

Krauss, S., Baumert, J., Blum, W., Neubrand, M., Jordan, A., **Brunner, M.,** et al. (2006). Die Konstruktion eines Tests zum fachlichen und zum fachdidaktischen Wissen von Mathematiklehrkräften. In *Beiträge zum Mathematikunterricht 2006: Vorträge auf der 40. Tagung für Didaktik der Mathematik vom 6.3. bis 10.3.2006 in Osnabrück* (pp. 319–322). Hildesheim: Franzbecker.

Krauss, S., & **Brunner, M.** (2005). Der naturwissenschaftliche Unterricht an der Laborschule: Empirische Befunde zu den naturwissenschaftlichen Kompetenzen. In R. Watermann, S. Thurn, K.-J. Tillmann, & P. Stanat (Eds.), *Die Laborschule im Spiegel ihrer PISA-Ergebnisse: Pädagogisch-didaktische Konzepte und empirische Evaluation reformpädagogischer Praxis* (pp. 155–166). Weinheim: Juventa.

Kreuter, F., **Maaz, K.,** & **Watermann, R.** (2006). Der Zusammenhang zwischen der Qualität von Schülerangaben zur sozialen Herkunft und den Schulleistungen. In K.-S. Rehberg (Ed.), *Soziale Ungleichheit, kulturelle Unterschiede* (pp. 3465–3478). Frankfurt a. M.: Campus.

Kreuter, F., **Maaz, K.,** & **Watermann, R.** (2005). Messung sozialer Herkunft in Schulleistungsuntersuchungen: Der Zusammenhang zwischen der Qualität von Schülerangaben und den Leistungen. In U. Engel (Ed.), *Bildung und soziale Ungleichheit: Methodologische und strukturelle Analysen* (pp. 9–35). Bonn: Informationszentrum Sozialwissenschaften.

Kunter, M. (2005). *Multiple Ziele im Mathematikunterricht.* Münster: Waxmann (Pädagogische Psychologie und Entwicklungspsychologie 51).

Kunter, M., & **Baumert, J.** (2006a). Linking TIMSS to research on learning and instruction: A re-analysis of the German TIMSS and TIMSS video data. In S. J. Howie & T. Plomp (Eds.), *Contexts of learning mathematics and science: Lessons learned from TIMSS* (pp. 335–351). London: Routledge.

Kunter, M., & **Baumert, J.** (2006b). Who is the expert? Construct and criteria validity of student and teacher ratings of instruction. *Learning Environments Research, 9,* 231–251.

Kunter, M., Baumert, J., & Köller, O. (in press). Effective classroom management and the development of subject-related interest. *Learning and Instruction.*

Kunter, M., Brunner, M., Baumert, J., Klusmann, U., Krauss, S., Blum, W., et al. (2005). Der Mathematikunterricht der PISA-Schülerinnen und -Schüler: Schulformunterschiede in der Unterrichtsqualität. *Zeitschrift für Erziehungswissenschaft, 8,* 502–520.

Kunter, M., Dubberke, T., Baumert, J., Blum, W., **Brunner, M.,** Jordan, A., et al. (2006). Mathematikunterricht in den PISA-Klassen 2004: Rahmenbedingungen, Formen und Lehr-Lernprozesse. In M. Prenzel, J. Baumert, W. Blum, R. Lehmann, D. Leutner, M. Neubrand et al. (Eds.), *PISA 2003: Untersuchungen zur Kompetenzentwicklung im Verlauf eines Schuljahres* (pp. 161–194). Münster: Waxmann.

Kunter, M., Klusmann, U., Dubberke, T., Blum, W., **Brunner, M.,** Jordan, A., **Krauss, S.,** Löwen, K., Neubrand, M., & **Tsai, Y.-M.** (in press). Linking aspects of teacher competence to their instruction: Results from the COACTIV project. In M. Prenzel (Ed.), *Studies on the educational quality of schools: The final report on the DFG priority program.* Münster: Waxmann.

Kunter, M., Stanat, P., & Klieme, E. (2005). Die Rolle von individuellen Eingangsvoraussetzungen und Gruppenmerkmalen beim kooperativen Lösen eines Problems. In E. Klieme, D. Leutner, & J. Wirth (Eds.), *Problemlösekompetenz von Schülerinnen und Schülern: Diagnostische Ansätze, theoretische Grundlagen und empirische Befunde der deutschen PISA-2000-Studie* (pp. 99–115). Wiesbaden: VS Verlag für Sozialwissenschaften.

Lang, F. R., & **Lüdtke, O.** (2005). Der Big Five-Ansatz der Persönlichkeitsforschung: Instrumente und Vorgehen. In S. Schumann (Ed.), *Persönlichkeit: Eine vergessene Größe der empirischen Sozialforschung* (pp. 29–39). Wiesbaden: VS Verlag für Sozialwissenschaften.

Limbird, C. K., & **Stanat, P.** (2006a). Prädiktoren von Leseverständnis bei Kindern deutscher und türkischer Herkunftssprache: Ergebnisse einer Längsschnittstudie. In A. Ittel & H. Mertens (Eds.),

Veränderungsmessung und Längsschnittstudien in der empirischen Erziehungswissenschaft (pp. 93–123). Wiesbaden: VS Verlag für Sozialwissenschaften.

Limbird, C. K., & **Stanat, P.** (2006b). Sprachförderung bei Schülerinnen und Schülern mit Migrationshintergrund: Ansätze und ihre Wirksamkeit. In J. Baumert, P. Stanat, & R. Watermann (Eds.), *Herkunftsbedingte Disparitäten im Bildungswesen: Differenzielle Bildungsprozesse und Probleme der Verteilungsgerechtigkeit: Vertiefende Analysen im Rahmen von PISA 2000* (pp. 257–307). Wiesbaden: VS Verlag für Sozialwissenschaften.

Lüdtke, O. (2006). *Persönliche Ziele junger Erwachsener.* Münster: Waxmann (Pädagogische Psychologie und Entwicklungspsychologie 53).

Lüdtke, O., Becker, M., Neumann, M., Nagy, G., Jonkmann, K., & **Trautwein, U.** (2007). Durchführung und methodische Grundlagen. In U. Trautwein, O. Köller, R. Lehmann, & O. Lüdtke (Eds.), *Schulleistungen von Abiturienten: Regionale, schulformbezogene und soziale Disparitäten* (pp. 31–42). Münster: Waxmann.

Lüdtke, O., & Köller, O. (2006). Mehrebenenanalyse. In D. H. Rost (Ed.), *Handwörterbuch Pädagogische Psychologie* (3rd, rev. ed., pp. 469–474). Weinheim: Beltz.

Lüdtke, O., Köller, O., Marsh, H. W., & **Trautwein, U.** (2005). Teacher frame of reference and the big-fish-little-pond effect. *Contemporary Educational Psychology, 30,* 263–285.

Lüdtke, O., Robitzsch, A., **Trautwein, U.,** Kreuter, F., & Ihme, J. M. (in press). Are there test administrator effects in large-scale educational assessments? Using cross-classified multilevel analysis to probe for effects on math achievement and sample attrition. *Methodology.*

Lüdtke, O., Robitzsch, A., **Trautwein, U.,** & Köller, O. (2007). Umgang mit fehlenden Werten in der psychologischen Forschung: Probleme und Lösungen. *Psychologische Rundschau, 58,* 103–117.

Lüdtke, O., & **Trautwein, U.** (2007). Aggregating to the between-person level in idiographic research designs: Personal goal research as an example of the need to distinguish between reliability and homogeneity. *Journal of Research in Personality, 41,* 230–238.

Lüdtke, O., Trautwein, U., Kunter, M., & **Baumert, J.** (2006a). Analyse von Lernumwelten: Ansätze zur Bestimmung der Reliabilität und Übereinstimmung von Schülerwahrnehmungen. *Zeitschrift für Pädagogische Psychologie, 20,* 85–96.

Lüdtke, O., Trautwein, U., Kunter, M., & **Baumert, J.** (2006b). Reliability and agreement of student ratings of the classroom environment: A reanalysis of TIMSS data. *Learning Environments Research, 9,* 215–230.

Lüdtke, O., Trautwein, U., Schnyder, I., & Niggli, A. (2007). Simultane Analysen auf Schüler- und Klassenebene: Eine Demonstration der konfirmatorischen Mehrebenen-Faktorenanalyse zur Analyse der Schülerwahrnehmungen am Beispiel der Hausaufgabenvergabe. *Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie, 39,* 1–11.

Maaz, K. (2006). *Soziale Herkunft und Hochschulzugang: Effekte institutioneller Öffnung im Bildungssystem.* Wiesbaden: VS Verlag für Sozialwissenschaften.

Maaz, K. (2005). Wie nutzen Jugendliche einen Computer? Prädiktoren vielfältiger Nutzungsmöglichkeiten. In U. Burrmann (Ed.), *Sport im Kontext von Freizeitengagements Jugendlicher: Aus dem Brandenburgischen Längsschnitt 1998–2002* (pp. 75–94). Köln: Sport & Buch Strauß.

Maaz, K., & **Baumert, J.** (in press). Bildungserträge: Soziale und regionale Disparitäten der Bildungsbeteiligung und des Kompetenzerwerbs. In K. S. Cortina, J. Baumert, A. Leschinsky, K. U. Mayer, & L. Trommer (Eds.), *Das Bildungswesen in der Bundesrepublik Deutschland: Strukturen und Entwicklungen* im Überblick. Reinbek: Rowohlt.

Maaz, K., & Burrmann, U. (2005). Freizeitmuster Jugendlicher. In U. Burrmann (Ed.), *Sport im Kontext von Freizeitengagements Jugendlicher: Aus dem Brandenburgischen Längsschnitt 1998–2002* (pp. 33–55). Köln: Sport & Buch Strauß.

Maaz, K., Gresch, C., Köller, O., & **Trautwein, U.** (2007). Schullaufbahnen, soziokulturelle Merkmale und kognitive Grundfähigkeiten. In U. Trautwein, O. Köller, R. Lehmann, & O. Lüdtke (Eds.), *Schulleistungen von Abiturienten: Regionale, schulformbezogene und soziale Disparitäten* (pp. 43–70). Münster: Waxmann.

Maaz, K., Hausen, C., **McElvany, N.,** & **Baumert, J.** (2006). Stichwort: Übergänge im Bildungssystem. *Zeitschrift für Erziehungswissenschaft, 9,* 299–327.

Maaz, K., Kreuter, F., & **Watermann, R.** (2006). Schüler als Informanten? Die Qualität von Schülerangaben zum sozialen Hintergrund. In J. Baumert, P. Stanat, & R. Watermann (Eds.), *Herkunftsbedingte Disparitäten im Bildungswesen: Differenzielle Bildungsprozesse und Probleme der Verteilungsgerechtigkeit: Vertiefende Analysen im Rahmen von PISA 2000* (pp. 31–59). Wiesbaden: VS Verlag für Sozialwissenschaften.

Maaz, K., & Waleschkowski, U. (2005). Erlebnispädagogik im Stadtteil: Entwicklungen moderner Erlebnispädagogik. *Deutsche Jugend, 53,* 309–316.

Maaz, K., & **Watermann, R.** (in press). Reproduktion oder Mobilität? Zur Wirkung familiärer Prozessmerkmale auf die Studienintention am Ende der gymnasialen Oberstufe. *Zeitschrift für Soziologie der Erziehung und Sozialisation.*

Maaz, K., & **Watermann, R.** (2006). Soziale Disparitäten im Bildungssystem im Spannungsfeld zwischen traditioneller Dreigliedrigkeit und institutionellen Erweiterungen. In K.-S. Rehberg (Ed.), *Soziale Ungleichheit, kulturelle Unterschiede* (pp. 2609–2620). Frankfurt a. M.: Campus.

Mähler, C., & **Stern, E.** (2006). Transfer. In D. H. Rost (Ed.), *Handwörterbuch Pädagogische Psychologie* (3rd, rev. ed., pp. 782–793). Weinheim: Beltz.

Marsh, H. W., Gerlach, E., **Trautwein, U., Lüdtke, O.,** & Brettschneider, W.-D. (in press). Physical self-concept and performance: Tests of reciprocal effects model of causal ordering in preadolescence. *Child Development.*

Marsh, H. W., Hau, K.-T., **Artelt, C., Baumert, J.,** & Peschar, J. L. (2006). OECD's brief self-report measure of educational psychology's most useful affective constructs: Cross-cultural, psychometric comparisons across 25 countries. *International Journal of Testing, 6,* 311–360.

Marsh, H. W., **Trautwein, U., Lüdtke, O.,** Köller, O., & **Baumert, J.** (in press). Big Fish Little Pond Effect: Persistent negative effects of selective high schools on self-concept after graduation. *American Educational Research Journal.*

Marsh, H. W., **Trautwein, U., Lüdtke, O.,** Köller, O., & **Baumert, J.** (2006). Integration

of multidimensional self-concept and core personality constructs: Construct validation and relations to well-being and achievement. *Journal of Personality, 74,* 403–456.

Marsh, H. W., **Trautwein, U., Lüdtke, O.,** Köller, O., & **Baumert, J.** (2005). Academic self-concept, interest, grades, and standardized test scores: Reciprocal effects models of causal ordering. *Child Development, 76,* 397–416.

McElvany, N. (in press). Die Bedeutung familiärer Merkmale für Lesekompetenz, Lesemotivation und Leseverhalten. *Psychologie in Erziehung und Unterricht.*

McElvany, N. (2007). *Förderung von Lesekompetenz im Kontext der Familie.* Münster: Waxmann.

McElvany, N., & **Artelt, C.** (in press-a). Das Berliner Eltern-Kind Leseprogramm: Konzeption und Effekte. *Psychologie in Erziehung und Unterricht.*

McElvany, N., & **Artelt, C.** (in press-b). Systematic reading training in the family: Development, implementation, and evaluation of the Berlin Parent-Child Reading Program. *Learning and Instruction.*

McElvany, N. & **Artelt, C.** (2006). Das Berliner Eltern-Kind Leseprogramm. *Diskurs Kindheits- und Jugendforschung, 1,* 157–159.

McElvany, N., Artelt, C., & Holler, S. (2005). Leseförderung in der Familie. In A. Sasse & R. Valtin (Eds.), *Lesen lehren* (pp. 151–167). Berlin: Deutsche Gesellschaft für Lesen und Schreiben.

Möller, K., **Hardy, I.,** Jonen, A., Kleickmann, T., & Blumberg, E. (2006). Naturwissenschaften in der Primarstufe: Zur Förderung konzeptuellen Verständnisses durch Unterricht und zur Wirksamkeit von Lehrerfortbildungen. In M. Prenzel & L. Allolio-Näcke (Eds.), *Untersuchungen zur Bildungsqualität von Schule: Abschlussbericht des DFG-Schwerpunktprogramms* (pp. 161–193). Münster: Waxmann.

Möller, J., & **Husemann, N.** (2006). Internal comparisons in everyday life. *Journal of Educational Psychology, 98,* 342–353.

Müller, A. G., Gallschütz, C., Puhr, K., & Thimm, K. (2005). Qualitätsstandards für Schulverweigererprojekte in Kooperation von Schule und Kinder- und Jugendhilfe. In B. Herz, K. Puhr, & H. Ricking (Eds.), *Problem Schulabsentismus: Wege zurück in die Schule* (pp. 273–288). Bad Heilbrunn: Klinkhardt.

Müller, A. G., & **Stanat, P.** (2006). Schulischer Erfolg von Schülerinnen und Schülern mit Migrationshintergrund: Analysen zur Situation von Zuwanderern aus der ehemaligen Sowjetunion und aus der Türkei. In J. Baumert, P. Stanat, & R. Watermann (Eds.), *Herkunftsbedingte Disparitäten im Bildungswesen: Differenzielle Bildungsprozesse und Probleme der Verteilungsgerechtigkeit: Vertiefende Analysen im Rahmen von PISA 2000* (pp. 221–255). Wiesbaden: VS Verlag für Sozialwissenschaften.

Müller, A. G., & Wegener, E. (2005). Kooperative Zusammenarbeit in Schulverweigererprojekten – Erfahrungen aus Projekten für schulabsente Kinder und Jugendliche. In B. Herz, K. Puhr, & H. Ricking (Eds.), *Problem Schulabsentismus: Wege zurück in die Schule* (pp. 289–303). Bad Heilbrunn: Klinkhardt.

Nagy, G., Garrett, J., **Trautwein, U.,** Cortina, K. S., **Baumert, J.,** & Eccles, J. (in press). Gendered high school course selection as a precursor of gendered occupational careers: The mediating role of self-concept and intrinsic value. In H. M. G. Watt & J. S. Eccles (Eds.), *Explaining gendered occupational outcomes: Examining individual and social explanations through school and beyond.* APA Books.

Nagy, G., Köller, O., & Heckhausen, J. (2005). Der Übergang von der Schule in die berufliche Erstausbildung: Wer die Sorgen scheut, wird von ihnen ereilt. *Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie, 37,* 156–167.

Nagy, G., Neumann, M., Becker, M., Watermann, R., Köller, O., **Lüdtke, O.,** et al. (2007). Mathematikleistungen am Ende der Sekundarstufe II. In U. Trautwein, O. Köller, R. Lehmann, & O. Lüdtke (Eds.), *Schulleistungen von Abiturienten: Regionale, schulformbezogene und soziale Disparitäten* (pp. 71–112). Münster: Waxmann.

Nagy, G., Trautwein, U., Baumert, J., Köller, O., & Garrett, J. (2006). Gender and course selection in upper secondary education: Effects of academic self-concept and intrinsic value. *Educational Research and Evaluation, 12,* 323–345.

Neubauer, A., & **Stern, E.** (2007). *Lernen macht intelligent: Warum Begabung gefördert werden muss.* München: Deutsche Verlags-Anstalt.

Neumann, M., & **Nagy, G.** (2007). Naturwissenschaftliche Grundbildung am Ende der Sekundarstufe II. In U. Trautwein, O. Köller, R. Lehmann, & O. Lüdtke (Eds.), *Schulleistungen von Abiturienten: Regionale, schulformbezogene und soziale Disparitäten* (pp. 143–159). Münster: Waxmann.

Neumann, M., Schnyder, I., **Trautwein, U.,** Niggli, A., **Lüdtke, O.,** & Cathomas, R. (in press). Schulformen als differenzielle Lernmilieus: Institutionelle und kompositionelle Effekte auf die Leistungsentwicklung im Fach Französisch. *Zeitschrift für Erziehungswissenschaft.*

Niggli, A., **Trautwein, U.,** Schnyder, I., **Lüdtke, O.,** & **Neumann, M.** (2007). Elterliche Unterstützung kann hilfreich sein, aber Einmischung schadet: Familiärer Hintergrund, elterliches Hausaufgabenengagement und Leistungsentwicklung. *Psychologie in Erziehung und Unterricht, 54,* 1–14.

Nunner-Winkler, G., & **Edelstein, W.** (2005). Introduction. In W. Edelstein & G. Nunner-Winkler (Eds.), *Morality in context* (pp. 1–24). Amsterdam: Elsevier (Advances in psychology 137).

Oesterreich, D. (2005a). *Demokratieerziehung in Mittel- und Osteuropa: Ergebnisse aus dem CIVIC-Education Projekt der IEA.* Berlin: Stiftung Erinnerung, Verantwortung und Zukunft.

Oesterreich, D. (2005b). Flight into security: A new approach and measure of the authoritarian personality. *Political Psychology, 26,* 275–297.

Prenzel, M., & **Baumert, J.** (2005). Editorial (Schwerpunkt: PISA-E). *Zeitschrift für Erziehungswissenschaft, 8,* 485–486.

Prenzel, M., **Baumert, J.,** Blum, W., Lehmann, R., Leutner, D., Neubrand, M., et al. (Eds.) (2006). *PISA 2003: Untersuchungen zur Kompetenzentwicklung im Verlauf eines Schuljahres.* Münster: Waxmann.

Prenzel, M., **Baumert, J.,** Blum, W., Lehmann, R., Leutner, D., Neubrand, M., et al. (2005). *PISA 2003: Der zweite Vergleich der Länder in Deutschland – Was wissen und können Jugendliche?* Münster: Waxmann.

Ramm, G., Prenzel, M., **Baumert, J.,** Blum, W., Lehmann, R., Leutner, D., et al. (Eds.). (2006). *PISA 2003: Dokumentation der Erhebungsinstrumente.* Münster: Waxmann.

Saalbach, H., & Imai, M. (2005). *Do classifier categories structure our concepts?* In *Proceedings of the 27th Annual Conference of the Cognitive Science Society* (unpaginated). Mahwah, NJ: Erlbaum.

Scheunpflug, A., **Baumert, J.,** & **Kunter, M.** (2006). Schwerpunkt: Professionelle Kompetenz von Lehrkräften. Editorial. *Zeitschrift für Erziehungswissenschaft, 9,* 465–467.

Schnyder, I., Niggli, A., Cathomas, R., & **Trautwein, U.** (2006). Unterscheidet sich das Hausaufgabenverhalten von Schülern aus unterschiedlichen Klassen? Befunde einer Mehrebenenanaylse im Fach Französisch [Are there any differences in homework behavior in students from different classroom? Results from a multilevel analysis in French as a second language]. *Revue suisse de sciences de l'education = Schweizerische Zeitschrift für Bildungswissenschaften, 28,* 295–478.

Schnyder, I., Niggli, A., Cathomas, R., **Trautwein, U.,** & **Lüdtke, O.** (2006). Wer lange lernt, lernt noch lange nicht viel mehr: Korrelate der Hausaufgabenzeit im Fach Französisch und Effekte auf die Leistungsentwicklung. *Psychologie in Erziehung und Unterricht, 53,* 107–121.

Schümer, G. (2006). Zur bildungspolitischen Bedeutung internationaler Schulleistungsstudien. In C. Brinkmann, S. Koch, & H. G. Mendius (Eds.), *Wirkungsforschung und Politikberatung – eine Gratwanderung?* Fachtagung am 24./25.2.2005 in Bonn (pp. 245–273). Nürnberg: Institut für Arbeitsmarkt- und Berufsforschung der Bundesagentur für Arbeit (Beiträge zur Arbeitsmarkt- und Berufsforschung 300).

Schümer, G. (2005). Schule und soziale Ungleichheit: Zum Umgang mit unterschiedlichen Lernvoraussetzungen in Deutschland und anderen OECD-Ländern. *Die Deutsche Schule, 97,* 266–284.

Schwanzer, A. D., **Trautwein, U., Lüdtke, O.,** & Sydow, H. (2005). Entwicklung eines Instruments zur Erfassung des Selbstkonzepts junger Erwachsener. *Diagnostica, 51,* 183–192.

Shajek, A., **Lüdtke, O.,** & **Stanat, P.** (2006). Akademische Selbstkonzepte bei Jugendlichen mit Migrationshintergrund. *Unterrichtswissenschaft, 34,* 125–145.

Sniehotta, F. F., **Nagy, G.,** Scholz, U., & Schwarzer, R. (2006). The role of action control in implementing intentions during the first weeks of behaviour change. *British Journal of Social Psychology, 45,* 87–106.

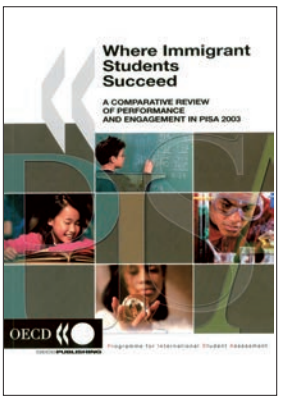
Stanat, P. (2006a). Disparitäten im schulischen Erfolg: Forschungsstand zur Rolle des Migrationshintergrunds. *Unterrichtswissenschaft, 34,* 98–124.

Stanat, P. (2006b). Schulleistungen von Jugendlichen mit Migrationshintergrund: Die Rolle der Zusammensetzung der Schülerschaft. In J. Baumert, P. Stanat, & R. Watermann (Eds.), *Herkunftsbedingte Disparitäten im Bildungswesen: Differenzielle Bildungsprozesse und Probleme der Verteilungsgerechtigkeit: Vertiefende Analysen im Rahmen von PISA 2000* (pp. 189–219). Wiesbaden: VS Verlag für Sozialwissenschaften.

Stanat, P. (2005a). Jungen und Mädchen in der Laborschule: Empirische Befunde zu Geschlechterunterschieden. In R. Watermann, S. Thurn, K.-J. Tillmann, & P. Stanat (Eds.), *Die Laborschule im Spiegel ihrer PISA-Ergebnisse: Pädagogisch-didaktische Konzepte und empirische Evaluation reformpädagogischer Praxis* (pp. 257–277). Weinheim: Juventa.

Stanat, P. (2005b). Sprachliches Lernen an der Laborschule: Empirische Befunde zur Lesekompetenz. In R. Watermann, S. Thurn, K.-J. Tillmann, & P. Stanat (Eds.), *Die Laborschule im Spiegel ihrer PISA-Ergebnisse: Pädagogisch-didaktische Konzepte und empirische Evaluation reformpädagogischer Praxis* (pp. 103–117). Weinheim: Juventa.

Stanat, P., Baumert, J., & **Müller, A. G.** (2005). Förderung von deutschen Sprachkompetenzen bei Kindern aus zugewanderten und sozial benachteiligten Familien: Evaluationskonzeption für das Jacobs-Sommercamp Projekt. *Zeitschrift für Pädagogik, 51,* 856–875.



Stanat, P., & **Christensen, G.** (2006). *Where immigrant students succeed: A comparative review of performance and engagement in PISA 2003.* Paris: OECD.

Stanat, P., & **Lüdtke, O.** (in press). Multilevel issues in international large-scale assessment studies on student performance. In F. J. R. van de Vijver, D. A. van Hemert, & Y. H. Poortinga (Eds.), *Individuals and cultures in multilevel analysis.* Hillsdale, NJ: Erlbaum.

Stanat, P., & **Lüdtke, O.** (2007). Internationale Schulleistungsvergleiche. In G. Trommsdorf & H. J. Kornadt (Eds.), *Enzyklopädie der Psychologie: Vol. C, VII, 3. Anwendungsfelder der Kulturvergleichenden Psychologie* (pp. 279–347). Göttingen: Hogrefe.

Stanat, P., & **Müller, A. G.** (2005). Förderung von Schülerinnen und Schülern mit Migrationshintergrund. In H. Bartnitzky & A. Speck-Hamdan (Eds.), *Deutsch als Zweitsprache lernen* (pp. 20–32). Frankfurt a. M.: Grundschulverband.

Stanat, P., Müller, A. G., & **Baumert, J.** (2005). Die Kofferbande auf Reisen in das Land der Sprache und des Theaters: Das Jacobs Sommercamp Projekt. *Pädagogik, 57,* 57–58.

Stanat, P., & **Watermann, R.** (2005). Schulevaluation im Anschluss an Schulleistungsuntersuchungen: Das Beispiel der Laborschule Bielefeld. In H. G. Holtappels & K. Höhmann (Eds.), *Schulentwicklung und Schulwirksamkeit: Systemsteuerung, Bildungschancen und Entwicklung der Schule* (pp. 206–222). Weinheim: Juventa.

Staudinger, U. M., & **Baumert, J.** (2007). Bildung und Lernen jenseits der 50: Plastizität und Realität. In P. Gruss (Ed.), *Die Zukunft des Alterns: Die Antwort der Wissenschaft* (pp. 240–257). München: Beck.

Stern, E. (in press). Wodurch unterscheiden sich Kinder von Erwachsenen? Neuere Ansätze zur Erklärung der geistigen Entwicklung im Kindesalter. *Schüler.*

Stern, E. (2006a). Frühe Lernprozesse aus kognitionspsycho-

logischer Sicht. In G. Opp, T. Hellbrügge, & L. Stevens (Eds.), *Kindern gerecht werden: Kontroverse Perspektiven auf Lernen in der Kindheit* (pp. 93–100). Bad Heilbrunn: Klinkhardt.

Stern, E. (2006b). Intelligentes Wissen als der Schlüssel zum Können. In W. Forner & S. Habscheid (Eds.), *Sprachliche und fachliche Kompetenzen: Zwei Seiten eines Blattes? 20 Jahre Siegener Institut für Sprachen im Beruf* (pp. 15–23). Frankfurt a. M.: Lang.

Stern, E. (2006c). Lernen: Was wissen wir über erfolgreiches Lernen in der Schule? *Pädagogik, 58* (1), 45–49.

Stern, E. (2006d). Was Hänschen nicht lernt, lernt Hans hinterher: Der Erwerb geistiger Kompetenzen bei Kindern und Erwachsenen aus kognitionspsychologischer Perspektive. In E. Nuissl (Ed.), *Vom Lernen zum Lehren: Lern- und Lehrforschung für die Weiterbildung* (pp. 93–105). Bielefeld: Bertelsmann.

Stern, E. (2006e). Wie viel Hirn braucht die Schule? Chancen und Grenzen einer neuropsychologischen Lehr-Lern-Forschung. In R. Caspary (Ed.), *Lernen und Gehirn: Der Weg zu einer neuen Pädagogik* (pp. 128–141). Freiburg: Herder.

Stern, E. (2006f). Wie viel Hirn braucht die Schule? Chancen und Grenzen einer neuropsychologischen Lehr-Lern-Forschung. In U. Herrmann (Ed.), *Neurodidaktik: Grundlagen und Vorschläge für gehirngerechtes Lehren und Lernen* (pp. 79–86). Weinheim: Beltz.

Stern, E. (2005a). Brain goes to school [Review of the book The learning brain: Lessons for education]. *Trends in Cognitive Sciences, 9,* 563–565.

Stern, E. (2005b). Editorial: Pedagogy meets neuroscience. *Science, 310,* 745.

Stern, E. (2005c). Je früher, desto besser? Über Lernstrategien von Vorschulkindern. In Deutscher Hochschulverband (Ed.), *Glanzlichter der Wissenschaft: Ein Almanach* (pp. 123–129). Stuttgart: Lucius & Lucius.

Stern, E. (2005d). Knowledge restructuring as a powerful mechanism of cognitive development: How to lay an early foundation for coneptual understanding in formal domains. In P. D. Tomlinson, J. Dockrell, & P. Winne (Eds.), *Pedagogy—Teaching for learning* (pp. 153-169). Leicester: British Psychological Society (British Journal of Educational Psychology Monograph Series II, 3).

Stern, E. (2005e). Kognitive Entwicklungspsychologie des mathematischen Denkens. In M. van Aster & J. H. Lorenz (Eds.), *Rechenstörungen bei Kindern: Neurowissenschaft, Psychologie, Pädagogik* (pp. 137–149). Göttingen: Vandenhoeck & Ruprecht.

Stern, E. (2005f). Optimierung durch Auslese? Umgang mit unterschiedlichen Lernvoraussetzungen. *Erziehung und Wissenschaft, 57,* 11–13.

Stern, E. (2005g). Pfadfinder im Neuronendschungel. *Gehirn & Geist, 9,* 53.

Stern, E. (2005h). Vom Gehirn zur Kultur: Mit Mathematik die Welt verstehen. In M. Hasselhorn, H. Marx, & W. Schneider (Eds.), *Diagnostik von Mathematikleistungen* (pp. 293–300). Göttingen: Hogrefe (Tests und Trends: Neue Folge 4).

Stern, E., & Felbrich, A. (2006). Erziehungs- und Schulpsychologie. In K. Pawlik (Ed.), *Handbuch Psychologie: Wissenschaft – Anwendung – Berufsfelder* (pp. 719–731). Heidelberg: Springer.

Stern, E., Felbrich, A., & **Schneider, M.** (2006). Mathematik lernen. In D. H. Rost (Ed.), *Handwörterbuch Pädagogische Psychologie* (3rd, rev. ed., pp. 461–469). Weinheim: Beltz.

Stern, E., Grabner, R., & Schumacher, R. (2005). *Lehr-Lern-Forschung und Neurowissenschaften: Erwartungen, Befunde und Forschungsperspektiven.* Bonn: BMBF, Referat Publikationen, Internetredaktion (Bildungsreform 13).

Stern, E., & **Hardy, I.** (2005). Anspruchsvolle Lernaufgaben. In W. Einsiedler, M. Götz, H. Hacker, J. Kahlert, R. W. Keck, & U. Sandfuchs (Eds.), *Handbuch Grundschulpädagogik und Grundschuldidaktik* (pp. 396–402). Bad Heilbrunn: Klinkhardt.

Trautwein, U. (in press). Hausaufgaben. In W. Schneider & M. Hasselhorn (Eds.), *Handbuch der Pädagogischen Psychologie.* Göttingen: Hogrefe.

Trautwein, U. (2007). The homework-achievement relation reconsidered: Differentiating homework time, homework frequency, and homework effort. *Learning and Instruction, 17,* 372–388.

Trautwein, U. (2005). Selbstständiges Lernen an der Laborschule: Empirische Befunde zu Selbstregulation und Selbstkonzept. In R. Watermann, S. Thurn, K.-J. Tillmann, & P. Stanat (Eds.), *Die Laborschule im Spiegel ihrer PISA-Ergebnisse: Pädagogisch-didaktische Konzepte und empirische Evaluation reformpädagogischer Praxis* (pp. 213–224). Weinheim: Juventa.

Trautwein, U., & Baeriswyl, F. (in press). Wenn leistungsstarke Klassenkameraden ein Nachteil sind: Referenzgruppeneffekte bei Übergangsentscheidungen. *Zeitschrift für Pädagogische Psychologie.*

Trautwein, U., & **Brunner, M.** (2005). Didaktische Prinzipien und Lehrerhandeln an der Laborschule: Empirische Befunde zu Unterricht, Beziehungsqualität und Elternsicht. In R. Watermann, S. Thurn, K.-J. Tillmann, & P. Stanat (Eds.), *Die Laborschule im Spiegel ihrer PISA-Ergebnisse: Pädagogisch-didaktische Konzepte und empirische Evaluation reformpädagogischer Praxis (*pp. 237–244). Weinheim: Juventa.

Trautwein, U., Köller, O., Lehmann, R., & **Lüdtke, O.** (Eds.). (2007a). *Schulleistungen von Abiturienten: Regionale, schulformbezogene und soziale Disparitäten.* Münster: Waxmann.

Trautwein, U., Köller, O., Lehmann, R., & **Lüdtke, O.** (2007b). Öffnung von Bildungswegen und Vergleichbarkeit von Leistungsniveaus: Zusammenfassung und Ausblick. In U. Trautwein, O. Köller, R. Lehmann, & O. Lüdtke (Eds.), *Schulleistungen von Abiturienten: Regionale, schulformbezogene und soziale Disparitäten* (pp. 161–170). Münster: Waxmann.

Trautwein, U., Köller, O., Lehmann, R., & **Lüdtke, O.** (2007c). Öffnung von Bildungswegen, erreichtes Leistungsniveau und Vergleichbarkeit von Abschlüssen. In U. Trautwein, O. Köller, R. Lehmann, & O. Lüdtke (Eds.), *Schulleistungen von Abiturienten: Regionale, schulformbezogene und soziale Disparitäten* (pp. 11–29). Münster: Waxmann.

Trautwein, U., Köller, O., Lehmann, R., & **Lüdtke, O.** (2007d). Vorwort. In U. Trautwein, O. Köller, R. Lehmann, & O. Lüdtke (Eds.), *Schulleistungen von Abiturienten: Regionale, schulformbezogene und soziale Disparitäten* (pp. 7–9). Münster: Waxmann.

Trautwein, U., Köller, O., **Lüdtke, O.,** & **Baumert, J.** (2005). Student tracking and the powerful effects of opt-in courses on self-concept: Reflected-glory effects do exist after all. In H. W. Marsh, R. G. Craven, & D. M. McInerney (Eds.), *New frontiers for self research* (pp. 307–327). Green-

wich, CT: Information Age Publishing (International Advances in Self Research 2).

Trautwein, U., & **Lüdtke, O.** (in press-a). Epistemological beliefs, school achievement, and academic choices: A large-scale, longitudinal study on the impact of the certainty dimension. *Contemporary Educational Psychology.*

Trautwein, U., & **Lüdtke, O.** (in press-b). Predicting global and topic-specific certainty beliefs: Domain-specifity and the role of the academic environment. *British Journal of Educational Psychology.*

Trautwein, U., & **Lüdtke, O.** (2007). Students' self-reported effort and time on homework in six school subjects: Between-student differences and within-student variation. *Journal of Educational Psychology, 99,* 432–444.

Trautwein, U., & **Lüdtke, O.** (2005). The Big-Fish-Little-Pond effect: Future research questions and educational implications. *Zeitschrift für Pädagogische Psychologie, 19,* 137–140.

Trautwein, U., Lüdtke, O., & **Husemann, N.** (2006). Die Qualität der Studienvorbereitung in der gymnasialen Oberstufe: Eine Längsschnittstudie mit Absolventen von allgemeinbildenden und beruflichen Gymnasien. In A. Ittel, L. Stecher, H. Merkens, & J. Zinnecker (Eds.), *Jahrbuch Jugendforschung* (Vol. 6, pp. 47–67). Wiesbaden: VS Verlag für Sozialwissenschaften.

Trautwein, U., Lüdtke, O., Kastens, C., & Köller, O. (2006). Effort on homework in grades 5–9: Development, motivational antecedents, and the association with effort on classwork. *Child Development, 77,* 1094–1111.

Trautwein, U., Lüdtke, O., Köller, O., & **Baumert, J.** (2006). Self-esteem, academic self-concept, and achievement: How the learning environment moderates the dynamics of self-concept. *Journal of Personality and Social Psychology, 90,* 334–349.

Trautwein, U., Lüdtke, O., Marsh, H. W., Köller, O., & **Baumert, J.** (2006). Tracking, grading, and student motivation: Using group composition and status to predict self-concept and interest in ninth-grade mathematics. *Journal of Educational Psychology, 98,* 788–806.

Trautwein, U., Lüdtke, O., Schnyder, I., & Niggli, A. (2006). Predicting homework effort: Support for a domain-specific, multilevel homework model. *Journal of Educational Psychology, 98,* 438–456.

Trautwein, U., & **Maaz, K.** (2006). Soziale Herkunft und Bildungserfolg: Die Rolle beruflicher Gymnasien. *Schulmanagement, 37,* 29–31.

Trautwein, U., Maaz, K., Lüdtke, O., Nagy, G., Husemann, N., Watermann, R., et al. (2006). Studieren an der Berufsakademie oder an der Universität, Fachhochschule oder Pädagogischen Hochschule: Ein Vergleich des Leistungsstands, familären Hintergrunds, beruflicher Interessen und der Studienwahlmotive von (künftigen) Studierenden aus Baden-Württemberg. *Zeitschrift für Erziehungswissenschaft, 9,* 393–412.

Vetter, P. H., **Krauss, S.,** Steiner, O., Moises, H. W., Kropp, P., Möller, W. D., et al. (in press). Vascular dementia: Do patients and family caregivers make adequate use of available supports? *Aging and Mental Health.*

Watermann, R. (2005). Die Laborschule als "polis", als Verantwortungsgemeinschaft: Empirische Befunde zur politischen Sozialisation. In R. Watermann, S. Thurn, K.-J. Tillmann, & P. Stanat (Eds.), *Die Laborschule im Spiegel ihrer PISA-Ergebnisse: Pädagogisch-didaktische Konzepte und empirische Evaluation reformpädagogischer Praxis* (pp. 189–200). Weinheim: Juventa.

Watermann, R., & **Baumert, J.** (2006). Entwicklung eines Strukturmodells zum Zusammenhang zwischen sozialer Herkunft und fachlichen und überfachlichen Kompetenzen: Befunde national und international vergleichender Analysen. In J. Baumert, P. Stanat, & R. Watermann (Eds.), *Herkunftsbedingte Disparitäten im Bildungswesen: Differenzielle Bildungsprozesse und Probleme der Verteilungsgerechtigkeit: Vertiefende Analysen im Rahmen von PISA 2000* (pp. 61–94). Wiesbaden: VS Verlag für Sozialwissenschaften.

Watermann, R., & **Brunner, M.** (2005). Durchführung und methodische Grundlagen der Untersuchung an der Laborschule Bielefeld. In R. Watermann, S. Thurn, K.-J. Tillmann, & P. Stanat (Eds.), *Die Laborschule im Spiegel ihrer PISA-Ergebnisse: Pädagogisch-didaktische Konzepte und empirische Evaluation reformpädagogischer Praxis* (pp. 37–47). Weinheim: Juventa.

Watermann, R., & **Maaz, K.** (in press). Der Übergang von der Schule in die Hochschule: Eine Anwendung der Theorie des geplanten Verhaltens. In A. Schellack & S. Große (Eds.), *Bildungswege: Aufgaben für die Wissenschaft – Herausforderungen für die Politik.* Münster: Waxmann.

Watermann, R., & **Maaz, K.** (2006a). Effekte der Öffnung von Wegen zur Hochschulreife auf die Studienintention am Ende der gymnasialen Oberstufe. *Zeitschrift für Erziehungswissenschaft, 9,* 219–239.

Watermann, R., & **Maaz, K.** (2006b). Soziale Herkunft und Studienintention am Ende der gymnasialen Oberstufe: Institutionelle und individuelle Einflussgrößen. In W. Georg (Ed.), *Soziale Ungleichheit im Bildungssystem: Eine empirisch-theoretische Bestandsaufnahme* (pp. 227–263). Konstanz: UVK Verlagsgesellschaft.

Watermann, R., Maaz, K., & **Brunner, M.** (2005). Die Schülerschaft an der Laborschule: Empirische Befunde zum soziokulturellen Hintergrund und zu den Eingangsvoraussetzungen des PISA-Jahrgangs. In R. Watermann, S. Thurn, K.-J. Tillmann, & P. Stanat (Eds.), *Die Laborschule im Spiegel ihrer PISA-Ergebnisse. Pädagogisch-didaktische Konzepte und empirische Evaluation reformpädagogischer Praxis* (pp. 73–88). Weinheim: Juventa.

Watermann, R., & **Nagy, G.** (2006). Egalitäre Orientierungen und Geschlecht: Ergebnisse einer Längsschnittstudie. In A. Ittel & H. Mertens (Eds.), *Veränderungsmessung und Längsschnittstudien in der empirischen Erziehungswissenschaft* (pp. 125–146). Wiesbaden: VS Verlag für Sozialwissenschaften.

Watermann, R., & **Stanat, P.** (2005). Schulentwicklung und multiple Zielerreichung in der Laborschule: Zusammenfassung und Diskussion der Ergebnisse. In R. Watermann, S. Thurn, K.-J. Tillmann, & P. Stanat (Eds.), *Die Laborschule im Spiegel ihrer PISA-Ergebnisse: Pädagogisch-didaktische Konzepte und empirische Evaluation reformpädagogischer Praxis* (pp. 285–295). Weinheim: Juventa.

Watermann, R., Thurn, S., Tillmann, K.-J., & **Stanat, P.** (Eds.). (2005a). *Die Laborschule im Spiegel ihrer PISA-Ergebnisse: Pädagogisch-didaktische Konzepte und empirische Evaluation reformpädagogischer Praxis.* Weinheim: Juventa.

Watermann, R., Thurn, S., Tillmann, K.-J., & **Stanat, P.** (2005b). Versuchsschule und Evaluationsforschung im Dialog. In R. Watermann, S. Thurn, K.-J. Tillmann, & P. Stanat (Eds.), *Die Laborschule im Spiegel ihrer PISA-Ergebnisse: Pädagogisch-didaktische Konzepte und empirische Evaluation reformpädagogischer Praxis* (pp. 15–23). Weinheim: Juventa.

Zimmer, K., **Brunner, M., Lüdtke, O.,** Prenzel, M., & **Baumert, J.** (in press). Die PISA-Spitzengruppe in Deutschland: Eine Charakterisierung hochkompetenter Jugendlicher. In K. A. Heller & A. Ziegler (Eds.), *Talentförderung – Expertiseentwicklung – Leistungsexzellenz: Vol. 1. Begabt sein in Deutschland.* Münster: LIT-Verlag.

Center for Lifespan Psychology

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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

Introductory Overview

Founded in 1981 by the late Paul B. Baltes, the Center for Lifespan Psychology at the Max Planck Institute for Human Development has helped to establish lifespan psychology as a distinct conceptual approach within developmental psychology. Recently, the Center has extended its research program into developmental behavioral neuroscience. Work at the Center is guided by three propositions: (i) to study lifespan changes in behavior as interactions among maturation, learning, and senescence; (ii) to develop theories and methods that integrate empirical evidence across domains of functioning, timescales, as well as behavioral and neuronal levels of analysis; (iii) to identify mechanisms of development by exploring age-graded differences in plasticity. While 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, it also has intensified its interest in early periods of ontogeny including infancy and early childhood.

Three Guiding Propositions

For more than two decades, the Center for Lifespan Psychology has promoted a perspective on behavioral development that seeks to integrate age periods, domains of functioning, timescales, and levels of analysis. In part through these efforts, lifespan psychology has evolved into a distinct conceptual approach within developmental psychology (e.g., Baltes, 1987; Baltes, Lindenberger, & Staudinger, 2006). The Center's current research agenda can be summarized by three interrelated theoretical propositions that reflect this tradition. In line with the general tenets of lifespan psychology, the three propositions emphasize conceptual and methodological issues in the study of lifespan behavioral development, and thereby provide a general script for formulating research questions in more 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 attempt to arrive at more or less comprehensive theories of behavioral development. To provide explanations that qualify as psychological and developmental, the effects of external influences, such as 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 the developing person. Hence, as John Nesselroade, Peter Molenaar, and others have emphasized, developing individuals, rather than groups of individuals or domains of functioning within individuals, form the privileged system of analysis and explanation.

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 both as antecedents and consequents of moment-to-moment variability and long-term changes in

Key References

Lindenberger, U., Li, S.-C., Lövdén, M., & **Schmiedek, F.** (in press). The Center for Lifespan Psychology at the Max Planck Institute for Human Development: Overview of conceptual agenda and illustration of research activities. *International Journal of Psychology.*

Baltes, P. B., Lindenberger, U., & Staudinger, U. M. (2006). Life span theory in developmental psychology. In W. Damon & R. M. Lerner (Eds.), *Handbook of child psychology: Vol. 1. Theoretical models of human development* (pp. 569–664). New York: Wiley.

Baltes, P. B. (1987). Theoretical propositions of lifespan developmental psychology: On the dynamics between growth and decline. *Developmental Psychology, 23,* 611–626.

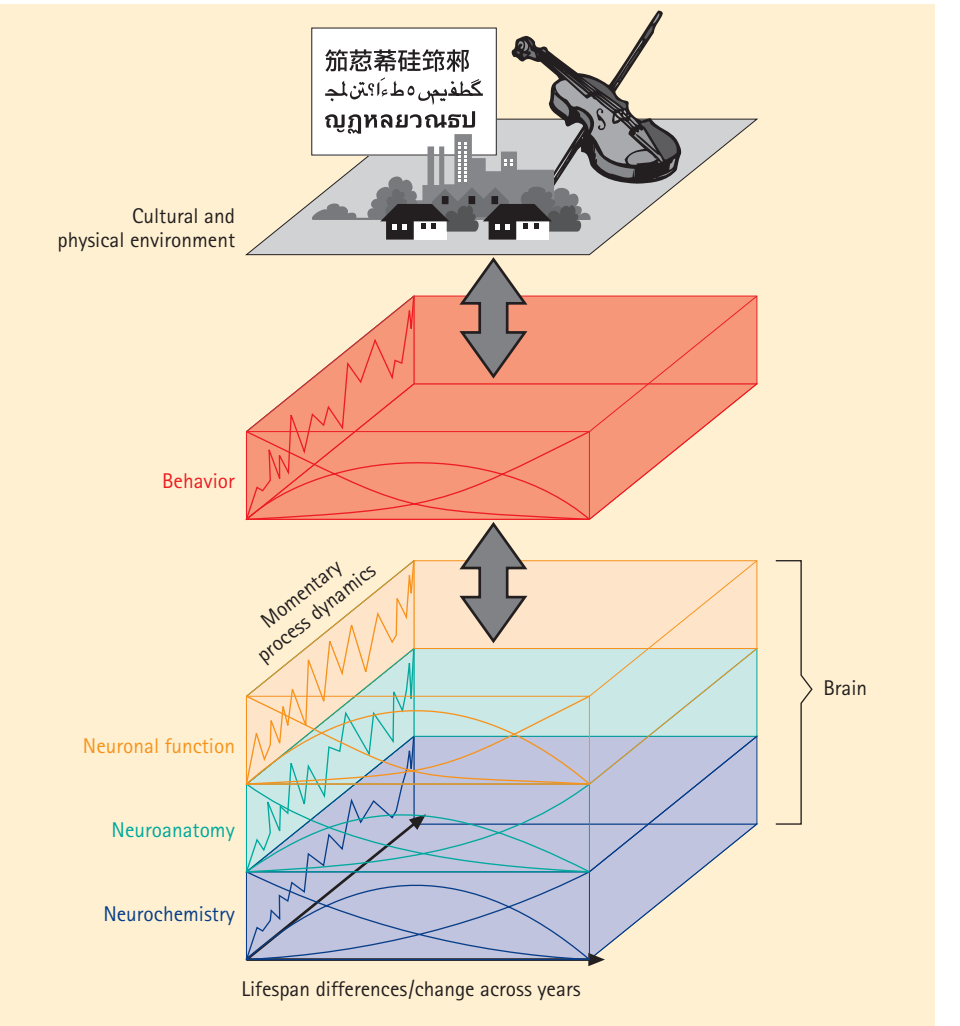

Figure 1. Environment and brain as antecedents and consequents of moment-to-moment variability and long-term changes in patterns of behavior. Lifespan changes in brain-behavior mappings are shaped by interactions among processes related to maturation, learning, and senescence. The identification of key 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 for studying variability and change in brain and behavior (adapted from Lindenberger, Li, & Bäckman, 2006b).

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.

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. Note, however, that maturation cannot take place without learning, and that learning cannot take place without maturation. Similarly, the ways in which senescence takes its toll on the brains of aging individuals depend on individuals' past and present learning and maturational histories. To complicate matters even more, 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 (Raz et al., 2005). For instance, neurogenesis and synaptogenesis, as expressions of maturation, continue to exist in the adult and aging brain, and declines in dopaminergic neuromodulation, which indicate senescence-related changes in brain chemistry, commence in early adulthood (Bäckman, Nyberg, Lindenberger, Li, & Farde, 2006).

Thus, maturation, senescence, and learning mutually enrich and constrain each other throughout the lifespan, and must be understood and studied as interacting forces driving the brain-behavior-environment system. In this endeavor, psychologists occupy a central position because they possess a rich and adequate repertoire of conceptual, experimental, and methodological tools to describe and modify the organization of behavior.

Brain–Behavior Dynamics Across the Lifespan
Neuroscience & Biobehavioral Reviews, 30 (6), 2006
Special Issue
Edited by *Ulman Lindenberger, Shu-Chen Li,* and *Lars Bäckman*

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Key References

Lindenberger, U., & **von Oertzen, T.** (2006). Variability in cognitive aging: From taxonomy to theory. In E. Bialystok & F. I. M. Craik (Eds.), *Lifespan cognition: Mechanisms of change* (pp. 297–314). Oxford: Oxford University Press.

Li, S.-C. (2003). Biocultural orchestration of developmental plasticity across levels: The interplay of biology and culture in shaping the mind and behavior across the lifespan. *Psychological Bulletin, 129,* 171–194.

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

If the lifespan development of behavior is defined to originate from recursive interactions among maturation, learning, and senescence, with the developing individual as the privileged system of analysis, then developmental psychology is faced with three difficult 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 (Schäfer, Huxhold, & Lindenberger, 2006). Similar observations can be made for many other domains of functioning whose changes generally have been studied in isolation, such as the ontogeny of social interaction and cognition or of emotion regulation and motivational states. Empirically, dense multivariate time-series data are needed to assess short-term variability and long-term changes in across-domain dependencies.

Second, there is a need to understand the mechanisms that link short-term variations to long-term change (Lindenberger & von Oertzen, 2006). 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 into different directions. For instance, aging cognitive systems show an increase in maladaptive moment-to-moment fluctuations or decrease in processing robustness, at both behavioral and neuronal levels of analysis. These maladaptive changes may signal impending long-term changes in other characteristics of the system (see Figure 2; Lövdén, Li, Shing, & Lindenberger, in press). In contrast, other forms of moment-

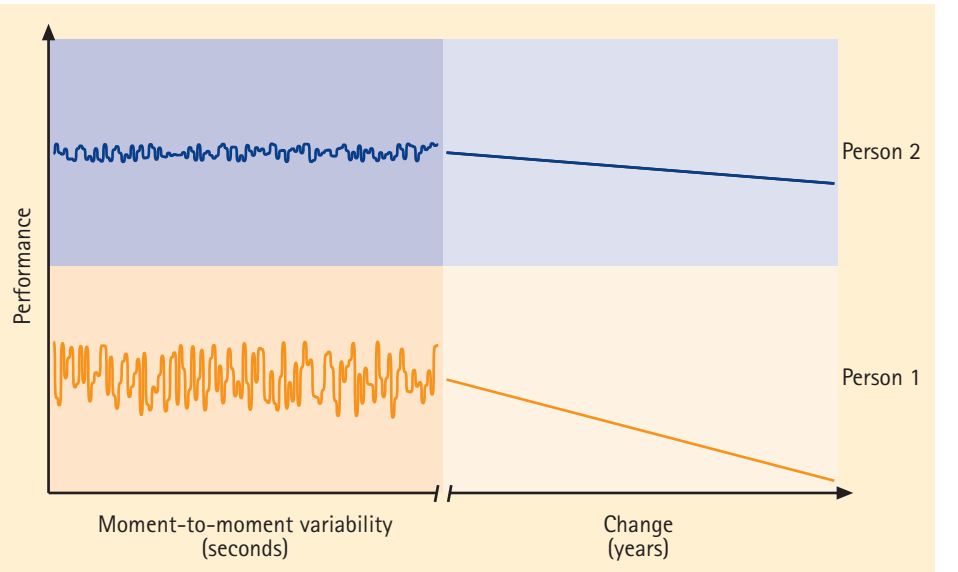


Figure 2. Example for predictions linking moment-to-moment variability to long-term change, and brain changes to behavioral changes. Senescent changes in neuromodulation lead to greater moment-to-moment fluctuations in neural signaling, enhance the prominence of background noise, reduce the distinctiveness of processing pathways and representations, and increase variability of cognitive performance. Aging individuals with greater moment-to-moment process fluctuations at a given point in time are expected to show greater subsequent longitudinal decline in mean levels of functioning than individuals who fluctuate less. Recent empirical evidence supports this prediction (Lövdén, Li et al., in press; adapted from Lindenberger, Li, & Bäckman, 2006b).

to-moment variability indicate an individual's ability to bring a wide variety of different strategies to the task, and are positively related to long-term change in both childhood and old age.

Third, to arrive at mechanistic explanations of behavioral change, there is the need to integrate behavioral and neuronal 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 offers more than one implementation of an adaptive behavioral outcome (Li, 2003). Therefore, ontogenetic changes in behavioral repertoires are accompanied by continuous changes in multiple brain-behavior mappings. Some of these re-mapping 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 the 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 neuronal and behavioral organization, and (c) cultural-social as well as physical regularities of the environment (Baltes, Lindenberger, & Staudinger, 2006).

In summary, developmental psychology needs theory and methodology apt to integrate (a) multiple domains of functioning, (b) multiple timescales, and (c) multiple levels of analysis. In recent years, the Center for Lifespan Psychology has relied on two methodologies that seem well-suited to these conceptual demands. First, random coefficient modeling (RCM), latent growth curve modeling (LGCM), and related statistical techniques have served as versatile tools for the analysis of multivariate data with nested time structures, such as trials, blocks of trials, days, weeks, and years. Dynamic extensions of these methods, such as the dual-change score model, introduced by John J. McArdle and Fumiaki Hamagami, permit the investigation of directed lead-lag hypotheses with longitudinal panel data (for examples, see Gerstorf, Ram, Röcke, Lindenberger, & Smith, in press; Lövdén, Li et al., in press; Project 3, Berlin Aging Study). Second, neurocomputational modeling, such as the neurocomputational theory of cognitive aging proposed by Shu-Chen Li and colleagues (Li, Lindenberger, & Sikström, 2001; Li, von Oertzen, & Lindenberger, 2006), has facilitated conceptual integration of empirical findings and concepts from a wide range of behavioral and neuronal research traditions, and provides a theoretical basis for major portions of the Center's research program.

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

Behavioral plasticity or the alteration of developmental trajectories through experience is a precious phenomenon (Figure 3). This statement holds both from scientific and societal perspectives. Scientifically, inquiries

Key Reference

Brehmer, Y., Li, S.-C., Müller, V., von Oertzen, T., & Lindenberger, U. (2007). Memory plasticity across the lifespan: Uncovering children's latent potential. *Developmental Psychology, 43,* 465–478.

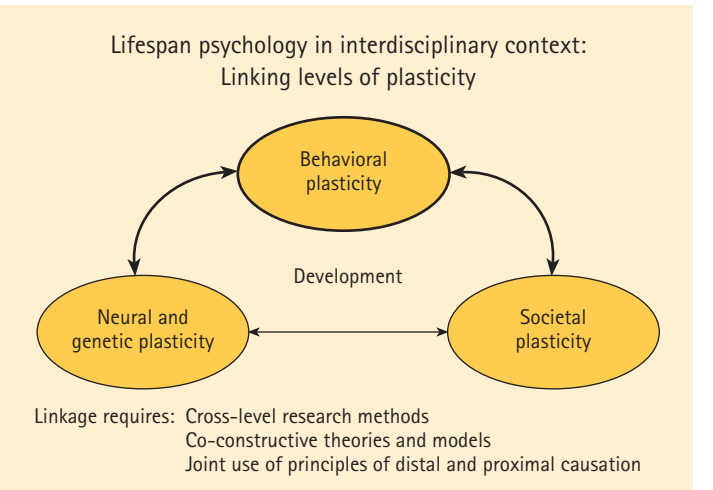


Figure 3. Lifespan development as biocultural co-construction. A central goal of lifespan psychology is to describe, explain, and optimize human potential and to identify its societal and neural causes and consequences.

into the plasticity of human behavior are a rich source of developmental information. Through the assessment of "changes in change," they offer the promise to observe the operation and proximal consequences of developmental mechanisms. In particular, cognitive intervention 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, or neurofunctional imaging measures are assessed before, during, and after training, intervention studies also offer new insights into relations between behavioral and neuronal levels of plasticity. Thus, by partly taking control over behavior-environment interactions, the mechanisms of learning can be studied in the context of maturation and senescence. When longitudinal information is available, intervention studies bridge the gap between short-term alterations in performance and long-term developmental trajectories (e.g., Lövdén, Li et al., in press).

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. The resulting knowledge about the plasticity of developmental trajectories is essential for improving human welfare. Hence, investigations of age changes in the plasticity of development carry the potential to explain and ameliorate human development. For these reasons, age-comparative intervention studies with focus on behavioral and neuronal manifestations of plasticity are the foundation stone of empirical research at the Center for Lifespan Psychology.

Overview of Research Projects at the Center for Lifespan Psychology

The empirical and conceptual work at the Center for Lifespan Psychology is currently structured into seven research projects or teams of scientific investigators (see Table 1). The research activities pursued in these projects cover a wide array of developmental topics. To provide a few examples for illustration, recent studies have addressed the following questions: (a) How do relations between body and mind change from childhood to adulthood, and from adulthood to old age? (b) How and why do functions, such as intelligence and memory, vary within and across individuals, and how and why do they change with age? (c) How and to what end do individuals acquire and maintain a sense of personal control, and how do they plan and manage their lives? (d) How do aging individuals cope with rapid technological change, and how can human engineering technologies facilitate the transition to old age? (e) How do young children learn to coordinate their behavior with others, and how does interpersonal action coordination affect social and cognitive development?

Sofja-Kovalevskaja Award

In 2006, Martin Lövdén received the Sofja Kovalevskaja Award of the Alexander von Humboldt Foundation. Financed by the Federal Ministry for Education and Research, the one million Euro award enables young scientists from outside Germany to finance their own research groups at a German university or nonuniversity research institution of their choice. Martin Lövdén's independent research group will be affiliated with the Center for Lifespan Psychology. The group will conduct a series of extensive training studies using magnetic resonance imaging to examine training-induced changes in behavior and brain among younger and older adults in the functional domains of spatial navigation and working memory.

Table 1
The Center for Lifespan Psychology: Overview of Research Projects

Name of the project	*Scientific investigators*	*Predoctoral research fellows*
Intra-Person Dynamics Across the Lifespan	Shu-Chen Li**; Christian Chicherio*, Hauke Heekeren, Martin Lövdén, Viktor Müller, Florian Schmiedek, Timo von Oertzen, Ulman Lindenberger	Yvonne Brehmer, Annette Brose, Dorothea Hämmerer, Oliver Huxhold, Irene Nagel, Christina Röcke, Yee Lee Shing, Markus Werkle-Bergner
Sensorimotor-Cognitive Couplings	Martin Lövdén**; Oliver Huxhold*; Sabine Schäfer*, Ulman Lindenberger	Michael Schellenbach, Julius Verrel
The Berlin Aging Study (BASE)	Ulman Lindenberger**, Jacqui Smith**; Julia Delius, Denis Gerstorf*, Shu-Chen Li, Martin Lövdén	Daniel Grühn
Developmental Regulation of Affect, Motivation, and Abilities (DRAMA)	Michaela Riediger**; Natalie Ebner*, Sabine Schäfer*, Ulman Lindenberger	Antje Rauers
Interactive Brains, Social Minds	Ulman Lindenberger**; Franziska Kopp*, Shu-Chen Li, Viktor Müller, Michaela Riediger	Karen Bartling, Anna Kleinspehn
Formal Methods and Theory in Lifespan Psychology	Timo von Oertzen**; Shu-Chen Li, Ulman Lindenberger	N.N.
Toward a Psychological and Developmental Theory of Sehnsucht (life-longings)	† Paul Baltes**; Susanne Scheibe*	Dana Kotter-Grühn

Note. The table refers to projects and project members as of Fall 2006; for updates, visit www.mpib-berlin.mpg.de
** Principal investigator(s); * Postdoctoral fellow.

Research Project 1
Intra-Person Dynamics Across the Lifespan

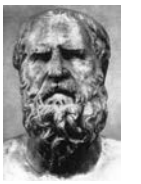
Scientific Investigators

Shu-Chen Li
Hauke Heekeren (also Head of the Independent Junior Research Group, see p. 180)
Martin Lövdén
Viktor Müller
Florian Schmiedek (until 11/2006)
Jacqui Smith (until 09/2006)
Timo von Oertzen
Ulman Lindenberger

Florian Schmiedek, Department of Psychology, Humboldt University Berlin (12/2006) (adjunct research scientist)

Christian Chicherio (postdoctoral fellow)

Yvonne Brehmer (until 12/2006)
Annette Brose
Dorothea Hämmerer
Oliver Huxhold
Irene E. Nagel
Christina Röcke (until 12/2006)
Yee Lee Shing
Markus Werkle-Bergner
(predoctoral fellows)



All is flux; nothing stays still.
Heraclite, ca. 500 B.C.

Conceptual Overview

Behavioral development comprises both short-term variability and long-term change, and is embedded in cultural, environmental, and different levels of neuronal contexts. Environment and brain both act as antecedents and consequences of moment-to-moment variability and long-term changes in behavior. The overarching objective of this project is to explore theories and research designs that articulate behavioral development across timescales, levels of analysis, and functional domains. Empirically, this emphasis on integration across timescales, domains, and levels requires a drastic increase in observation density within individuals.

Intra-Person Dynamics: Forms and Functions

In examining relations between short-term variability and long-term age changes or age differences, different forms and functions of variability can be set apart. Specifically, one may distinguish among plasticity, diversity, adaptability, fluctuation, and temporal coupling (see Figure 1 and Table 1). *Plasticity,* in this context, refers to various forms of progressive performance alterations, such as learning induced by instruction, practice, and training. *Diversity* refers to variations in responses to environmental demands, such as exploration of behavioral strategies during initial phases of complex skill acquisition. *Adaptability* indicates an individual's ability to regain earlier functional levels after perturbations arising from either internal processing fluctuations (e.g., attention slips) or changes in the external environment (e.g., more demanding tasks). *Processing fluctuation,* or lack of processing robustness (e.g., Lövdén, Li et al., in press; Li, Lindenberger et al., 2004), reflects stochastic fluctuations around a modal response. Processing fluctuations can be observed more easily when the functional value of other forms of variability is low to begin with, as is often the case for standard reaction time tasks, or when the functional values have been reduced, as is the case when individuals have consolidated the use of a particular strategy and are operating near

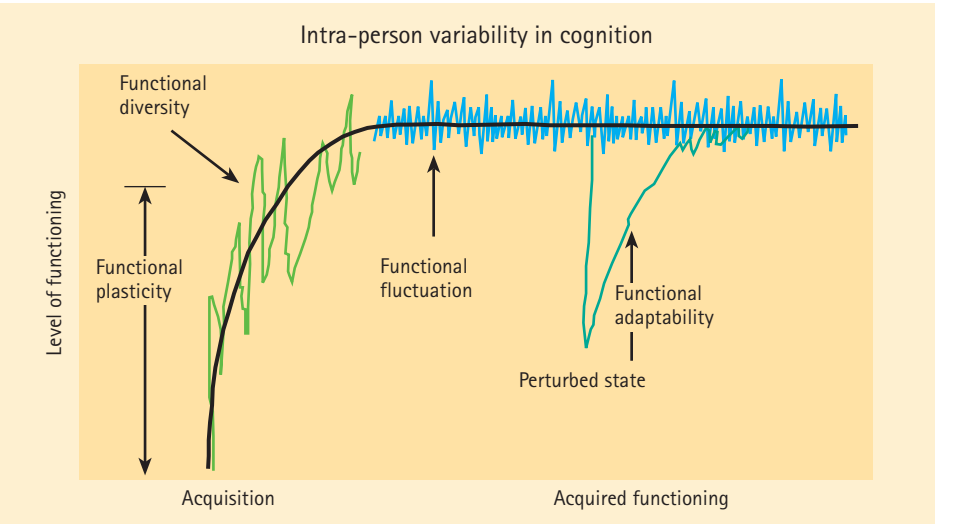


Figure 1. Types of intra-person variability in cognitive functioning.

Table 1
Taxonomy of Within-Person Variability in Cognitive Functioning Across the Lifespan

	Scope	
Timescales	*Variations in a single function (e.g., local, univariate)*	*Transformations in functional organization (e.g., global, multivariate)*
Microgenetic (e.g., usually across trials, sessions, or weeks)	*Relatively reversible variations in one function* Examples: • processing fluctuation (processing lability or lack of processing robustness) • neural and behavioral plasticity (short-term learning potential) • within-task strategic diversity (richness of within-task behavioral repertoire) • adaptability/resilience to environmental perturbations • cyclic (e.g., state) variations in any specific function	*Relatively reversible variations in functional organization* Examples: • shifts in resource allocation, coordination, and compensatory behavior during multitasking • context-driven variations in mental set and functional organization (e.g., posture control with eyes open or closed) • situational choice and preference behavior
Ontogenetic (e.g., usually across months, years, or decades)	*Relatively permanent (e.g., cumulative, progressive) changes in one function* Examples: • physical growth • progressive (e.g., trait) changes in any specific cognitive function • long-term learning and skill acquisition	*Relatively permanent (e.g., cumulative, progressive) alterations in functional organization* Examples: • ability differentiation from adulthood to old age • ability dedifferentiation from childhood to early adulthood • corticogenesis and functional specification of brain areas during maturation and learning • functional reintegration of brain circuitry in old age

Note. This taxonomy is not meant to be exhaustive. For instance, societal sources of variability are not systematically considered. All listed forms of variability can be studied at behavioral and neuronal levels of analysis. Examples are drawn from both levels. A major challenge for lifespan psychology is to identify mechanisms that link local to global variations, microgenetic variations to ontogenetic change, and neuronal mechanisms to behavior. Theories that link neuronal mechanisms in a single function acting at a microgenetic timescale to global ontogenetic transformations in behavior are high in parsimony and explanatory power (adapted from Lindenberger & von Oertzen, 2006; cf. Li, Huxhold, & Schmiedek, 2004).

maximum levels of functioning. Finally, *temporal coupling* refers to associations between two or more forms of processing within or across domains of functioning, such as concurrent covariation, lead-lag relations, and synchronization, at identical, different, or hierarchically nested timescales.

Overview of Subprojects

The Intra-Person Dynamics Project currently consists of four subprojects. Subproject I investigates adult age differences in intra-person variability and ability structures. Subproject II studies lifespan age differences in the plasticity and components of episodic learning and memory. Subproject III investigates lifespan age differences in electrophysiological correlates of monitoring mechanisms in various types of cognitive conflicts. Finally, subproject IV focuses on adult age differences in neuromodulatory efficacy and their effect on patterns of brain activation and cognitive performance. Altogether, the project endorses a multilevel multimethod approach by combining behavioral and neuronal observations with experimental, correlational, and computational methods.

Subproject I: Intra-Person Variability and Ability Structures

A first microlongitudinal study, completed in November 2005, covered 45 daily measurement occasions to examine adult age differences in intra-person fluctuations in four domains of functioning: postural control, spatial working memory, positive and negative affect, and task-specific motivation. Eighteen younger adults (20–30 years of age) and 19 older adults (70–80 years of age) participated in the study across 9 weeks. With respect to cognitive and sensorimotor functions, older

Key References

Li, S.-C., & **Baltes, P. B.** (2006). Cognitive developmental research from lifespan perspectives: The challenge of integration. In E. Bialystok & F. I. M. Craik (Eds.), *Lifespan cognition: Mechanisms of change* (pp. 344–363). Oxford: Oxford University Press.

Li, S.-C., Lindenberger, U., Hommel, B., Aschersleben, G., Prinz, W., & **Baltes, P. B.** (2004). Transformations in the couplings among intellectual abilities and constituent cognitive processes across the life span. *Psychological Science, 15,* 155–163.

Key References

Lövdén, M., & **Lindenberger, U.** (2005). Development of intellectual abilities in old age: From age gradients to individuals. In O. Wilhelm & R. W. Engle (Eds.), *Handbook of understanding and measuring intelligence* (pp. 203–221). Thousand Oaks, CA: Sage.

Li, S.-C., Lindenberger, U., & Sikström, S. (2001). Aging cognition: From neuromodulation to representation. *Trends in Cognitive Sciences, 5,* 479–486.

adults showed greater intra-person fluctuations than younger adults. For instance, older adults' reaction times in a spatial working memory task had a higher mean and a wider distribution than younger adults' reaction times, and varied more from day-to-day in older adults than in younger adults (see Figure 2).

We also examined whether intra-person fluctuations in sensorimotor functioning (e.g., postural control) and cognitive functioning (e.g., spatial working memory) are more strongly coupled in older than in younger adults. Individuals who fluctuated more in postural control (i.e., older males) showed stronger couplings between daily fluctuations in postural control and daily fluctuation in working memory than individuals who fluctuated less in postural control (Dissertation Oliver Huxhold; see Figure 3A). In addition, older adults, but not younger adults, showed increasing sway with increasing cognitive demands. This finding suggests that older adults need to invest more cognitive resources into the execution of simple sensorimotor tasks than younger adults (Huxhold, Li, Schmiedek, & Lindenberger, 2006; see Figure 3B; see also Project 2, Sensorimotor-Cognitive Couplings).

Regarding emotional functioning (Dissertation Christina Röcke), older adults showed significantly less day-to-day fluctuations in positive and negative affect than younger adults (Figure 4A). This pattern of findings is consistent with the notion advanced by Laura Carstensen and others that emotion regulation improves with advancing adult age. However, alternative explanations, such as age-linked differences in social contexts or arousal, cannot be ruled out. In addition, the correlation between age and affect fluctuations was more stronger than the correlation between personality factors, such as extraversion and neuroticism, and affect fluctuations (Figure 4B), demonstrating the importance of a lifespan perspective on dynamic aspects of well-being.

As a continuation and expansion of the goals of the first study, the project carried out a second study to explore differences and commonalities between covariance structures of intellectual abilities measured either across individuals at a given occasion or across occasions within a given individual. Most existing research on intellectual abilities assumes that covariance structures based on inter-individual differences generalize to intra-person structures. As Jacques Lautrey, John Nesselroade, Peter Molenaar, and others have argued for a long time, differences between intra-person and inter-person structures are to be expected. Conceptually, the malleability of functional organization at both behavioral and neuronal levels and the diversity of de-

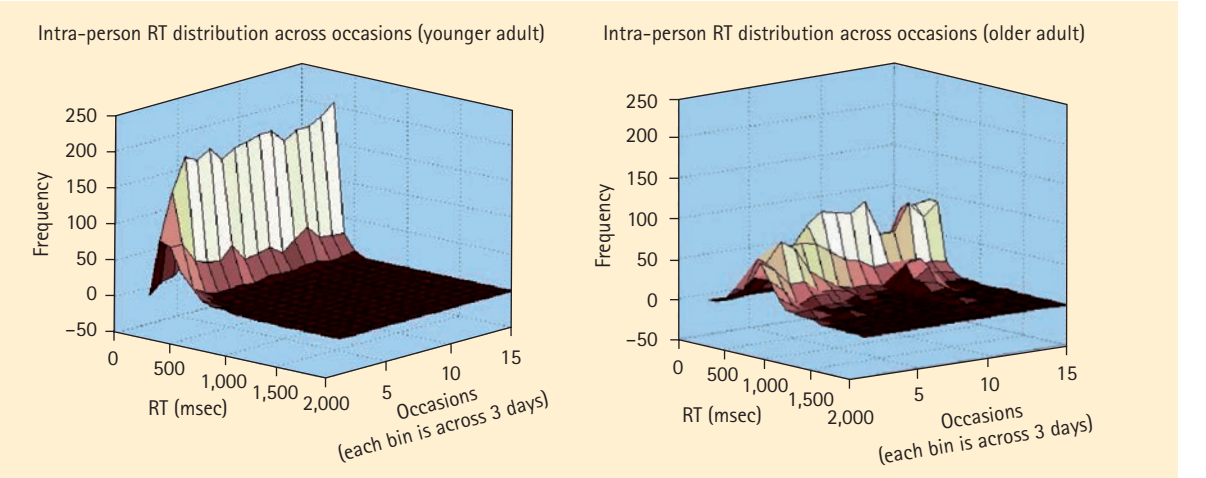


Figure 2. Short-term development of reaction-time distributions in one younger and one older adult. Each occasion represents three consecutive days of the 45-day assessment. The older adult's performance is more variable and show less change over time.

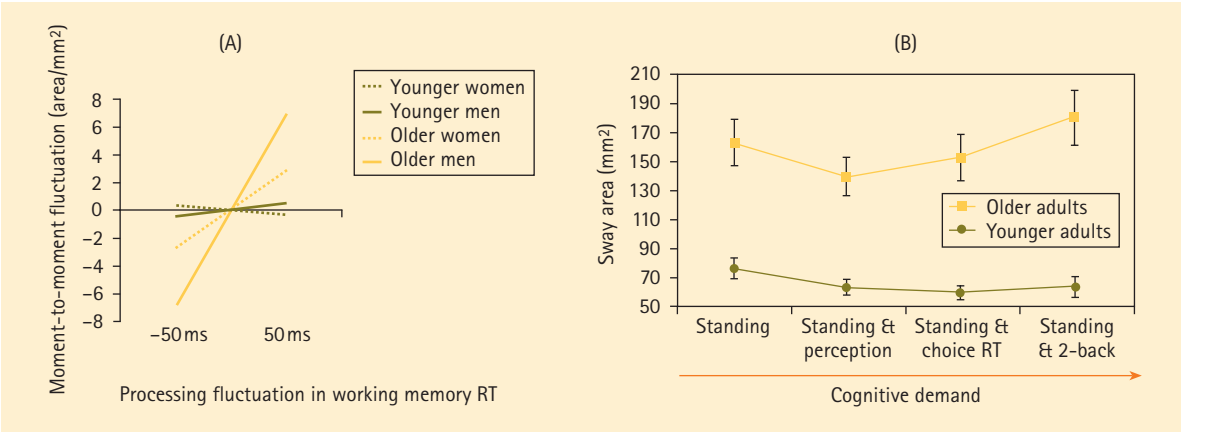


Figure 3. (A) The coupling between daily fluctuations in postural control and working memory is stronger in older men whose postural control function is less robust. (B) Increasing cognitive demands in a dual-task increases postural sway more in older adults than in younger adults (Huxhold et al., 2006).

velopmental trajectories and life experiences render any strict congruence between intra-person and inter-person structures unlikely (cf. Li & Lindenberger, 2002).

The main empirical study, preceded by extensive pilot work and labelled the *Cognition Ergodicity Study of the MPI for Human Development* (COGITO ERGO SUM), was started in 2006. One hundred younger (20–30 years) and 100 older (65–80 years) adults participated in 100 daily sessions, working each day on a set of 12 cognitive tasks comprising perceptual speed, episodic memory, and working memory (see Figure 5). Self-report measures of affect, motivation, and mood were also assessed on a daily basis (Dissertation Annette Brose). In addition, all participants completed comprehensive pretests and posttests, with baseline measures of cognitive abilities, and transfer tasks for the practiced abilities. A subsample of about 25 younger and 25 older participants also took part in structural and functional magnetic resonance imaging sessions and electroencephalographic recordings at pretest and posttest. Data collection will be completed in summer 2007.

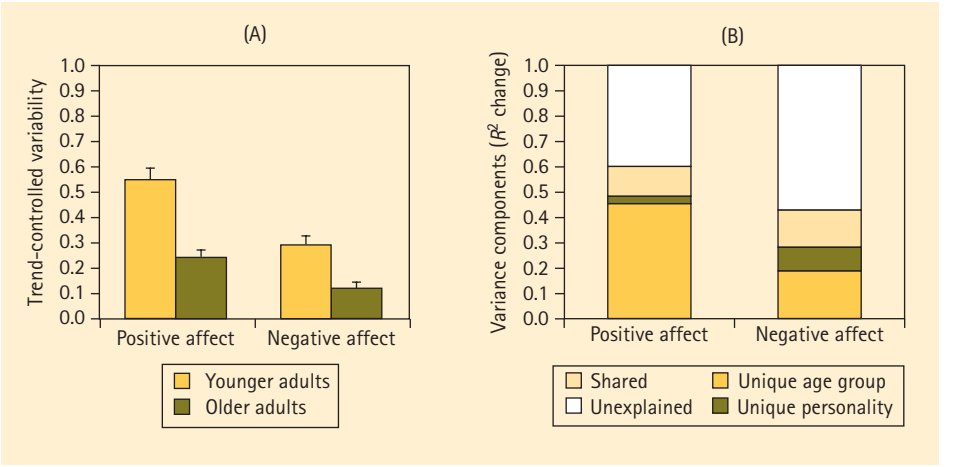


Figure 4. (A) Older adults show less day-to-day fluctuations in both positive and negative affects than younger adults. (B) Age is more highly correlated with individual differences in affect fluctuation than personality measures (Dissertation Christina Röcke).

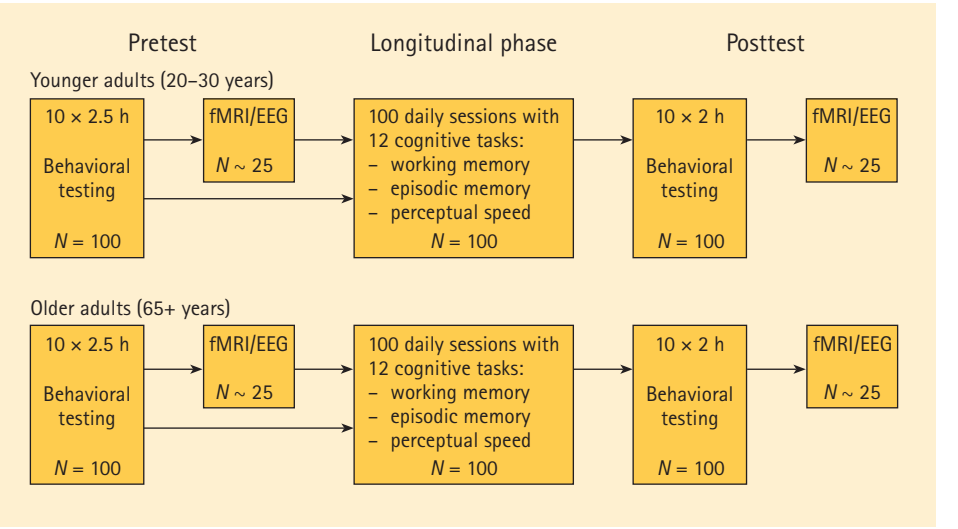


Figure 5. Design of COGITO study.

The data of this study will allow researchers to systematically examine differences and commonalities between covariance structures of intellectual abilities measured either (a) across individuals at a given occasion or (b) across occasions within a given individual. Most existing research and theorizing on cognitive abilities assumes that covariance structures based on between-person differences generalize to intra-person structures. Surprisingly, it is not yet known whether ability structures representing between-person differences are good approximations of ability structures representing day-to-day variations in cognitive performance within individuals. To find out about this issue, developmental researchers need to abandon a quid-pro-quo research practice, in which between-person differences stand-in for within-person variations (cf. Lindenberger & von Oertzen, 2006; Lövdén & Lindenberger, 2005).

To complicate matters, the degree of congruence between within-person and between-person structures may vary by age. For instance, given that alterations in cognitive functioning among older adults reflect variable combinations of age-related, pathology-related, and death-related mechanisms, the average similarity of the within-person structures to the between-person structures of old adults may be smaller than the average similarity of the within-person structures to the between-person structures of younger adults. For related reasons, the study will also shed new light on the dedifferentiation hypothesis of old-age intelligence (cf. Lövdén & Lindenberger, 2005). According to this hypothesis, increasing correlations among cognitive abilities with advancing age reflect the operation of domain-general resource limitations. The critical question here is whether earlier observations of increasing correlations among cognitive abilities with advancing age, when assessed *across persons*, are matched by increasing correlations among cognitive abilities with advancing age, when assessed *within persons* across days. Extending this question to the neuronal level of analysis, we can ask whether older individuals who show low levels of average performance and high correlations among different cognitive abilities tend to be those who show diffuse cortical activation patterns relative to older individuals with high average levels of performance and low correlations among cognitive abilities.

In sum, the data of this study will provide a full data cube of persons × timepoints × variables as envisioned by Raymand B. Cattell. This will open up new data-analytic approaches, and allow new insights into between-person differences in intra-person variability and change.

Subproject II: Lifespan Age Differences in Episodic Memory Plasticity

This subproject examines lifespan age differences in plasticity and components of episodic memory. The subproject is partially funded by a research grant from the German Research Foundation (Deutsche Forschungsgemeinschaft, Forschergruppe 448, Binding: Functional architecture, neuronal correlates, and ontogeny). It pursues two interrelated goals: (a) to investigate age differences in the plasticity of skilled episodic memory performance from middle childhood to later adulthood; (b) to estimate the relative contribution of strategic and associative components to lifespan differences in episodic memory. Lifespan age differences in memory plasticity were initially investigated in a first multisession memory training study involving 23 younger children (9–10 years), 27 older children (11–12 years), 29 younger adults (20–25 years), and 29 older adults (65–78 years). Participants in all age groups were instructed and trained in a simplified variant of the Method of Loci, an imagery-based mnemonic strategy. Whereas all age groups benefited from mnemonic training, substantial age differences in gains were observed as a function of instruction versus training practice (see Figure 6A; Dissertation Yvonne Brehmer; Brehmer et al., 2007). Older adults showed considerable instruction-related performance gains (baseline plasticity), but did not profit much from further training and practice (developmental plasticity). In contrast, younger children initially showed smaller instruction-related performance gains, but considerably larger practice-related gains than older adults. The resulting memory plasticity advantage of middle childhood over late adulthood provides direct empirical support for central assumptions about lifespan changes in behavioral plasticity.

To examine lifespan age differences in the maintenance of skilled memory performance, a longitudinal follow-up study was carried out 11 months after completion of the first study. Whereas younger and older adults were able to maintain their earlier levels of performance, younger and older children actually improved their performance beyond the levels they had originally attained (Brehmer et al., submitted; see Figure 6B). This performance improvement points to a powerful coalition between learning and maturation during middle childhood.

In order to further study strategic and associative components of lifespan differences in

Key References

Brehmer, Y., Li, S.-C., Müller, V., von Oertzen, T., & **Lindenberger, U.** (2007). Memory plasticity across the lifespan: Uncovering children's latent potential. *Developmental Psychology, 43,* 465–478.

Werkle-Bergner, M., Müller, V., Li, S.-C., & **Lindenberger, U.** (2006). Cortical EEG correlates of successful memory encoding: Implications for lifespan comparisons. *Neuroscience & Biobehavioral Reviews, 30,* 839–854.

Li, S.-C., Naveh-Benjamin, M., & **Lindenberger, U.** (2005). Aging neuromodulation impairs associative binding: A neurocomputational account. *Psychological Science, 16,* 445–450.

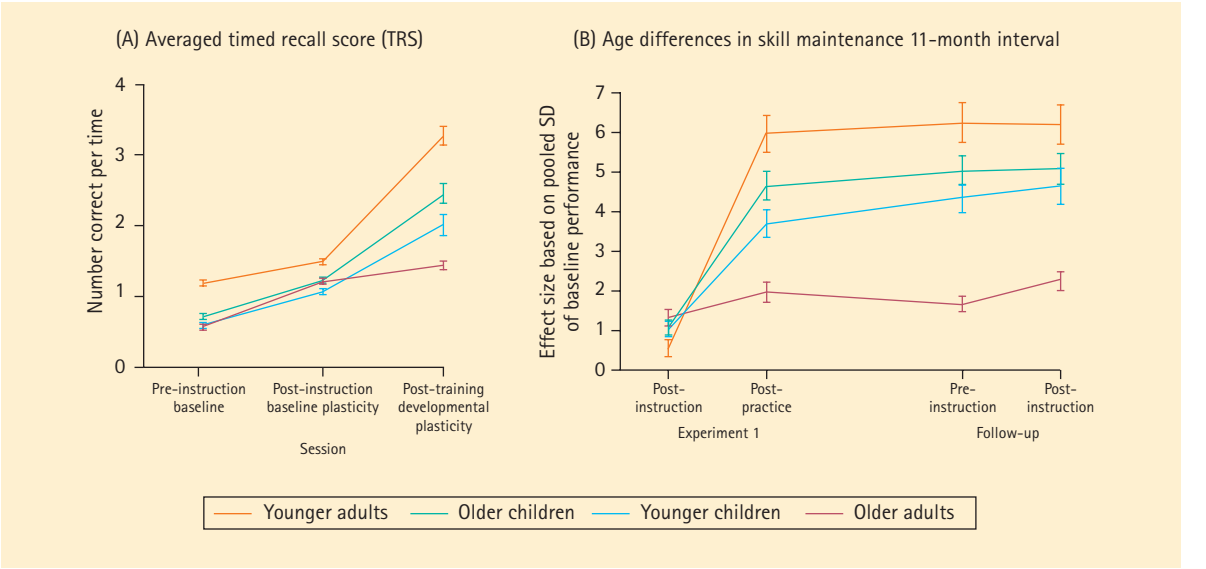


Figure 6. (A) Lifespan age differences in episodic memory plasticity (Brehmer et al., 2007). (B) Maintenance of skilled performance (Brehmer et al., submitted).

episodic memory, a new series of experiments was initiated to progress to a mechanistic explanation of lifespan differences in associative and strategic components of episodic memory. With the strategic component of episodic memory, we refer to the selection, organization, and elaboration of episodic features during encoding and retrieval. In contrast, the associative component refers to mechanisms that bind features into a coherent memory representation or compound trace. Due to the late maturation of prefrontal regions and associated neuronal pathways, we assume that the strategic component of learning and memory is less efficient in middle childhood than in early and young adulthood. In contrast, the associative component, which primarily involves mediotemporal structures, should be fully functional by middle childhood, so that differences to younger adults in this component should be small. With respect to older adults, we expect impairments in both strategic and associative components relative to younger adults, reflecting senescent alterations in both prefrontal and mediotemporal regions of the brain.

A new series of experiments tested these predictions using a paired-associates recognition memory paradigm, similar to paradigms used by Moshe Naveh-Benjamin from the University of Missouri and Fergus Craik from the University of Toronto. The study involved a total of 170 participants aged 10 to 12, 13 to 15, 20 to 25, and 70 to 75 years. We utilized a fully crossed within-participant repeated measures design, in which the associative component was varied by preexisting word pair associations, whereas the strategic component was varied by encoding instruction. Specifically, we manipulated two levels of preexisting associative strength between word pairs by language types. For German speakers, German-German word pairs have higher associative strength than pairs with one German and one foreign language word (Malay language was used in the current study). We manipulated the extent of explicit strategic encoding with three levels of instruction (i.e., ranging from incidental item

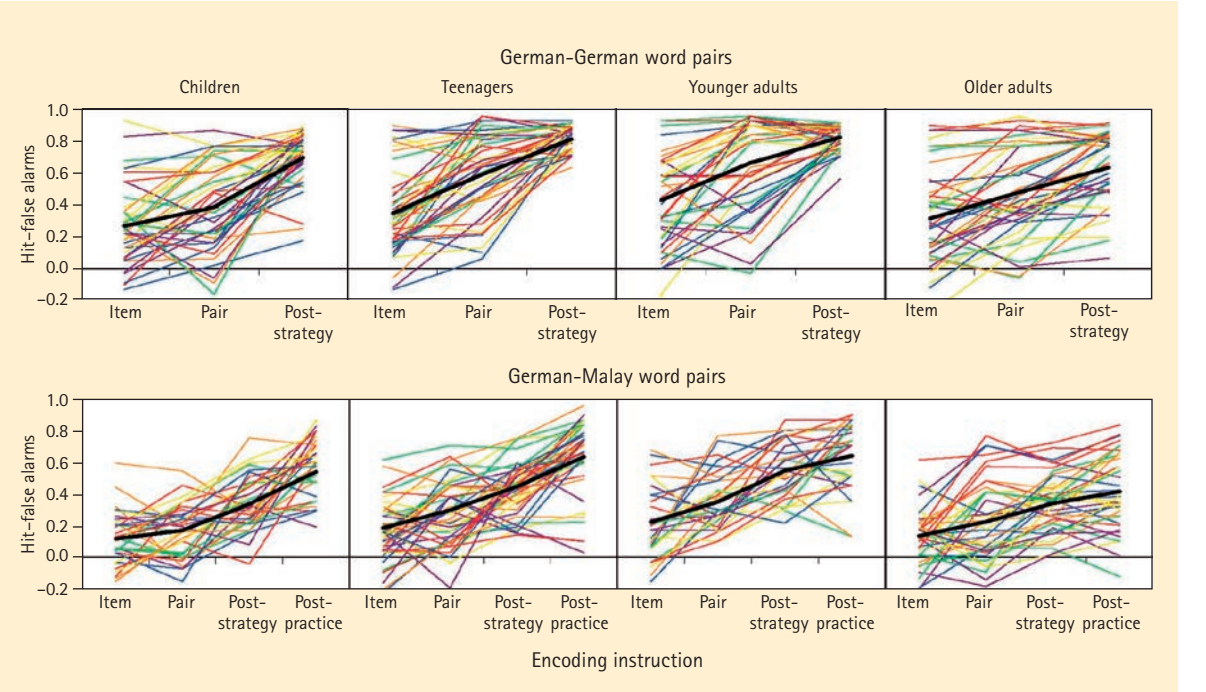


Figure 7. Individual (colored lines) and mean performance (in black bold line) within each age group across levels of encoding instruction in the German-German (top panel) and German-Malay (bottom panel) condition (Dissertations Yee Lee Shing and Markus Werkle-Bergner).

instruction to explicit pair instruction and elaborative strategy instruction). In the elaborative strategy condition, participants were instructed to elaborate on the word pairs with visual imagery that integrates the two words of the pair (e.g., to imagine a dog sitting on the back seat of a car for the word pair "dog-car"). For the German-Malay condition, we also included a practice phase (five sessions) for participants to practice the use of the elaborative strategy due to the higher difficulty of the condition.

For both associative strength conditions, children's initial performance was similar to that of the older adults, whereas teenagers and younger adults performed at comparable levels (see Figure 7 for intra- and inter-group variability; note also that younger adults were provided less time to encode the words than the other three groups). In the German-German condition, children benefited the most from the strategy instruction, and tended to perform above the level of older adults. In the German-Malay condition, children, teenagers, and younger adults benefited from the strategy instruction, and continued to improve their performance after five sessions of practice. In contrast, older adults did not show much improvement across different encoding instructions and continued to show the lowest average performance of all four groups. Thus, it seems that children's latent potential in the associative component could be brought to the fore by combining strategic support with task-relevant practice. In contrast, older adults were less able to benefit from either of the training components. Furthermore, older adults were particularly disadvantaged when associative demands were high (i.e., in the German-Malay condition), probably due to deficits in both strategic elaboration and associative binding. In summary, these findings are consistent with the guiding hypothesis of a lifespan dissociation between strategic and associative components of episodic memory (Dissertations Yee Lee Shing and Markus Werkle-Bergner). Currently, we are developing EEG paradigms to examine age differences in binding mechanisms at the neuronal level in the domains of visual perception and episodic memory (cf. Werkle-Bergner, Müller, Li, & Lindenberger, 2006; Dissertations Yee Lee Shing and Markus Werkle-Bergner).

Subproject III: Lifespan Age Differences in Conflict Monitoring Mechanisms

This subproject examines lifespan age differences in conflict monitoring mechanisms. It was started in August 2006, and is partially funded by a research grant from the German Research Foundation (Deutsche Forschungsgemeinschaft, Forschergruppe 778, Conflicts as Signals in Cognitive Systems). Mechanisms for monitoring conflicts between one's responses *(response conflicts),* between habits and deliberate actions *(overriding conflicts),* or between actual outcomes and desired goals *(outcome conflicts)* help individuals to dynamically adapt to changes in the environment by regulating and changing their behavioral repertoires. Neuroimaging and electrophysiological studies show that the anterior cingulate cortex (ACC) and related regions are activated during conflict monitoring.

Little is known about how conflict-monitoring mechanisms change across the lifespan. Older adults and children perform more slowly and less accurate than young adults on tasks involving response error monitoring and overriding conflicts (e.g. Li et al., 2004). Relatedly, event-related potentials are reduced in amplitude in children and older adults relative to young adults. Age differences in processing outcome conflict have not yet been investigated so far. Using several well-established experimental paradigms adapted for lifespan comparisons, this subproject has begun to examine lifespan age differences in electrophysiological correlates of monitoring mechanisms during response, overriding, and outcome conflicts. Preliminary results suggest that children and younger adults show larger outcome conflict related ERPs than older adults (Dissertation Dorothea Hämmerer).

Key References

Bäckman, L., Nyberg, L., **Lindenberger, U., Li, S.-C.,** & Farde, L. (2006). The correlative triad among aging, dopamine, and cognition: Current status and future prospects. *Neuroscience & Biobehavioral Reviews, 30,* 791–807.

Li, S.-C., Brehmer, Y., Shing, Y.-L., Werkle-Bergner, M., & **Lindenberger, U.** (2006). Neuromodulation of associative and organizational plasticity across the life span: Empirical evidence and neurocomputational modeling. *Neuroscience and Biobehavioral Reviews, 30,* 775–790.

Subproject IV: Neuromodulation of Cognitive Dynamics

In collaboration with the Berlin Neuroimaging Center, this large-scale subproject combines genomic, pharmacological, and brain imaging approaches to investigate the triadic relation between aging, dopaminergic modulation and cognition (Bäckman, Nyberg, Lindenberger, Li, & Farde, 2006). Specifically, we investigate the main effects and interactions of three factors that affect dopaminergic neuromodulatory efficacy: (a) chronological age, (b) the Catechol-O-Methyltransferase (COMT) genetic polymorphism, and (c) pharmacological intervention. Effects are examined at behavioral, neurofunctional, and neurostructural levels of analysis (see Figure 8).

Based on theoretical models and data in support of a curvilinear relation between dopaminergic activity and cognitive performance, this subproject will examine the following hypotheses (Dissertation Irene Nagel): (a) Older age and val/val COMT genotype are associated with lower cognitive performance, higher within-person variability, and more diffuse (e.g., bilateral) patterns of brain activation; (b) older val/val carriers will show disproportionately reduced cognitive performance and inefficient brain responses (e.g., overactivation for a given level of performance); (c) older val/val carriers will exhibit the largest cognitive improvement and the most pronounce increase in neural efficiency following the administration of a dopamine agonist.

Given the distribution of COMT polymorphisms (val/val, val/met, met/met) in the population and the need to exclude individuals not suitable for a neuroimaging study with a pharmacological component, the main study in this subproject, which was initiated in 2006, proceeds in two phases. In the first phase, more than 1,000 younger (20–30 years old) and older (60–70 years old) individuals are being screened for COMT polymorphisms and administered a comprehensive battery of cognitive tests (see Figure 8 for domains of cognitive functions assessed). In the second phase, which will start in summer 2007, we plan to test a total of 96 participants in a double-blind placebo-controlled cross-over design involving three imaging sessions. The participants will be equally divided by age group and COMT polymorphism (val/val vs. met/met), in three imaging sessions: (a) functional imaging session with placebo treatment, (b) functional imaging session with D-amphetamine, and (c) structural imaging including diffusion tensor imaging. By early 2007, about 500 participants had completed the first phase. Preliminary analyses suggest expected associations between cognitive performance and COMT

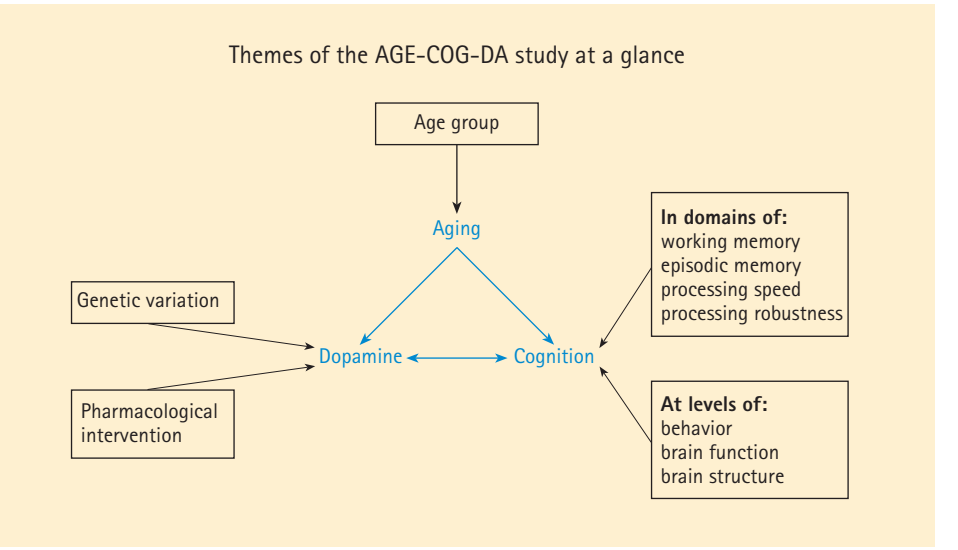


Figure 8. Combined genomic, pharmacological, and brain imaging investigations of interactive relations between aging, cognition, and dopaminergic modulation.

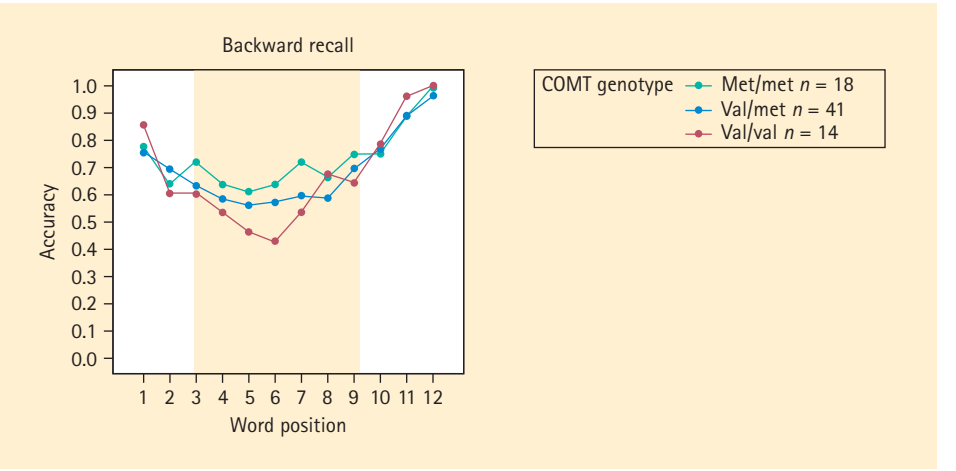


Figure 9. Effects of COMT genotype on backward serial recall performance as observed in a preliminary sample of younger adults. The negative effect of the val allele on cognitive performance is most pronounced in the middle segment of the serial position curve, probably reflecting differential susceptibility to interference.

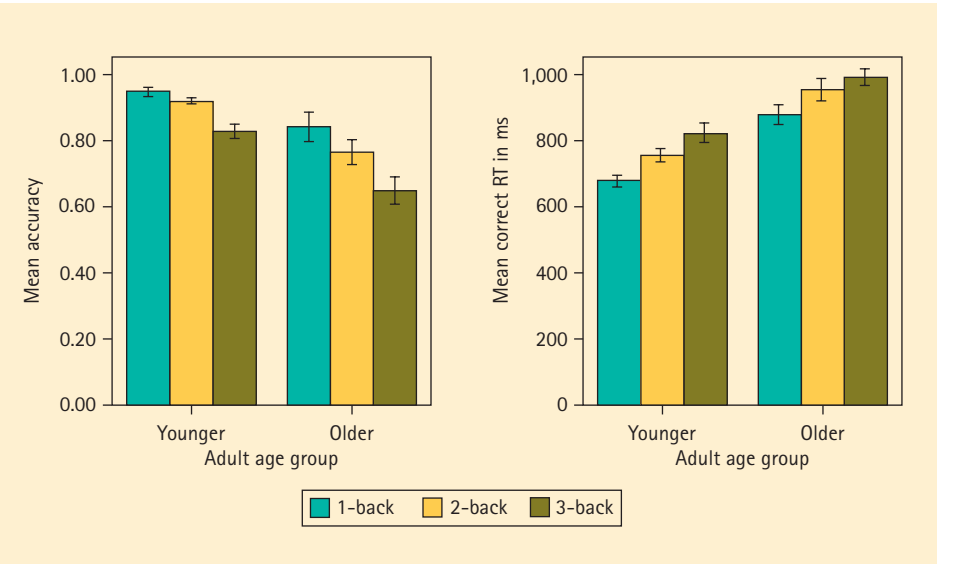


Figure 10. Adult age differences in a spatial working memory task performed in the imaging session. Increasing working memory load reduces accuracy, but increases reaction time. Furthermore, older adults performed worse and slower than younger adults. (Dissertation Irene Nagel; data are based on 11 younger and 11 older adults).

polymorphisms (Figure 9). Furthermore, initial behavioral (Figure 10) and functional brain imaging (Figure 11) results based on pilot work with a spatial working memory task suggest that older adults tend to show more diffuse bilateralized brain activation patterns in prefrontal regions (Dissertation Irene Nagel).

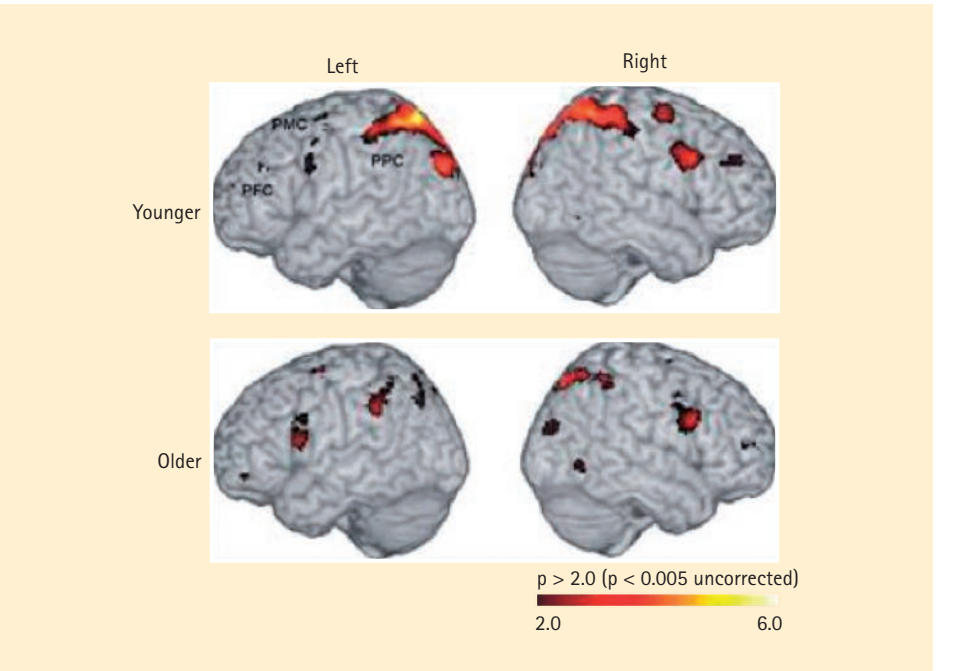


Figure 11. Brain activation patterns during a spatial working memory task. Activation are derived by subtracting a high-load condition from the fixation baseline. Brighter colors indicate higher activation. The fronto-posterior network, usually found during spatial working memory tasks, is active. Older adults tend to show more activation in prefrontal cortex than younger adults, and the activation appears to be more bilateral (Dissertation Irene Nagel; data are based on 11 younger and 11 older adults).

Research Project 2
Sensorimotor–Cognitive Couplings

Scientific Investigators

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Michael Schellenbach
Julius Verrel
(predoctoral fellows)

Conceptual Overview

This project investigates lifespan changes in the interactions between sensorimotor and cognitive aspects of behavior. Everyday life often requires integration of multiple sensory inputs and concurrent coordination of sensorimotor and cognitive demands. Examples are walking while trying to memorize a shopping list, maintaining one's balance on a bus while trying to read an advertisement, or trying to remember the way to a friend's house while driving in the hectic morning traffic. Everyday observation further suggests that older adults, and young children, need to invest more attention into sensorimotor aspects of their behavior than teenagers and young adults. For example, when facing an obstacle on a narrow path, older adults may tend to stop talking and resume their conversations after the obstacle has been overcome, whereas the same obstacle will affect younger adults' conversation to a lesser extent. How do individuals of different ages adapt to multiple sensorimotor and cognitive demands? How does the interaction between sensorimotor and cognitive dimensions of behavior change across the lifespan? This project seeks to provide answers to these questions by studying sensorimotor and cognitive behavior in multiple-task settings with a high degree of everyday validity. A related goal of the project is to propose and test criteria for effective technological assistance in old age.

Dual-Task Costs in the Domain of Walking

Earlier studies from this project demonstrated that older adults invest considerable cognitive resources to compensate for the decreased efficiencies of their sensorimotor functions. For instance, Lindenberger, Marsiske, and Baltes (2000) had participants from three age groups walk different tracks while memorizing word lists. They found that speed and accuracy of walking were reduced when participants had to simultaneously walk and memorize, particularly in older adults. Compared to younger adults, older adults also showed more pronounced performance reductions in the cognitive domain when walking on the track.

In our recent work, we expanded the study of the old-age quandary between increasing cognitive control demands of sensorimotor functioning and decreasing efficiency of relevant control operations to the domain of spatial navigation. To this end, we developed a virtual environment paradigm with a walking component (Figure 1). A scenary, designed to give participants the impression of walking through, for example, an art museum or a zoo, is projected in front of a treadmill. The movement of the treadmill is synchronized to the visual flow of the virtual environment such that participants have the impression of actually walking through this environment. The task for participants might be, for example, to find and remember the way from the entrance of a museum to the bistro. This laboratory furthermore features

Figure 1. The motion laboratory used for studies on dual-task costs in the domain of walking and for examining effects of assistive technology on walking stability and spatial navigation performance.

Key References

Schäfer, S., Huxhold, O., & **Lindenberger, U.** (2006). Healthy mind in healthy body? A review of sensorimotor-cognitive interdependencies in old age. *European Review of Aging and Physical Activity, 3,* 45–54.

Lövdén, M., Schellenbach, M., Grossman-Hutter, B., Krüger, A., & **Lindenberger, U.** (2005). Environmental topography and postural control demands shape aging-associated decrements in spatial navigation performance. *Psychology and Aging, 20,* 683–694.

Lindenberger, U., Marsiske, M., & **Baltes, P. B.** (2000). Memorizing while walking: Increase in dual-task costs from young adulthood to old age. *Psychology and Aging, 15,* 417–436.

an advanced motion capture system and integrated synchronized assessment of EEG and EMG components. To visualize the participant's movement (e.g., while walking), markers reflecting infrared light are attached to the participant's body. In turn, cameras capture the position of the markers, which are postprocessed offline according to biomechanical models. This procedure allows for the visualization of the participant's movements and further analyses. Figure 2 shows captures of different motions that have been taken in this laboratory: A single participant has performed different typical motions (e.g., walking, dancing, playing tennis).

The first study with this paradigm (Lövdén, Schellenbach, Grossman-Hutter, Krüger, & Lindenberger, 2005) tested our fundamental hypothesis that aging-induced cognitive permeation of sensorimotor functions contributes to adult age differences in spatial navigation performance. Sixteen 20- to 30-year-old and sixteen 60- to 70-year-old men were required to find and remember the way to the bistro in museums under conditions of walking with support (holding on to a handrail) or without support until they reached perfect performance. Walking support attenuated age-related decrements in navigational learning (see Figure 3), and walking with navigation load increased older adults', but not younger adults', trunk-angle variability. Thus, walking demands influenced the navigation performance of older but not younger adults.

Thus far, studies of the interaction between cognitive tasks and walking behavior point to greater dual-task costs in older adults, presumably due to increased demands of motor control on cognitive control and reductions in cognitive control capacity. However, a recent study on postural control during upright standing, undertaken in collaboration with with the Intra-Person Dynamics Project (see Figure 3, p. 139), suggests that this may not be the whole story (Huxhold et al., 2006). Instead, a dual-process model may be needed to capture the interactions between cognitive control and motor control. Specifically, a U-shaped relationship between motor control and difficulty of concurrent cognitive activities during balance was found; that is, motor control was improved by concurrent cognitive tasks with low difficulty and attenuated

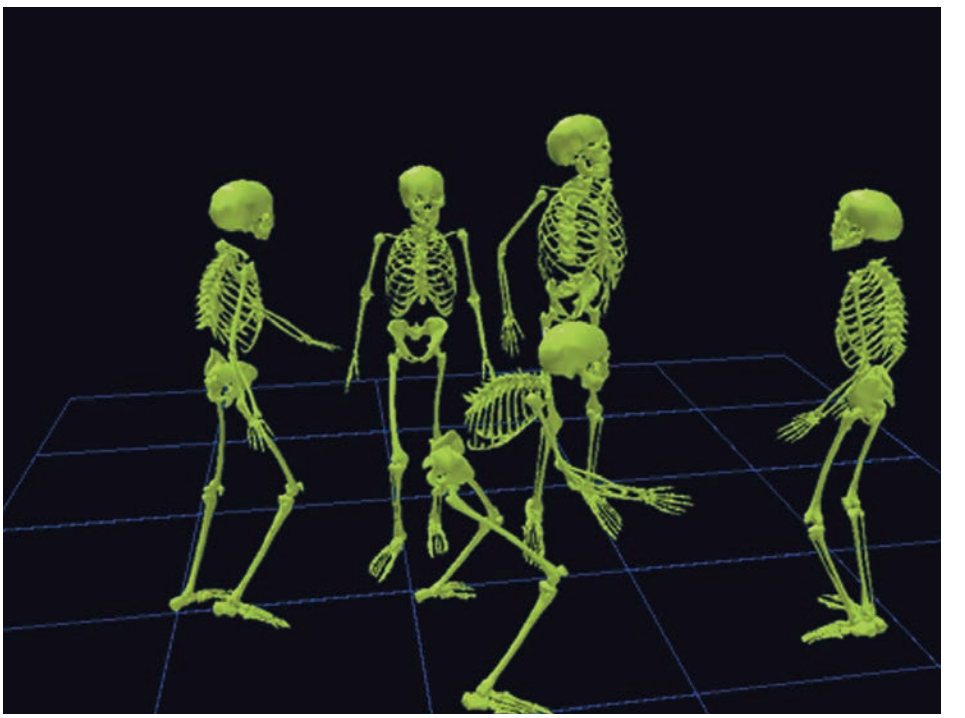

Figure 2. Processed motion captures of an individual performing various different movements. The position of reflective markers attached to the body of the participant is captured by infrared cameras and postprocessed according to biomechanical models to arrive at a dynamic visualization of the participant's movements.

by additional increases in difficulty. Presumably, cognitive activities of lower difficulty may promote an external focus of attention that allow the motor system to self-organize and smoothly execute movement. At the same time, higher levels of cognitive task difficulty may hamper motor control performance through cross-domain resource competition, much like those found in the walking studies reported above. The point at which performance improvements due to the first process is surpassed by decrements induced by the second process in a given individual should be predictable by the individual's sensorimotor and cognitive resources and the demands of motor control on cognitive control.

In a recent study Lövdén, Schäfer, Pohlmeyer, and Lindenberger tested the dual-process account in the domain of walking by parametrically manipulating working memory load, using the *n*-back task, in 32 younger adults with a mean age of 25 years and 32 older adults with a mean age of 74 years who were asked to walk on a treadmill at self-selected speed. Effects of age and age by working memory load, but not dual-tasking, were found for cognitive performance. Stride-to-stride variability was reduced when participants simultaneously performed an easy working memory task (1-back), compared to walking without a task. Further increments in working memory load (i.e., from 1-back up to 4-back) caused reductions in variability, but not in means, of stride time and stride length in younger adults, but not in older adults. In line with these observations, a principal component analysis based on gait patterns indicated a U-shaped pattern for residual whole-body variability in older adults (see Figure 4; Verrel, Lövdén, Schäfer, & Lindenberger, in prep.). We conclude that normal aging is associated with alterations in the trade-offs between two continuous control processes involving positive effects of external focus of attention and negative effects of resource competion, respectively. Our current work on this issue also includes lifespan comparisons. In a first study, Schäfer, Lövdén, Wieckhorst, Pohlmeyer, and Lindenberger found that children, similar to older adults, tend to increase their gait variability with increasing working memory load. In the cognitive domain, however, both children's and young adults' working memory performance was higher when walking than when sitting on a chair. Thus, at least in children and young adults, cognitive performance may benefit from periodic forms of body movement, such as continuous walking across a wide range of difficulty levels.

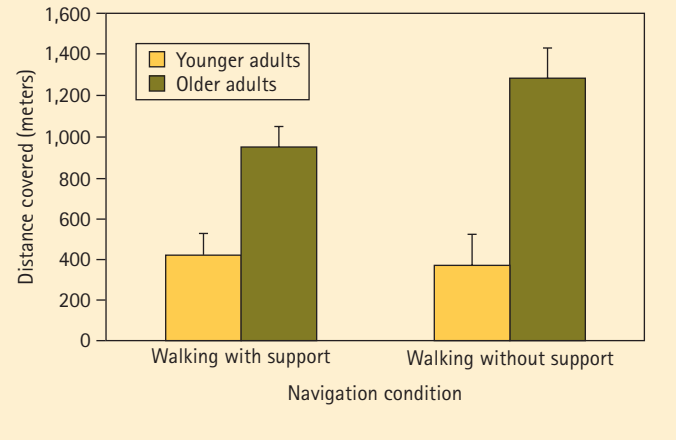

Figure 3. Walking support reduces adult age differences in spatial navigation performance (Lövdén, Schellenbach et al., 2005).

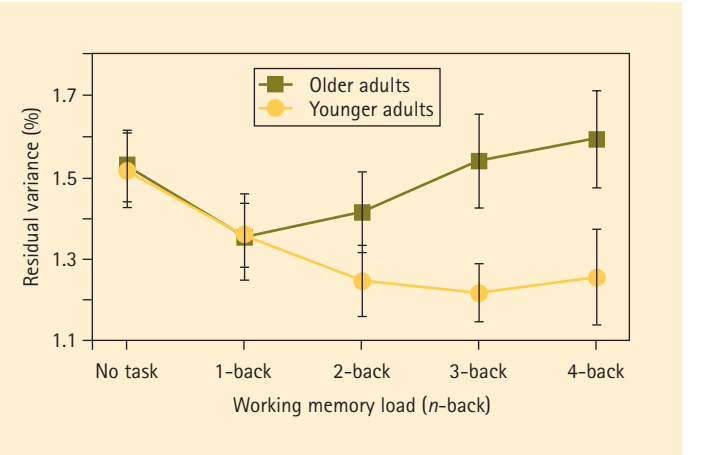

Figure 4. Residual variance of whole-body motion after accounting for the first four principal components as a function working memory load and adult age. Whole-body motion variability decreases with low cognitive demands, and then increases again. This increase occurs earlier for older adults, pointing to increasing cross-domain resource competition with advancing adult age (Verrel et al., in prep.).

Dual-Task Costs in the Domain of Balance

Balance performance can be measured by dynamic posturography. For this purpose, participants stand on a force platform that measures their stability at any given point in time. Previous research in our laboratory has shown that older adults tend to prioritize the balance task in a challenging dual-task situation, by showing less pronounced dual-task related performance decrements (dual-task costs) in the balance domain as opposed to the cognitive domain (e.g., Rapp, Krampe, & Baltes, 2006). In her dissertation thesis, Sabine Schäfer extended this research to the other end of the lifespan, by investigating how children differ from young adults in their ability to balance on a special balance device, the ankle-disc board, while concurrently memorizing word lists or working on a working memory task. While both children and young adults showed performance decrements (dual-task costs) in the cognitive domain, young adults also increased their body sway on the ankle-disc board when concurrently working on a demanding cognitive task. Children, on the other hand, swayed even less when concurrently performing a cognitive task, resulting in negative dual-task costs (see Figure 5; Schäfer, Krampe, Lindenberger, & Baltes, submitted). Children continued to show performance improvements in the balance domain under dual-task conditions even when participants were instructed to focus their attention more strongly on the cognitive task. This pattern of resource allocation is interpreted as an incidence of adaptive resource allocation, since it helps children, who are operating closer to their stability boundaries than young adults, to stabilize their body's equilibrium in a challenging situation.

Future Perspectives

In our future work, we will examine the effects of assistive technology on spatial navigation while walking. For instance, we hypothesize that providing older adults with appropriate spatial navigation support, which is not requiring more cognitive resources for operation that it releases, enhances their ability to find and remember the way to a place in the environment as well as their walking stability (Lindenberger & Lövdén, 2006). Moreover, we will address the processes involved in the increased demands of motor control on cognitive control, and the possibility of separating flexibility and stability of motor behavior, such as in walking.

Key Reference

Lindenberger, U., & **Lövdén, M.** (2006). Co-constructing human engineering technologies in old age: Lifespan psychology as a conceptual foundation. In P. B. Baltes, P. A. Reuter-Lorenz, & F. Rösler (Eds.), *Lifespan development and the brain: The perspective of biocultural co-constructivism* (pp. 350–375). Cambridge, UK: Cambridge University Press.

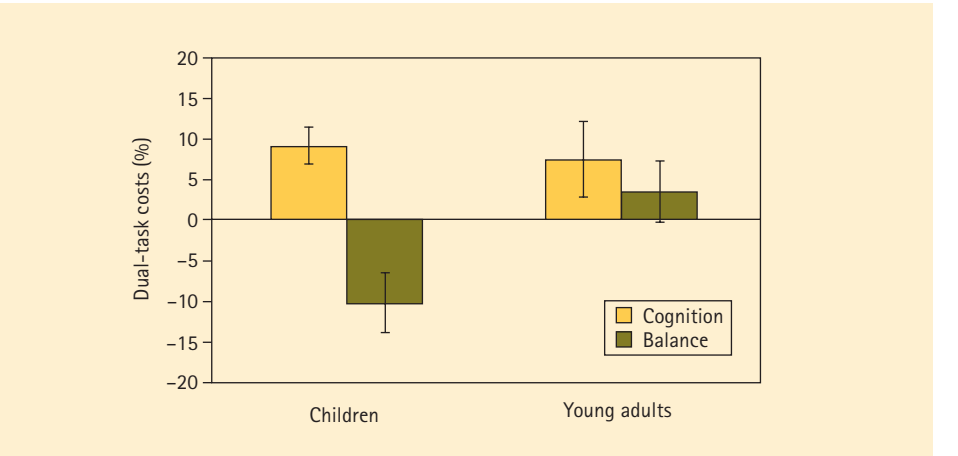

Figure 5. In young adults, dual-task costs are comparably high in the cognitive and the balance domain. Children show a trade-off pattern between dual-task costs in the two domains, with performance improvements in the balance task under dual-task conditions, assumably because they are operating closer to their stability boundaries when balancing on the ankle-disc board (Schäfer et al., submitted).

Research Project 3
The Berlin Aging Study (BASE): Dynamic Modeling of Longitudinal Change and Mortality

Scientific Investigators

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Daniel Grühn (predoctoral fellow, until 09/2005)

During the 20th century, average life expectancy nearly doubled. More and more individuals in current cohorts of older individuals experience additional years of life between the ages of 70 and 100+. What do these added years mean in terms of levels of functioning and life quality for most people? Are there constraints on aging successfully in the last years of life? To examine these issues, members of the Center of Lifespan Psychology have been investigating age- and death-related changes in psychological functioning from age 70 to 100+ in the context of the Berlin Aging Study (Baltes & Mayer, 1999).

At present, longitudinal data in BASE are available for seven measurement occasions spanning over 15 years. Mortality-related information is updated at regular intervals. As of March 2007, 85 % (n = 439) of the 516 individuals who had participated in the 14-session multidisciplinary assessment at the first occasion about 16 years ago were no longer alive.

The analyses of the BASE data set during the 2005–2006 period can be classified into three broad categories. First, the BASE research team made increasing use of a specific variant of latent growth curve modeling, the multivariate dual-change score model introduced by John J. McArdle and Fumiaki Hamagami, in order to test dynamic hypotheses about lead-lag relations between and

Overview of the Berlin Aging Study (BASE)

The multidisciplinary Berlin Aging Study (BASE), initially directed by Paul B. Baltes and Karl Ulrich Mayer, was started in 1989 under the sponsorship of the former West Berlin Academy of Sciences and Technology and its Committee on Age and Societal Development as well as the Federal Ministry for Family Affairs, Senior Citizens, Women, and Youth. Later, the study came under the auspices of the Berlin-Brandenburg Academy of Sciences.

As of 2006, the study involves 7 measurement occasions spaced over 15 years. In addition, several subsamples have been recruited for intensive study. The distinguishing features of BASE 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 (involving two research groups from the Free University Berlin, Internal Medicine and Psychiatry, and two from the MPIB, 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) the 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 aged 70 to 100+ years who completed a 14-session intensive protocol that involved detailed measures from each of the four participating disciplines. The original sample participating in this initial intensive protocol consisted of 258 men and 258 women from the western districts of Berlin. Up to 2005, six longitudinal follow-ups of the survivors from this initial sample involving different amounts of assessment had been completed at approximately 2-year intervals. A single-session multidisciplinary assessment was collected in 1993 and 1994 (n = 361), reduced versions of the intensive protocol (six sessions) were collected in the periods 1995 and 1996 (n = 206) and 1997–1998 (n = 132), and a repeat of parts of the psychology battery together with multidisciplinary outcome variables (e.g., screening for dementia, assessment of well-being) in 2000 (n = 88), 2004 (n = 47), and 2005 (n = 38). In addition, mortality information about the entire BASE sample was updated at regular intervals.

The initial sample of 516 individuals formed the basis of the cross-sectional analyses reported in a German monograph first published in 1996 (Mayer & Baltes, 1996, 1999), in a featured section of Psychology and Aging (1997), and an English monograph published with Cambridge University Press (Baltes & Mayer, 1999, 2000). Six papers reporting two-wave longitudinal findings were published in November 2002 in a special section of the Journal of Gerontology: Psychological Sciences (57B, P471–P571). Specific interests of the Psychology Unit of BASE include issues of sample selectivity and representativeness, cognitive aging, subgroup profiles of psychological functioning, the Fourth Age, gender differences, mortality prediction, self-related change, well-being, and models of successful aging, such as selective optimization with compensation.

www.base-berlin.mpg.de

Key References

Smith, J. (2006a). Berlin Aging Study. In R. Schulz, L. S. Noelker, K. Rockwood, & R. L. Sprott (Eds.), Encyclopedia of aging: A comprehensive resource in gerontology and geriatrics (4th ed., Vol. 1, pp. 110–112). New York: Springer.

Baltes, P. B., & **Mayer, K. U.** (1999). *The Berlin Aging Study: Aging from 70 to 100.* New York: Cambridge University.

Lindenberger, U., & **Baltes, P. B.** (1994). Sensory functioning and intelligence in old age: A strong connection. *Psychology and Aging, 9,* 339–355.

within domains of functioning. Second, and in line with the project's emphasis on selective attrition and predictors of mortality, we continued our attempts to separate age-associated, pathology-associated, and death-related contributions to developmental change. Third, we continue to examine individual differences in aging patterns. In the following, we selectively summarize research from each of the three categories.

Key Reference

Lövdén, M., Ghisletta, P., & **Lindenberger, U.** (2005). Social participation attenuates decline in perceptual speed in old and very old age. *Psychology and Aging, 20,* 423–434.

The Dynamics of Longitudinal Change: Identifying Lead-Lag Relations

A central question in cognitive aging research concerns the relation between social participation and cognitive change. Does an engaged and active lifestyle in old age alleviate cognitive decline, does high cognitive functioning in old age increase the possibility of maintaining an engaged and active lifestyle, or both? Lövdén, Ghisletta, and Lindenberger (2005) addressed these questions by applying the bivariate dual-change score model to BASE longitudinal data. The authors found that prior scores of social participation influence subsequent changes in perceptual speed, while the opposite does not hold. These results lend direct support to the hypothesis that an engaged and active lifestyle in old and very old age may alleviate cognitive decline.

Earlier cross-sectional analyses of the BASE data set revealed a strong association between intellectual and sensory functioning in old age (Lindenberger & Baltes, 1994). However, based on cross-sectional data, the lead-lag relations between sensory and cognitive decline remain unclear. Therefore, Ghisletta and Lindenberger (2005) applied advanced structural equation models to longitudinal BASE data in order to explore the structural dynamics among perceptual speed, verbal knowledge, close visual acuity, and distance visual acuity. The authors found latent regression paths influencing longitudinal changes within and across intellectual and sensory domains. Their findings support the hypothesis that intellectual and sensory domains are dynamically linked in old and very old age. At the same time, they lend little support to the view that one domain of functioning takes clear developmental precedence over the other.

Gerstorf, Lövdén, Röcke, Smith, and Lindenberger (2007) examined cross-domain associations between perceptual speed and well-being. Reports of well-being were found to influence subsequent decline in perceptual speed. No evidence was found for a directed effect in the other direction. Potential covariates, such as initial health constraints, personality, or social participation, did not account for these differential lead-lag associations. These results are of general importance for understanding patterns of aging across different functional domains, as they suggest that well-being is not only a consequence of but also a source for successful (cognitive) aging.

Finally, Lövdén, Li, Shing, and Lindenberger (in press) examined the hypothesis that losses in neuronal signaling fidelity cause senescent changes in behavior by testing whether trial-to-trial reaction time variability in one test of perceptual speed (Identical Pictures) antecedes and predicts longitudinal decline in levels of performance on another test of perceptual speed (Digit Letter Substitution) and a test of ideational fluency (Categories). Higher trial-to-trial variability preceded and predicted greater decline in levels of perceptual speed and ideational fluency performance, whereas the reverse direction of influence was not reliably different from zero (see Figure 1). In accord with neurocomputational theories of cognitive aging (see Project 6), this finding suggests a developmental cascade from senescent changes in variability to senescent changes in central tendency.

The extensive use of the dual-change score model in these and other ongoing longitudinal analyses of the BASE data set mandates close attention to the model's statistical properties. Methodological work on this issue is currently being undertaken in collaboration with Paolo Ghisletta from the University of Geneva and Christopher Hertzog from the Georgia Institute of Technology, Atlanta (see Project 6).

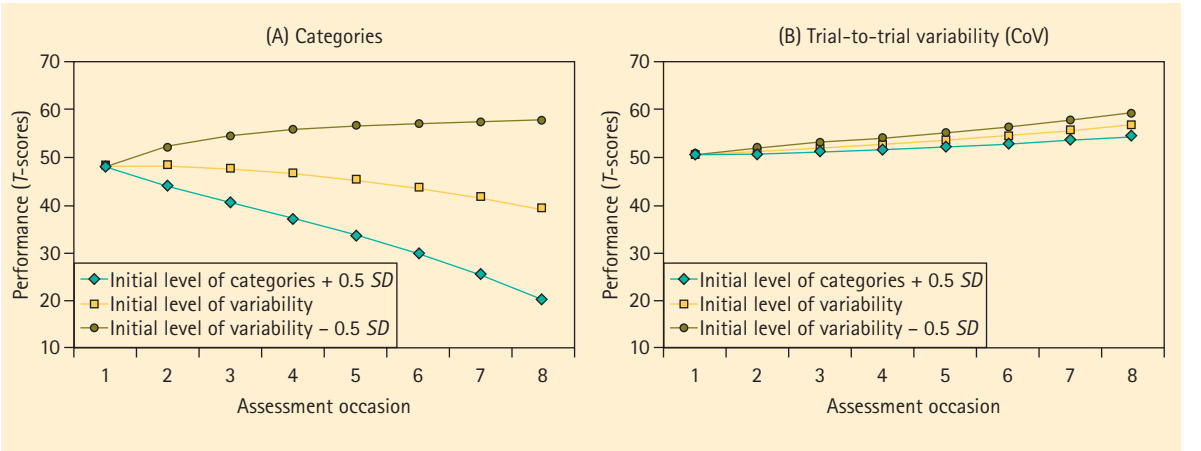

Figure 1. Is high trial-to-trial variability (coefficient of variation, CoV) preceding and predicting decline in performance on the Categories test, a measure of ideational fluency? The two panels of this figure show the model-implied means from the bivariate dual change score model for Categories performance (Panel A) and for trial-to-trial variability (Panel B) as a function of measurement occasion and initial (t1) levels of performance (–0.5 *SD,* estimated mean, and +0.5 *SD*) on either trial-to-trial variability (Panel A) or categories (Panel B). Lower initial trial-to-trial variability is associated with a less negative development of Categories performance (Panel A). In contrast, variations in initial level of Categories performance have little influence on the development of trial-to-trial variability (Panel B) (adapted from Lövdén, Li et al., in press).

Disentangling Age- and Mortality-Related Changes

In the context of a special section on death and cognition in the *European Psychologist* edited by Lars Bäckman and Stuart MacDonald, Ghisletta, McArdle, and Lindenberger (2006) made combined use of latent growth curve modeling and survival analysis to estimate the influence of level and change in cognition on age at death in old and very old age. When cognitive performance was accounted for, age, sex, and motor performance predicted survival, while socioeconomic status and broad personality factors did not, and sensory performance did only at times. Also, when cognitive variables were analyzed independently of each other, both level and change in speed and fluency, as well as level in memory and knowledge, predicted survival. However, when all cognitive variables were analyzed simultaneously, none of them were significantly associated to survival. Taken together, these findings suggest that survival is related to cognitive development in old and very old age in a global rather than ability-specific manner.

In a further attempt to separate death-related from age-associated changes in psychological functioning, Denis Gerstorf, Nilam Ram, Christina Röcke, Ulman Lindenberger, and Jacqui Smith explored terminal decline in reported life satisfaction. Life satisfaction as a function of distance to death was associated with greater interindividual differences and steeper average decline than life satisfaction as a function of distance from birth (i.e., age). Furthermore, the authors identified a point about 4 years before death at which decline showed a two-fold increase in steepness relative to the preterminal phase. For individuals 85 years and older, they observed a three-fold increase. Established mortality predictors including sex, comorbidities, dementia, and cognition accounted for only small portions of the observed associations between life satisfaction and distance to death. Thus, it appears that late-life changes in subjective well-being are related to mechanisms predicting death (see Figure 2).

Key Reference

Ghisletta, P., McArdle, J. J., & **Lindenberger, U.** (2006). Longitudinal cognition-survival relations in old and very old age: 13-year data from the Berlin Aging Study. *European Psychologist, 11,* 204–223.

Individual Differences in Psychological Aging Profiles

Gerstorf, Herlitz, and Smith (2006) examined whether patterns of sex differences on tasks of perceptual speed, episodic memory, verbal fluency, and verbal knowledge are maintained during advanced old age. Using longitudinal BASE data from participants screened

Key Reference

Gerstorf, D., Herlitz, A., & **Smith, J.** (2006). Stability of sex differences in cognition in advanced old age: The role of education and attrition. *Journal of Gerontology: Psychological Sciences, 61B,* P245–P249.

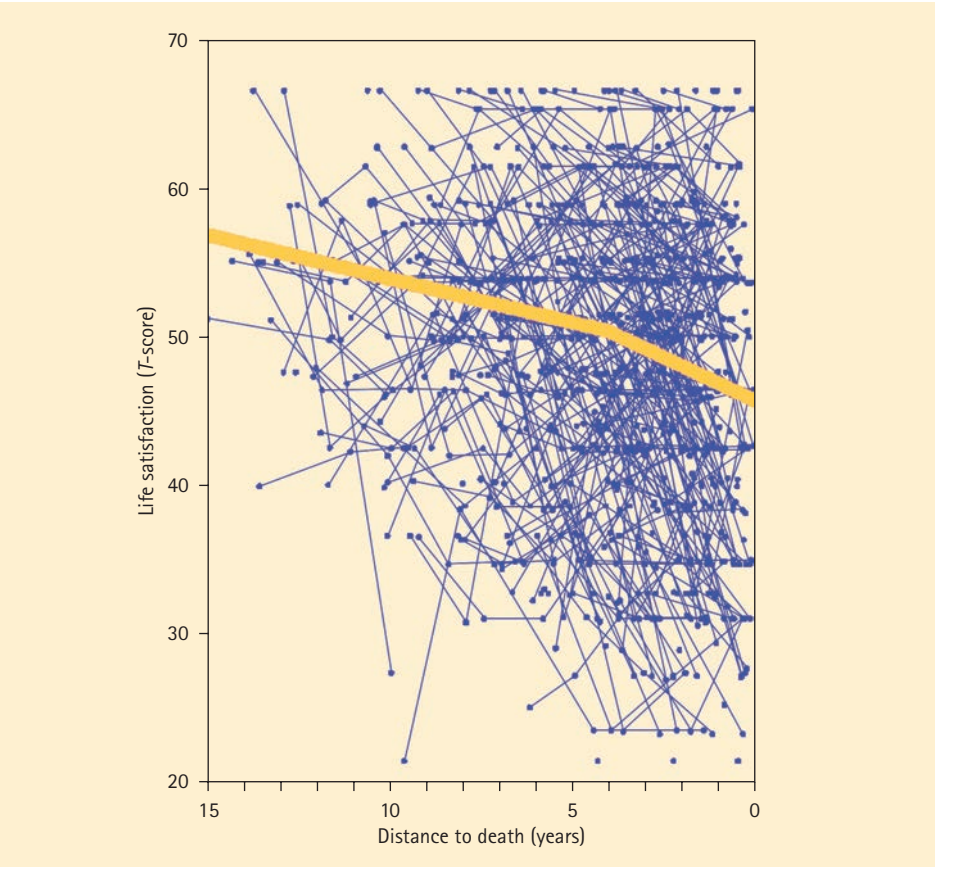

Figure 2. Prototypical (thick line) and individual changes (thin lines) in life satisfaction over distance to death, as revealed by the optimal multiphase growth model with a transition point about 4 years prior to death. Such a two-phase model described the structure of intraindividual changes in life satisfaction in the BASE data set better than a single-phase model covering the complete 15-year period. The prototypical rate of decline steepened from the preterminal phase (–0.59 *T*-score units per year) to the terminal phase (–1.16 *T*-score units per year) by a factor of 2 (adapted from Gerstorf et al., in press).

for dementia, the authors estimated sex-specific age trajectories of cognitive change and explored the roles of education and selective attrition. The authors found that both women and men declined virtually in parallel, with no evidence of differential change. After statistically controlling for differences in education, women's average performance exceeded that of men on tasks from all four domains of functioning (see Figure 3).

Gerstorf, Smith, and Baltes (2006) extended cross-sectional work in BASE to 6-year longitudinal cluster analyses (n = 132). At baseline, three different subgroups had been identified, with distinct within-person profiles across cognitive, personality, and social-integration constructs. Over time, about two thirds of the participants remained in the same subgroups. Baseline subgroups differed in level and slope of subsequent change and in two long-term outcomes, well-being and mortality. Independent of subgroup membership, subgroup-to-subgroup change was associated with greater decline and later mortality.

To further examine the link between sensory and intellectual functioning, Ulman Lindenberger and Paolo Ghisletta examined covariances in longitudinal change for eight cognitive measures assessing four intellectual abilities as well as close vision, distance vision, and hearing. Cognitive declines were highly correlated, with a single factor accounting for 60% of the variance (65% when controlling for age at the first occasion, distance to death, and risk for dementia). In contrast, correlations between cognitive and sensory declines were less prominent. While confirming the need to search for general mechanisms of behavioral senescence, these results also suggest that sensory-cognitive links may be less pronounced when observed longitudinally than when observed cross-sectionally.

Christiane Hoppmann, Denis Gerstorf, Jacqui Smith, and Petra Klumb investigated links of possible selves in three domains—health, everyday cognition, and social relations—to daily activities. In the domains of health and social relations, hoped-for selves were associated with higher probabilities of performing daily activities in these domains. Also, individuals who engaged in hope-related activities reported higher positive affect, and were more likely to survive a subsequent 10-year observation period. These findings speak to important associations between beliefs about possible selves and activities in advanced old age. Life-history-related differences in possible selves were explored by Hoppmann and Smith (2007).

Future analyses in BASE will focus on selective mortality, longitudinal patterns, and the in-depth assessments taken in 2005. In addition, we plan to conduct an eighth longitudinal assessment wave in 2008.

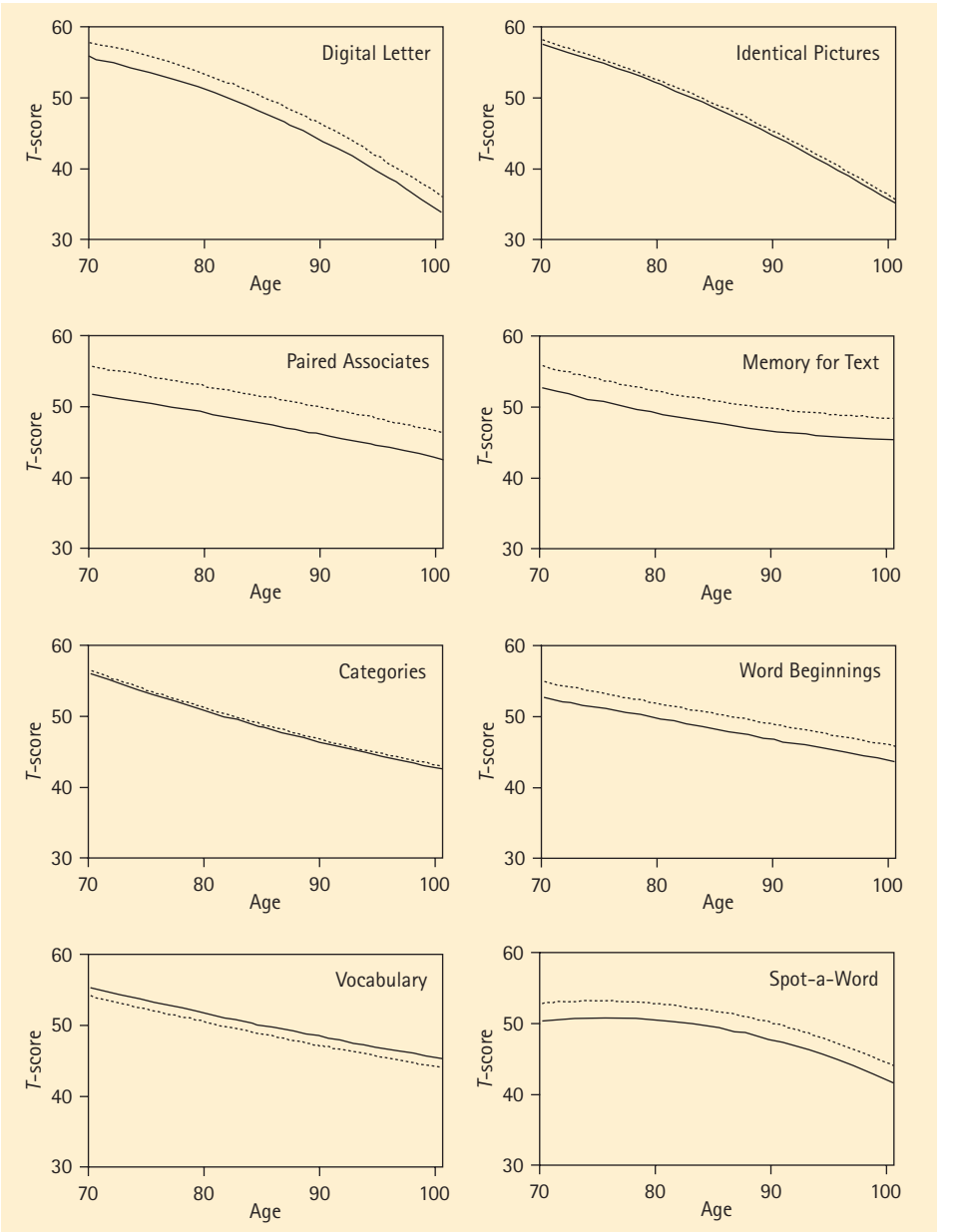

Figure 3. Estimated intellectual ability age gradients for men and women in the Berlin Aging Study (BASE), residualized for education using regression analyses. Solid lines represent men and dashed lines represent women. At the zero-order level, there were sex differences in intercepts of cognitive functioning favoring women on the Paired Associates and Memory for Text tests and those favoring men on the Vocabulary test. Once we took sex differences in education into account, the advantage for men vanished, and a reliable advantage of women over men was found for five out of the eight cognitive tests: Digit Letter, Paired Associates, Memory for Text, Word Beginnings, and Spot-a-Word. For example, on the Paired Associates test, the average performance of women exceeded the average performance of men by 4 *T*-score units. The magnitude of sex differences remained constant throughout the age range studied in BASE. We standardized the *T*-scores (mean = 50, *SD* = 10) to the T1 parent BASE sample to ensure a common metric while maintaining both the psychometric properties of the scores and the longitudinal changes in means and variances (adapted from Gerstorf, Herlitz, & Smith, 2006).

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Research Project 4
Developmental Regulation of Affect, Motivation, and Abilities (DRAMA)

Overview

The DRAMA Project investigates lifespan changes in the regulation of goals and preferences. This includes the pursuit and coordination of personal goals, the use of shared knowledge in the goal-directed behavior of couples, and the implications of lifespan changes in cognitive resources on schema reliance and task selection. To strike a balance between external and internal validity and to assess both intentional and implicit facets of self-regulation, the project uses a variety of empirical methods, ranging from laboratory experiments over self- and peer reports to microlongitudinal studies embedded into participants' everyday lives. The conceptual framework of the project owes much to the selection, optimization, and compensation (SOC) metamodel of lifespan development introduced by the late Margret M. and Paul B. Baltes. According to this model, successful development requires the regulation of four universal developmental mechanisms: elective selection, loss-based selection, optimization, and compensation (see Figure 1).

Currently, the DRAMA project is structured into three subprojects. Subproject I studies the regulation of personal goals and other forms of goal-directed behavior in individuals and dyads. Subproject II examines whether younger and older adults differentially rely on schematic knowledge about the lifespan when processing developmental goals and emotions. Subproject III experimentally investigates SOC mechanisms from a lifespan perspective.

Subproject I: Goal Regulation in Individuals and Dyads

Lifespan theory posits that people actively shape their own life course in the context of malleable cultural, historical, and biological constraints. Selecting, pursuing, and regulating such personalized developmental goals play important roles in intentional self-development, particularly in adolescence and adulthood.

Younger adulthood typically offers access to resources that allow the acquisition of skills

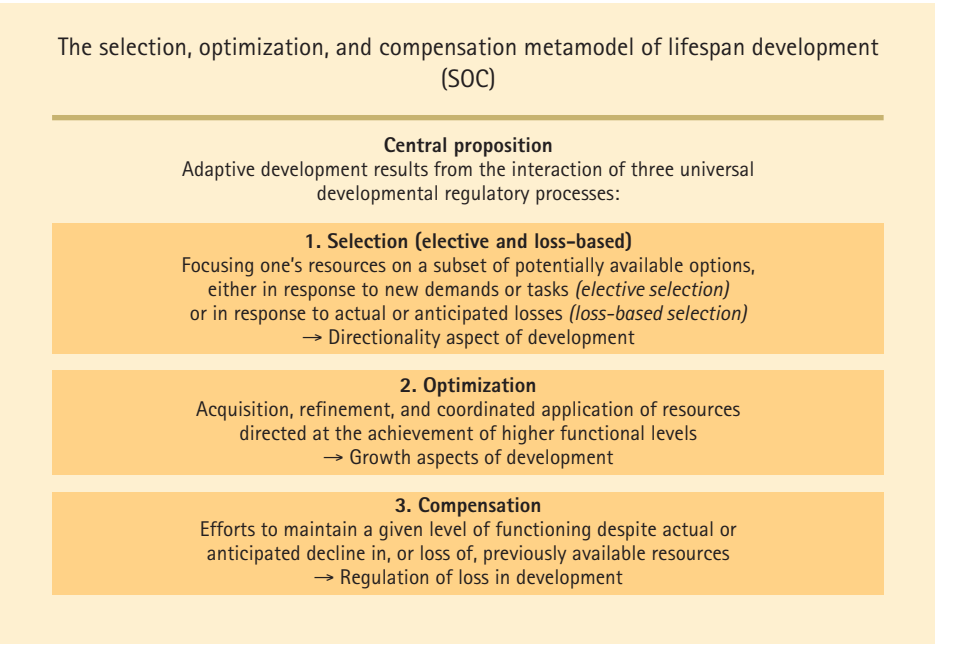
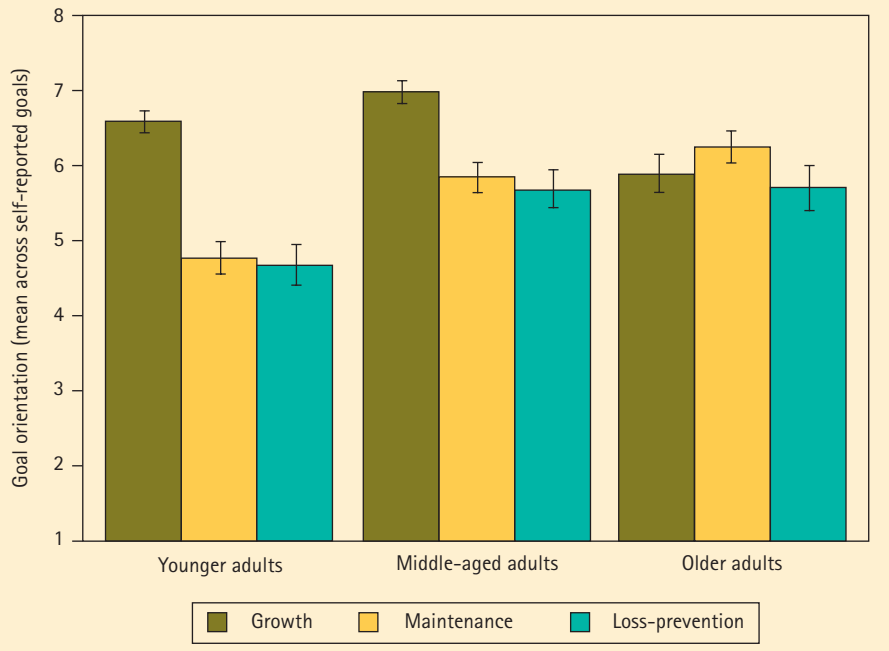


Figure 1. The selection, optimization, and compensation (SOC) metamodel of lifespan development (Baltes & Baltes, 1990).

and the improvement of abilities, whereas later parts of adulthood offer fewer opportunities for growth (Ebner & Freund, in press; Freund & Ebner, 2005). In a first series of studies carried out in 2003 and 2004, we examined individuals' tendency to frame developmental goals in terms of (a) achieving positive states (e.g., "I want to become healthy"), (b) maintaining achieved states (e.g., "I want to stay healthy"), or (c) avoiding negative states (e.g., "I don't want to become sick"). Results from both self-report and experimental studies confirmed the expectation, based on lifespan theory (Baltes, Lindenberger, & Staudinger, 2006), that goal orientations shift from growth toward maintenance and loss-prevention throughout adulthood (Ebner, Freund, & Baltes, 2006; see Figure 2). These studies also show that loss-prevention orientation is negatively related to well-being in younger, but not in middle-aged and older adults, and that maintenance orientation is positively associated with well-being in older but not in younger and middle-aged adults (Ebner et al., 2006).

A second series of studies carried out explored facilitative and interfering relations among multiple developmental goals within the same person (cf. Riediger, 2006). Using experience sampling and observational methods, we found that *intergoal interference* is associated with impairments in subjective well-being, and that *intergoal facilitation* is associated with enhanced behavioral involvement in goal pursuit. Also, older adults tended to report more mutually facilitative goals than younger and middle-aged adults, resulting from increasing motivational selectivity from middle to early-late adulthood. Thus, in line with the SOC metamodel of successful lifespan development (see Figure 1), older adults' ability to invest resources into fewer more central and more similar goals may promote their subjective well-being and everyday competence. Specifically, intergoal facilitation may contribute to high levels of engagement in goal pursuit among older adults in the face of age-associated declines in external and internal resources (Riediger, Freund, & Baltes, 2005; Riediger & Freund, 2006; see Figure 3).



Note. Error bars represent two standard errors.

Figure 2. Adult age-group differences in motivational orientation of self-reported personal goals: Goal orientations shift from growth toward maintenance and loss-prevention throughout adulthood (adapted from Ebner et al., 2006).

Key References

Ebner, N. C., Freund, A. M., & **Baltes, P. B.** (2006). Developmental changes in personal goal orientation from young to late adulthood: From striving for gains to maintenance and prevention of losses. *Psychology and Aging, 21,* 664–678.

Riediger, M., Li, S.-C., & **Lindenberger, U.** (2006). Selection, optimization, and compensation as developmental mechanisms of adaptive resource allocation: Review and preview. In J. E. Birren & K. W. Schaie (Eds.), *The handbooks of aging: Vol. 2. Handbook of the psychology of aging* (6th ed., pp. 289–313). Amsterdam: Elsevier.

Baltes, P. B., & Baltes, M. M. (1990). Psychological perspectives on successful aging: The model of selective optimization with compensation. In P. B. Baltes & M. M. Baltes (Eds.), *Successful aging: Perspectives from the behavioral sciences* (pp. 1–34). New York: Cambridge University Press.

Key References

Riediger, M., & Freund, A. M. (2006). Focusing and restricting: Two aspects of motivational selectivity in adulthood. *Psychology and Aging, 21,* 173–185.

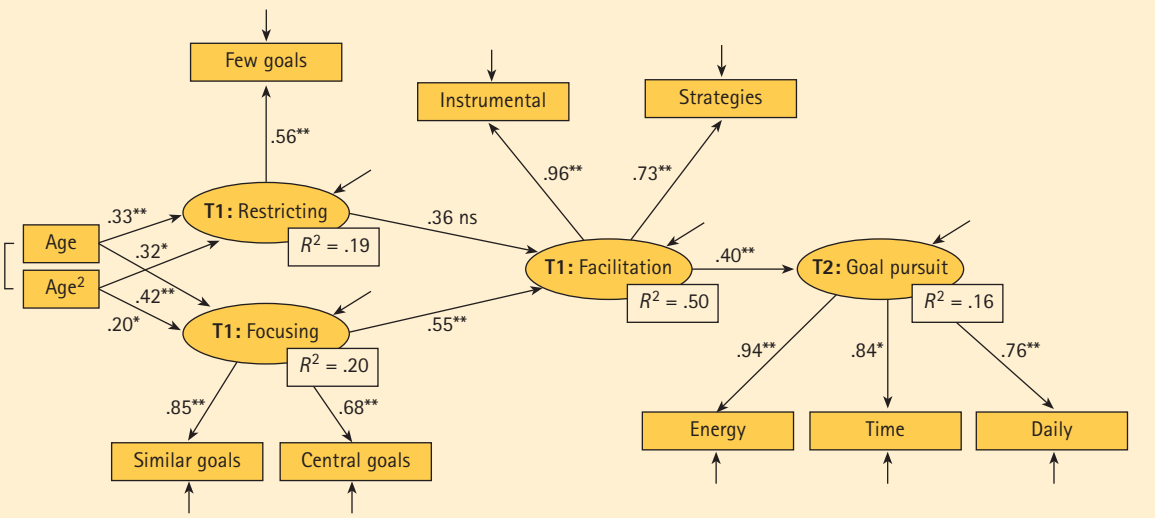
Riediger, M., Freund, A. M., & **Baltes, P. B.** (2005). Managing life through personal goals: Intergoal facilitation and intensity of goal pursuit in younger and older adulthood. *Journal of Gerontology: Psychological Sciences, 60B,* P84–P91.

Developmental psychologists generally agree that individual development is embedded into social systems. However, research on developmental regulation has rarely examined individuals' social contexts (for overviews, see Freund & Riediger, 2005, 2006). The DRAMA project seeks to take a direct look at developmental goals and goal-directed behavior in social contexts. In an initial study completed in 2005, Michaela Riediger and Antje Rauers longitudinally investigated the role of dyadic goal representations for partnership development in 69 couples. We defined dyadic ("we") goals as mental representations of states that "we as a couple" seek to obtain, maintain, or avoid in the future. Results cast some doubt on the notion that dyadic goals are collective-level phenomena. For instance, partners were not aware of how well they corresponded with their partners in ideas about dyadic goals, and the extent of dyadic-goal correspondence between partners was unrelated to partnership-quality evaluations. Dyadic-goal representations, however, nevertheless contributed to positive partnership development, but primarily on the basis of their individual-level characteristics. Individuals' subjective judgment of assumed dyadic-goal correspondence was positively associated with evaluations of partnership quality. Furthermore, individual salience of assumed dyadic goals, as indicated by centrality and longer term stability of reported dyadic goals, predicted individuals' own and their partners' positive evaluations of partnership quality as well as improvements in these evaluations over time.

In a second line of research, we examine the use and usefulness of dyadic knowledge ("common ground") among younger and older adults. We assume that the use of common ground facilitates mutual understanding, but also draws upon cognitive resources. Therefore, we predict: (a) that younger adults use common ground more often than older adults; but (b) that older adults, whenever they use common ground, profit more from it than younger adults.

We currently test these predictions in a quasi-experimental study with a modified version of the collaborative-cognition game Taboo (Dissertation Antje Rauers). Forty younger and 42 older couples participated in the study. Data collection started in 2006, and will end in Spring 2007.

The third line of research in this subproject uses experience-sampling methods to explore



χ^2(df = 29) = 48.1*; CFI = .97; NNFI = .94; RMSEA = .06 (90% CI: .03 – .09).
Note. Standardized solution ** $p < .01$; * $p < .05$; ns $p > .05$.

Figure 3. Throughout adulthood, motivational selectivity increases (in terms of both restricting to few goals and focusing on central and similar goals), contributing to higher intergoal facilitation and higher levels of involvement in goal pursuit (adapted from Riediger & Freund, 2006).

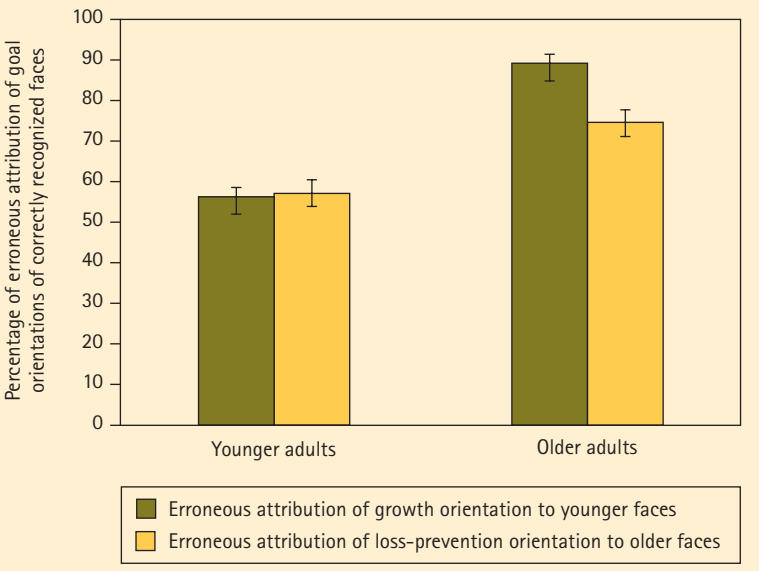
the regulation of affect, motives, and abilities in everyday life. Alexandra M. Freund from the University of Zurich and Michaela Riediger investigated whether negative affective experiences help to activate goal-directed action. Results suggest that negative affective experiences play a role in regulating action, especially when the need for regulation is high. For example, we found that the negative affective valence of goal-detrimental activities was particularly pronounced when participants dealt with overcoming difficulties. In addition, negative affective tone predicted subsequent decrease in goal-detrimental behaviors.

We also investigated age-related differences in the implications of motivational conflict experiences for affective well-being in daily life. Results showed that affective reactivity to motivational conflicts increased, but that the prevalence of motivational conflicts decreased with age. The decreased prevalence of motivational conflicts accounted for age-related improvements in average emotional well-being, suggesting that older adults may be motivated to situations that evoke negative affect or motivational conflicts.

A second study using experience-sampling procedures has been initiated in late 2006. This study is undertaken in collaboration with the Socioeconomic Panel (SOEP), and is funded by the Federal Ministry for Education, Science, Research, and Technology. Gert Wagner from the German Institute for Economic Research is a co-investigator in this project. The main goal of this study is to chart everyday life processes of affective self-regulation from adolescence to older adulthood—their frequency and form, effectiveness, and attentional requirements. Self-report and cognitive measures will be assessed in everyday contexts using JAVA-programmable mobile phones.

Subproject II: Normative Beliefs About the Lifespan as a Schema in Learning and Memory

Lifespan theoreticians have argued repeatedly that normative beliefs about the lifespan influence our perceptions and actions in various ways. For instance, adults of all ages are more likely to expect that individuals are trying to avoid losses when they are older than when they are younger (Freund & Ebner, 2005). At the same time, research on adult age differences in episodic memory by Marcia Johnson, Moshe Naveh-Benjamin, and others



Note. Error bars represent two standard errors.

Figure 4. Age-associated increase in schema reliance: Older adults are more likely than younger adults to erroneously attribute growth goal orientations to young faces and loss-prevention goal orientations to old faces.

suggests that older adults may be less able to form, consolidate, and retrieve associations that are at odds with their schematic beliefs. Therefore, they should rely to a greater extent on lifespan schemas when learning and retrieving schema-relevant new associations. Natalie Ebner, Michaela Riediger, and Ulman Lindenberger tested these predictions in two recent studies, one completed in 2006 and the other ongoing. In both studies, we used a recognition-memory paradigm in which participants are presented adult faces of various ages along with one of two developmental goal orientations (growth vs. loss-prevention), and are later asked to recognize the initially presented faces and the developmental goal orientations with which they were associated. The results of the first study were consistent with our predictions. Specifically, for younger faces presented with a loss-prevention goal during encoding, the likelihood to erroneously associate these faces with growth during recognition was very high among older adults, and considerably lower among younger adults. Conversely, for older faces presented with a growth orientation during encoding, the likelihood to erroneously associate these faces with loss-prevention during recognition was again very high among older adults, and lower among younger adults (see Figure 4).

In addition to goal orientation, the second study also varied the emotional valence of the face (happy vs. sad) in a fully crossed design. The design of this study required the creation of a new set of emotional facial stimuli, as available stimulus materials do not fully cross the age of the face with emotional expression. In collaboration with professional photographers and digital media designers, we compiled a database of naturalistic photographs of younger, middle-aged, and older women and men, each showing two instances of six different facial expressions (neutrality, sadness, disgust, fear, anger, and happiness; see Figure 5). This database, called FACES, will be made available for research purposes as soon as results from an ongoing validation study have been analyzed and submitted for publication.

Figure 5. A lifespan database of six facial expressions (FACES)—sample photographs.

Subproject III: Experimental Investigation of Selection, Optimization, and Compensation Mechanisms From Childhood to Old Age

The general goal of this subproject is to better understand lifespan changes in developmental regulation by investigating the mechanisms of selection, optimization, and compensation in age-comparative quasi-experiments. The subproject is partially funded by a research grant from the German Research Foundation (Deutsche Forschungsgemeinschaft, Forschergruppe 778, Conflicts as Signals in Cognitive Systems). Shu-Chen Li is a scientific investigator in this project, together with Sabine Schäfer, Michaela Riediger, and Ulman Lindenberger.

So far, the subproject has examined the selection mechanism of the SOC model. Given the predominantly positive, relatively balanced, and predominantly negative gain-loss ratio of developmental resources in childhood, adulthood, and old age, respectively, we expected lifespan age differences in the operation of the selection mechanism. In particular, we propose the concept of *selection margins* to study the development of adaptive resource allocation processes in multiple-task situations. We focus on deviations between self-selected and maximally manageable number of simultaneous tasks, which we refer to as selection margins (see Figure 6). In an ongoing study started in 2006, we are currently collecting data on children, teenagers, younger adults, and older adults playing a modified version of the BINGO task, in which called-out numbers have to be found on computerized game cards. Overestimating one's performance potential and choosing too many cards reduces the chance to reach a high score (progressive selection margin) just like underestimating one's potential and choosing too few cards (conservative selection margin). We assume that children and older adults will show more variable performances and selection margins, whereas younger adults will be most accurate in estimating their maximum manageable task difficulty. We furthermore expect that children and teenagers will show progressive selection margins and that older adults will show relatively conservative selection margins. Such lifespan differences in selection margins may mirror differences in developmental trajectories, such as the experience and anticipation of improvement in childhood, and of losses in later adulthood.

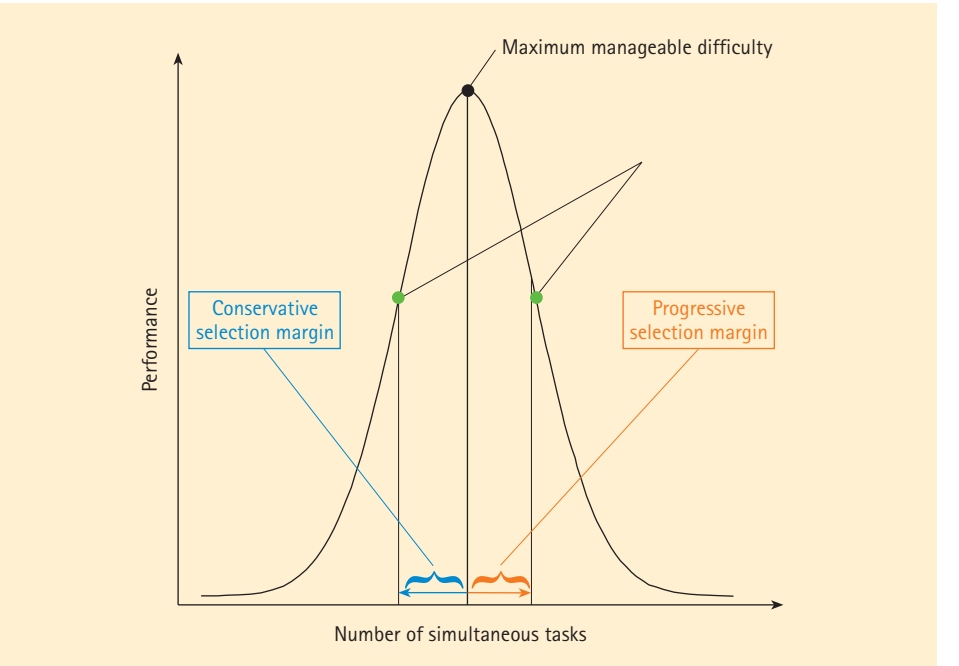


Figure 6. Schematic diagram of selective margins defined as discrepancies between the number of multiple tasks an individual could maximally manage given the available processing resources and the number of tasks he or she actually selects to work on.

Research Project 5
Interactive Brains, Social Minds

Scientific Investigators

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In everyday life, people often need to coordinate their actions with each other. Some common examples are walking with someone at a set pace, playing collective sports, dancing, playing music in duet or a group as well as a wide range of social bonding behaviors, such as eye-gaze coordination and joint attention between mother and infant or between partners. Little if any is known about brain mechanisms implementing interpersonally coordinated behavior. The Interactive Brains, Social Minds project investigates lifespan changes in behavioral and neuronal mechanisms that permit individuals to coordinate their behavior with each other in time and space. The empirical focus is on temporal aspects of interpersonal action coordination as assessed by simultaneous behavioral and EEG recordings. General and ontogenetically early aspects of social activities, such as joint gaze, imitation, and turn-taking are assumed to require interpersonal action coordination. The project has begun to develop several experimental paradigms to study the ontogeny of interpersonal action coordination across the lifespan.

Conceptual Introduction

Natural systems often show a tendency to synchronize (e.g., swarms of bees, schools of fish, or clapping of audiences). As a part of this general phenomenon, the primary focus of the project is on interpersonal synchronization in the context of goal-directed actions between two or more human agents. We assume that interpersonal action coordination requires the *perception, representation,* and *anticipation* of other persons' actions. Theories of *ideomotor processes* specify how actions of others selectively influence one's own actions, as can be observed, for example, in mimicry or imitation. Informed by the work of Steve Baker, Jean Decety, Chris Frith, Wolfgang Prinz, Daniel Wolpert, and others, Figure 1 depicts a forward model of interper-

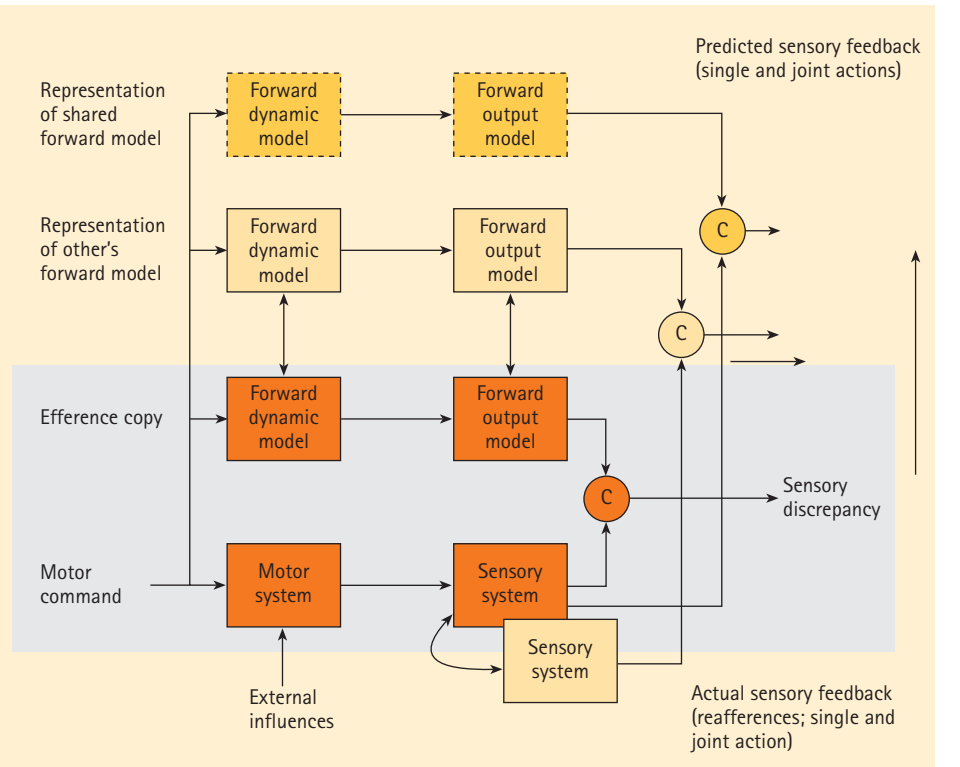


Figure 1. Simplified dyadic forward model of interpersonal action coordination. (The single-person part of the model is grey-shaded.)

sonal action coordination. The model moves from the single-person to the two-person case by assuming two additional representational layers beyond the representation of the person's own actions. The first additional layer represents the assumption that individuals continuously update and revise representations about the other individual's forward model and sensory feedback. To achieve synchronization, individuals need to coordinate the forward model regarding their own actions with the forward model regarding the other person's actions. The second additional layer, also shown in Figure 1, tentatively captures the possibility that highly skilled individuals may represent jointly performed activities as a unified supra-personal action with a joint forward model and partially joint sensory feedbacks. We assume that this privileged format may emerge from the two lower layers in the course of acquiring skills that place high demands on interpersonal synchronization, such as acrobatics, dancing, or chamber music. A central objective of the project is to explore the temporal dynamics of these crossed reciprocal feedback loops from a lifespan perspective.

Interpersonal Action Coordination in Mother–Infant Interactions

Research in the project's infant laboratory, which has been set up in 2006, will focus on behavioral and neural correlates of mother-infant interactions. Already in their first year of life, infants perceive others as social partners and learn through imitation, contingency detection, or joint attention. It is known that infants use social cues from others, such as eye gaze, facial expression, or pointing, and that these cues facilitate focusing of attention and object processing. We hypothesize that oscillatory activity in the infant and in the adult brain may synchronize in situations when the infant follows social cues of the adult toward an external object or event. The interbrain coupling is hypothesized to be particularly prominent in situations when the interactive partner is the infant's parent (see also subproject below).

The human brain undergoes major anatomical and functional changes during the first years of life. Therefore, the task to relate oscillatory activity in adults, compared to infants, will not be easy. To address these methodological issues, we assessed the EEG in 4-month-, 8-month-, and 12-month-old infants and in younger adults in a passive auditory oddball task. Standard 1000 Hz tones and deviant 800 Hz tones were presented while participants were watching a movie (Figure 2). Results based on this standard EEG paradigm will ascertain age-graded differences in general properties of oscillatory activity, such as frequency bands, power, and phase, and will help in the implementation and analysis of EEG measures taken during mother-infant interactions.

Lifespan Development of Interpersonal Action Coordination

This subproject investigates the development of interpersonal behavioral synchronization across the lifespan. Using a dyadic drumming paradigm, we investigated lifespan age differences in dyadic action synchrony in four

Figure 2. EEG recording while an infant is watching a movie during the passive auditory oddball task.

Key References

Drewing, K., Aschersleben, G., & **Li, S.-C.** (2006). Sensorimotor synchronization across the life span. *International Journal of Behavioral Development, 30,* 280–287.

Striano, T., **Kopp, F.,** Grossmann, T., & Reid, V. M. (2006). Eye contact influences neural processing of emotional expressions in 4-month-old infants. *Social Cognitive and Affective Neuroscience, 1,* 87–94.

Baltes, P. B., & Staudinger, U. M. (1996). Interactive minds in a life-span perspective: Prologue. In P. B. Baltes & U. M. Staudinger (Eds.), *Interactive minds: Life-span perspectives on the social foundation of cognition* (pp. 1–32). New York: Cambridge University Press.

Principal Investigator
Franziska Kopp

Figure 3. Dyadic drumming paradigm for studying interpersonal action coordination.

age groups covering early childhood to old age (5-, 12-, 20- to 30-, and 70- to 80-year-olds; Dissertation Anna Kleinspehn). Participants were asked to synchronize their drumming either with metronome frequencies of human-like variability or with four different interaction partners in same- and mixed-age dyads (see Figure 3). Preliminary results indicate that the precision of interpersonal synchronization is highest in younger adults, followed by older adults, older children, and younger children (see Figure 4). Further analyses will focus on the role of flexibility and relevant social abilities in the development of interpersonal action synchronization, and on the association between dyadic asynchrony and the subjective experience of the interaction partner.

Principal Investigator
Viktor Müller

Brain Mechanisms of Interpersonal Action Coordination

This subproject seeks to identify cortical mechanisms of individuals' ability to coordinate their actions by assessing activities that impose high synchronization demands. Little if any is known about brain mechanisms implementing interpersonally coordinated behavior. These mechanisms most likely will have to meet two constraints: (a) They need to be sufficiently fast to permit fluidity in interpersonal action coordination; (b) they need to integrate and regulate sensory, motor, and brain activity to generate and sustain action coordination between two or more persons. Synchronous oscillatory brain activities appear to meet both criteria. First, brain oscillations bind spatially distributed, but functionally related, information at the level of individual neurons, cell assemblies, and cortical areas. Onset times and frequency ranges of coherent or synchronized oscillations are sufficiently fast to permit, in principle, the speed and precision of information exchange required by interpersonal action coordination.

By simultaneously recording the EEG of two people, we measured brain electrophysiological activities from eight pairs of guitarists while playing a short melody together over about 60 trials (see Figure 5). Synchronous brain activities within and between brains were investigated and analyzed by Phase Locking Index (PLI) and Interbrain Phase Coherence (IPC), respectively. We found that phase synchronization both within and between brains increased significantly during the periods of (i) preparatory metronome tempo setting and (ii) coordinated play onset

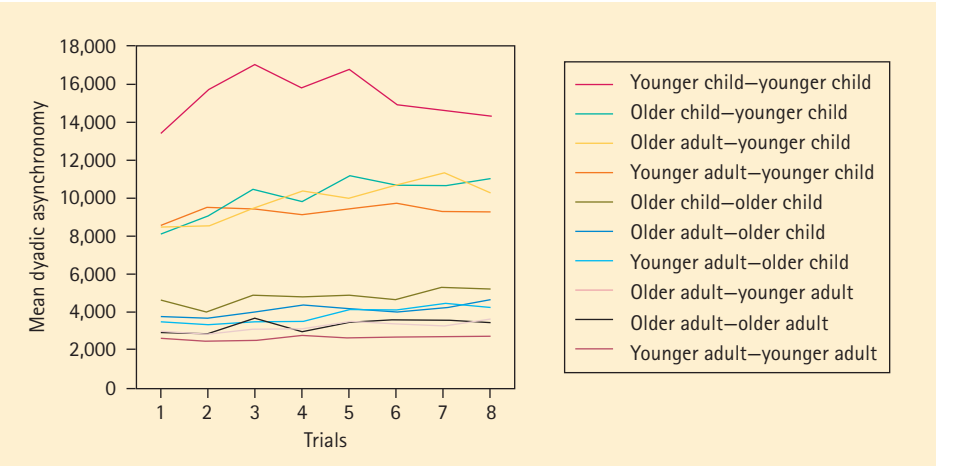


Figure 4. Mean dyadic asynchrony of different age-group combinations: Young children show highest asynchrony, especially when drumming in same-age dyads.

(Figure 6). Phase alignment extracted from within-brain dynamics was related to behavioral play onset asynchrony between guitarists. We tentatively propose that oscillatory couplings between brains provide the neurophysiologic basis for interpersonally coordinated voluntary actions, which may serve as a basic mechanism for social interaction.

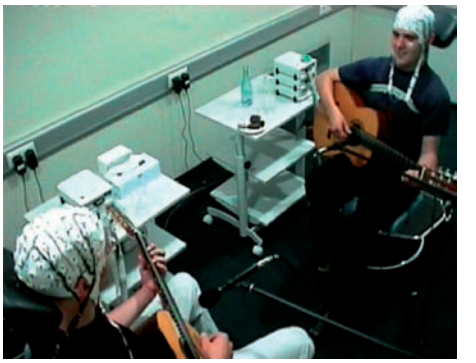


Figure 5. One pair of guitarists with electrode caps during the experimental session.

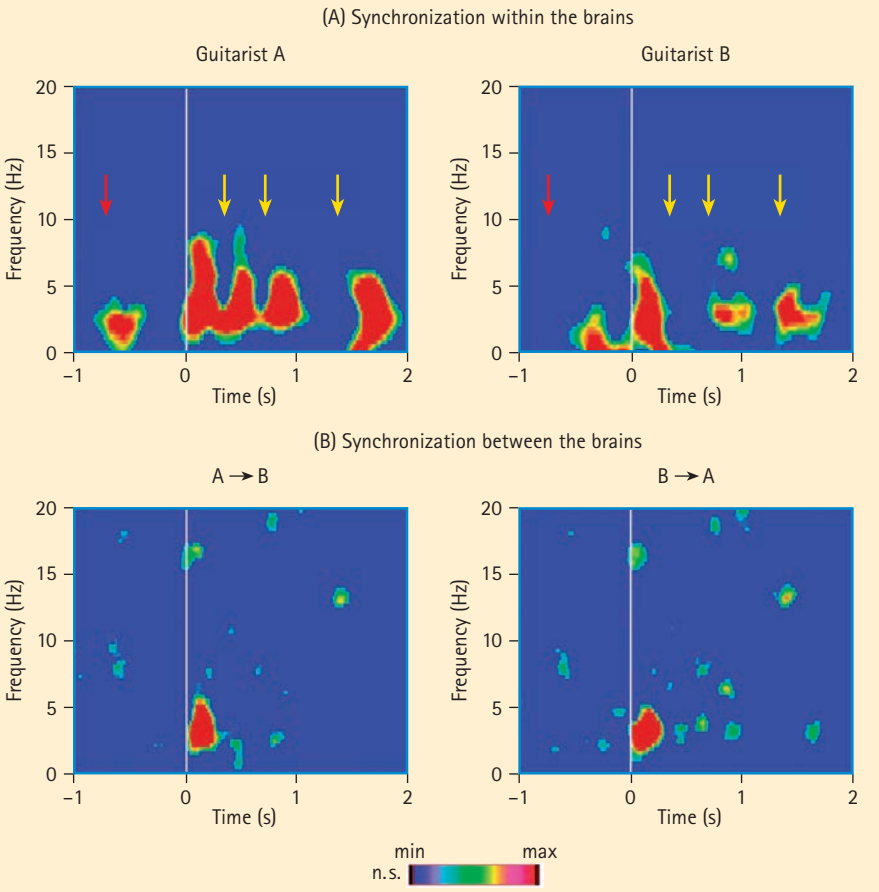


Figure 6. Phase synchronization within and between the brains during the period of guitar playing. (A) Time-frequency diagrams of the average Phase Locking Index (PLI) for guitarists A and B separately. PLI was averaged across six fronto-central electrodes showing PLI maxima (F3, Fz, F4, C3, Cz, and C4). Only significant PLI values ($p < 0.003$) are highlighted. Time zero is time locked to play onset of the leading guitarist A. The leading guitarist's finger gesture to start playing together is depicted with the red arrow. The yellow arrows marked single guitar notes as recorded. High phase synchronization in both guitarists took place not only at play onset but also at the time point of gesture to start, and at the individual guitar strikes. (B) Time-frequency diagram of the average IPC averaged across six electrode pairs. On the left diagram (A → B), the selected electrode pairs represent interphase coherence between one electrode of guitarist A (Cz) to the six fronto-central electrodes of subject B. On the right diagram (B → A), the selected electrode pairs represent phase coherence between one electrode of guitarist B (Cz) to the six fronto-central electrodes of subject A. Only significant IPC values ($p < 0.003$) are highlighted. High phase synchronization between the guitarists took place at play onset.

Research Project 6
Formal Methods in Lifespan Psychology

Scientific Investigators

Timo von Oertzen (as of 02/2006)
Shu-Chen Li
Ulman Lindenberger

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 Methods Project of the Center continues this tradition with an added emphasis on computer algebra and computational neuroscience.

Currently, the Methods Project has three main research foci. First, it investigates the properties of statistical methods commonly used in developmental psychology, with an emphasis on structural equation modeling and maximum likelihood estimation. Second, the project develops neurocomputational models to integrate lifespan theorizing across behavioral and neuronal levels of analysis. Third, and more recently, the project has started to work on brain signal analysis.

Principal Investigator
Timo von Oertzen

Statistical Modeling

Together with Paolo Ghisletta (University of Geneva), Christopher Hertzog (Georgia Institute of Technology, Atlanta), and Jack McArdle (University of Southern California), this part of the project uses formal mathematical analysis and Monte Carlo simulations to examine statistical properties of methods that are widely used in developmental research.

A first line of formal analysis concerned the relation between correlated individual differences in longitudinal change and correlations among variables as they are observed in cross-sectional age-heterogeneous data sets. By decomposing cross-sectional correlations in terms of bivariate linear growth, we formally showed that longitudinal change in a mediator variable that shares large amounts of age-related variance with the target variable does not have to correlate with longitudinal change in the target variable. Conversely, longitudinal change in a mediator variable that does not share any age-related variance with the target may nevertheless correlate highly with longitudinal change in the target variable. We conclude that mediator analyses performed on the basis of cross-sectional data provide invalid approximations to the dimensionality and causal structure of behavioral change, and discourage its use for this purpose (see also Lindenberger & Pötter, 1998).

A second line of formal analysis and simulation aimed at the issue of statistical power in structural equation modeling (Hertzog, Lindenberger, Ghisletta, & von Oertzen, 2006). Variants of structural equation modeling, such as latent growth curve models, are widely used in developmental research, but surprisingly little is known about their statistical power. For instance, researchers are generally unaware about how many individuals or occasions they would need to detect individual differences in change of a given magnitude, or to detect covariations between two change processes across individuals.

Figure 1, adapted from Hertzog et al. (2006), displays the power to detect the covariance of change for two linear change processes, mapping reliability (x-axis) against power (y-axis) for different numbers of longitudinal occasions. Even with large samples ($N = 200$ or 500) and several longitudinal occasions (4 or 5), statistical power to detect covariance of slopes was moderate to low unless growth curve reliability at study onset was above $.80$. Thus, studies using latent growth curve models may fail to detect slope correlations due to low power rather than the lack of relationship of change between variables. In combination with other results on the power to detect variances of change, our results allow researchers to make more informed design decisions when planning a longitudinal study. Current extensions of this work include the gain in power associated with the use of multiple indicators at each point in time, and the programming of a statistical tool that allows researchers to perform

Key References

Hertzog, C., Lindenberger, U., Ghisletta, P., & **von Oertzen, T.** (2006). On the power of multivariate latent growth curve models to detect correlated change. *Psychological Methods, 11*, 244–252.

Lindenberger, U., & Pötter, U. (1998). The complex nature of unique and shared effects in hierarchical linear regression: Consequences for cross-sectional developmental research. *Psychological Methods, 3*, 218–230.

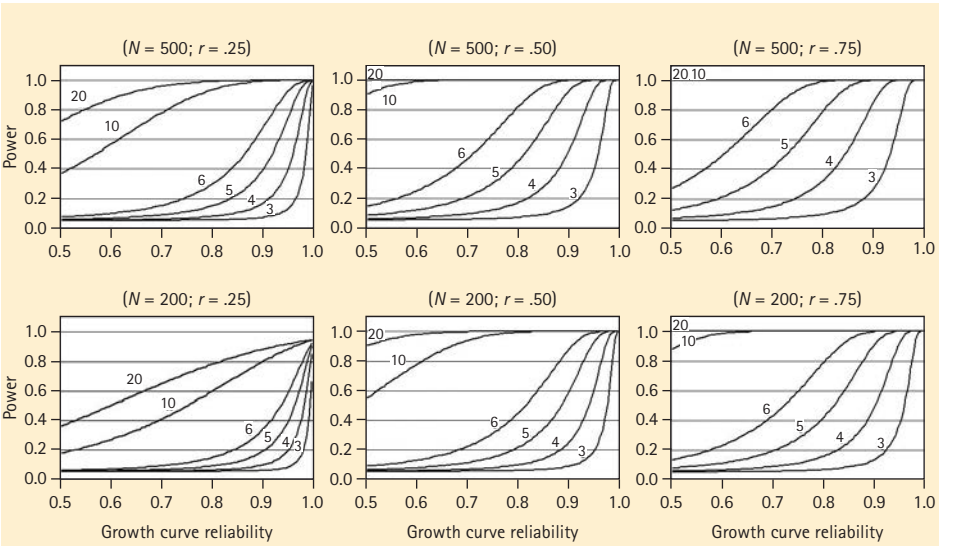


Figure 1. The statistical power to detect covariance of change in latent growth curve models. Satorra-Saris power plots mapping reliability (x-axis) against power (y-axis) for different numbers of longitudinal occasions (organized from left to right as 20, 10, 6, 5, 4, and 3 occasions). The top row corresponds to $N = 500$, the bottom row to $N = 200$. The columns represent slope-slope correlations (from left to right) of .25, .50, and .75.

power calculation for a wide range of developmental research designs.

To further facilitate the computation of statistical power in structural equation modeling, Timo von Oertzen is currently exploring *power equivalence*, or the relation between two structural equation models that have the same statistical power to detect a given effect. The main purpose of this work is to reduce complex models into simple models with equivalent power. Power-equivalent transformations would allow researchers to analytically arrive at "iso-power lines" projecting design parameters, such as the number of measurement occasions, the number of indicators per measurement, and the reliability of measurement onto simpler computationally more tractable models.

Neurocomputational Modeling

In a series of neurocomputational investigations, Shu-Chen Li and colleagues have promoted the use of neural networks as a computational platform for cross-level integration of lifespan differences in cognitive and neuronal processes (e.g., Li, Lindenberger, & Sikström, 2001). The neurocomputational approach proposed by Li et al. (2001) represents central aspects of cognitive senescence as a developmental cascade of suboptimal neuronal gain control that is caused by deficient neuromodulation, which then leads to noisier neuronal signaling, less separable processing pathways, and less differentiated cortical representations (see also Project 1, pp. 136-146).

During the 2005–2006 periods, this line of inquiry was extended in two directions. First, together with Moshe Naveh-Benjamin (University Missouri-Columbia), the project investigated the relation between age changes in neuromodulation and associative binding deficits in old age (Li, Naveh-Benjamin, & Lindenberger, 2005; see also Project 1, p. 136). Our results support the conjecture that neuromodulatory processes act as a basic memory binding mechanism by affecting the efficiency of distributed conjunctive coding. Currently, we are developing multimodule networks to study interactions between reward-related phasic dopaminergic modulation in the midbrain and aging-related deficits in tonic dopaminergic modulation in prefrontal and hippocampal regions in tasks involving attention, working memory, and episodic memory.

Second, we studied the effects of aging-related increments in intrinsic neuronal noise on *stochastic resonance*, a fundamental property of physical and biological systems, in which noise acts as an amplifier of weak signals (see Figure 2). We showed that

Key References

Li, S.-C., von Oertzen, T., & **Lindenberger, U.** (2006). A neurocomputational model of stochastic resonance and aging. *Neurocomputing, 69,* 1553–1560.

Li, S.-C., Lindenberger, U., & Sikström, S. (2001). Aging cognition: From neuromodulation to representation. *Trends in Cognitive Sciences, 5,* 479–486.

Principal Investigators
Timo von Oertzen
Shu-Chen Li

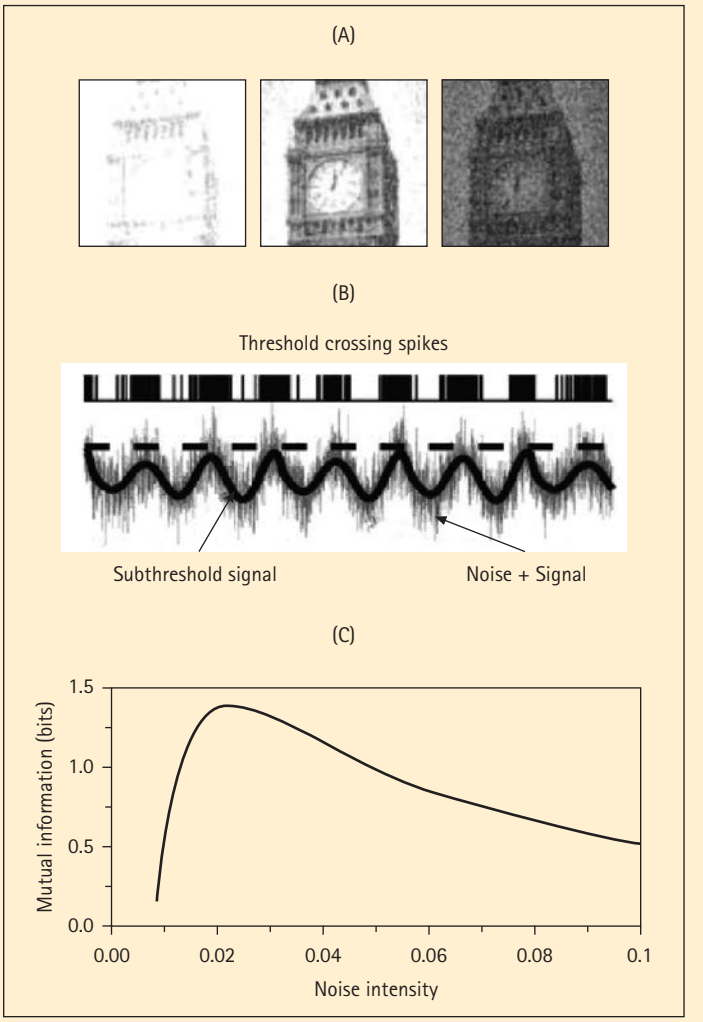


Figure 2. Stochastic resonance as a means to enhance the processing of weak signals. In Panel (A), a grey scale picture of Big Ben is shown on the left, with all pixels below 100 removed. The figure is downscaled such that the building can hardly be recognized. In the two other pictures, noise is added such that the picture first shows clearly (middle), and then fades again (right). In Panel (B), the operation of stochastic resonance is illustrated. A subthreshold signal is not recognizable unless an optimal amount of noise raises it above threshold. With too much noise, the signal blurs again and can be detected less well. Panel (C) displays detection accuracy as a function of noise.

Principal Investigator
Timo von Oertzen

systems with greater intrinsic neuronal noise and less plasticity continue to exhibit stochastic resonance at both single-neuron and network levels. However, the stochastic resonance effect is smaller and, somewhat counter-intuitively, requires greater amounts of external noise for its operation (Li, von Oertzen, & Lindenberger, 2006; see Figure 3). Empirical evidence in line with these predictions were independently obtained in an age-comparative study on aging and vibrotactile perception by Cari Wells and colleagues from the University of British Columbia.

Brain Signal Modeling

This part of the project was initiated in summer 2006. Here, we seek to refine methods in brain signal analysis as a means to improve our understanding of lifespan changes in brain-behavior relations (e.g., Lindenberger, Li, & Bäckman, 2006b). Currently, three lines of inquiry are being pursued. First, in collaboration with Oliver Stegle from Cambridge University, Timo von Oertzen is working on Bayesian methods for the localization of sources of neuronal activity on the basis of electro-encephalic recordings (EEG). Of particular interest is the simultaneous estima-

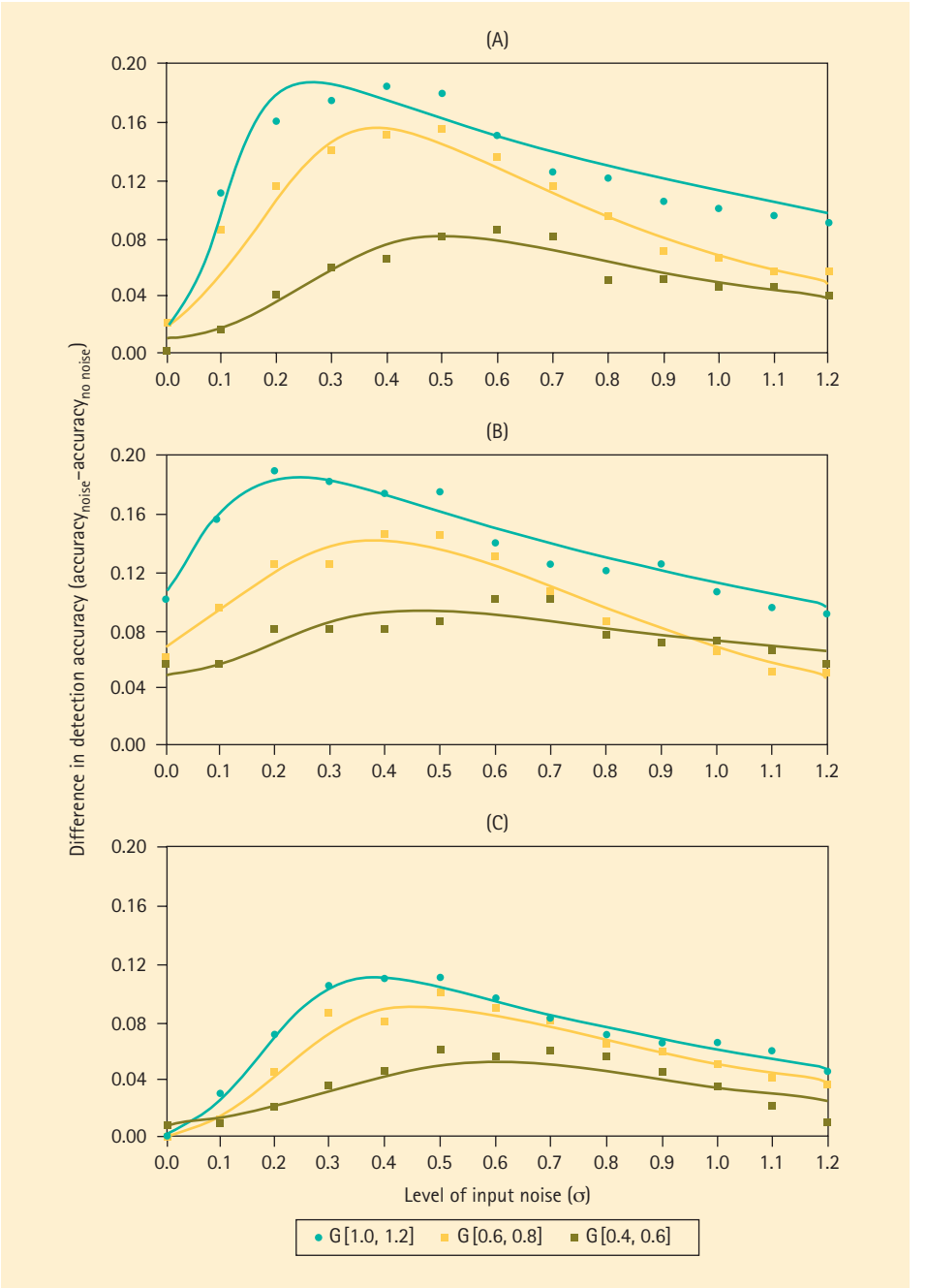


Figure 3. Stochastic resonance (SR) in neural networks with different levels of stochastic gain (G) simulates the effects of senescent changes in dopaminergic neuromodulation on perceptual processing. (A) Stochastic resonance functions at different levels of gain. Peaks of stochastic resonance functions with smaller stochastic gains are lower and right shifted. (B) Short-term plasticity and stochastic resonance. Stochastic resonance functions after exposure to subthreshold stimuli and external noise for different levels of gain. (C) Long-term plasticity and stochastic resonance. Stochastic resonance functions assessed after extensive exposure to suprathreshold stimuli and external noise.

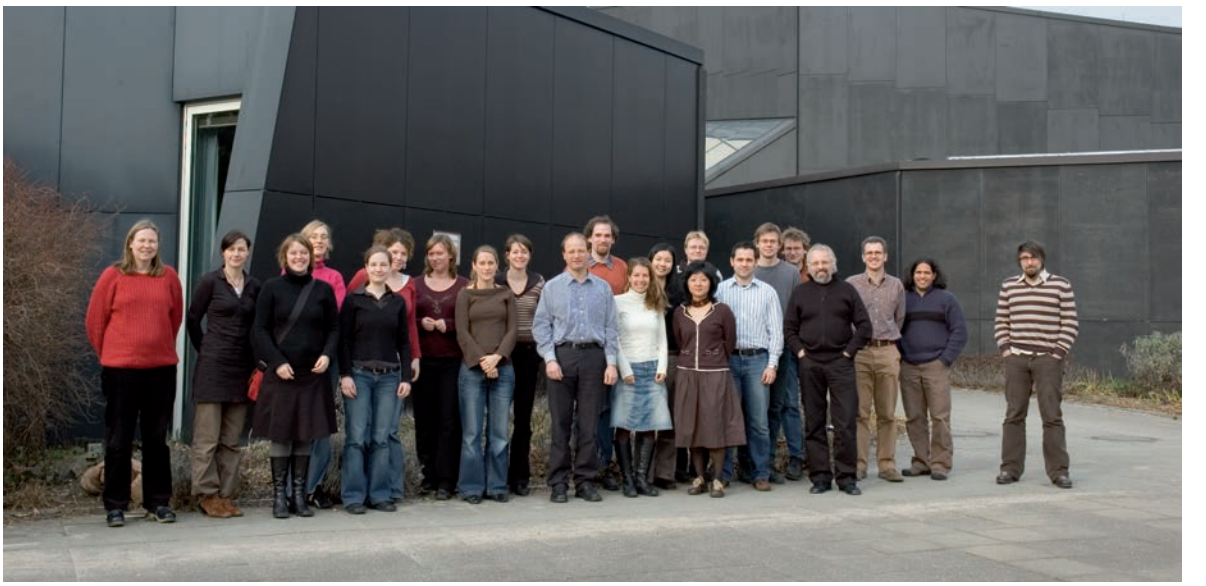
tion of multiple sources defined by frequency, power, or spatial position for two or more brains of individuals performing the same task. This comprises the brains of two individuals who are performing a joint action, such as playing music together, as a special case (see Project 5, p. 162).

Second, we are investigating spiking neuron models and synfire chains. Building on our work on stochastic resonance, we explore ways of modeling age-associated processing changes in integrate-and-fire neurons, and assess the effect of these changes on stochastic resonance and the signaling robust-

ness of synfire chains. We plan to use such models to simulate the emergence of electrical fields in synchronized neuronal assemblies, with the goal to link integrate-and-fire models to simulated and empirical EEG data.

Third, we plan to relate our work on power equivalence to EEG data analysis, with the goal to pool EEG data in ways that optimize the statistical power to detect hypothesized effects.

The Center for Lifespan Psychology in February 2007



Left to right: Julia Delius, Michaela Riediger, Imke Kruse, Dorothea Hämmerer, Anna Kleinspehn, Karen Bartling, Franziska Kopp, Antje Rauers, Natalie Ebner, Ulman Lindenberger, Timo von Oertzen, Irene Nagel, Yee Lee Shing, Sabine Schäfer, Shu-Chen Li, Michael Schellenbach, Martin Lövdén, Julius Verrel, Viktor Müller, Christian Chicherio, Nilam Ram, Markus Werkle-Bergner.

Research Project 7
Toward a Psychological and Developmental Theory of Sehnsucht (Life Longings)

Scientific Investigator

† Paul B. Baltes

Susanne Scheibe (postdoctoral fellow)

Dana Kotter-Grühn (predoctoral fellow)

One of the exciting events in lifespan psychology is the identification of novel constructs that appear worthwhile of investigation when considering the life course as a whole. With the construct of "Sehnsucht" (German for longing, yearning), this project aims at capturing individual and collective thoughts and feelings about one's optimal or utopian life. The concept highlights two central topics of life in the modern world, a permanent search for perfection and a permanent sense of incompleteness, objectively and subjectively (Baltes, 1997). "Sehnsucht" is difficult to translate into English. After much deliberation, we have chosen to characterize the emerging research program as the "psychology of life longings." We view life longings as emotional and mental representations of personal peaks of life, akin to personal utopias. In principle, however, these personal utopias are unattainable and, therefore, ambivalent in emotional quality.

Introduction

In German everyday life, the concept of "Sehnsucht" is salient. In fact, "Sehnsucht" was the third most often nominated word in a recent contest of "the most beautiful German word" (Spiegel Online, 2004). Building on everyday dictionary-like definitions of "Sehnsucht" on the one hand, and applying principles of lifespan psychology (e.g., Baltes, 1997) on the other, we derived a family of six characteristics to capture the structure of life longings (see Table 1). Empirical data confirmed this conceptualization (Scheibe, Freund, & Baltes, in press).

To assess life longings, we generally ask study participants to undertake a guided "mental journey through life" during which they are asked to generate a list of personal life longings. They then evaluate each of their most important life longings on a questionnaire designed to measure the six structural characteristics and other important aspects of life longings. Sample items are given in Table 1. Reliability indices and confirmatory factor analyses indicate that life longings can be satisfactorily measured by self-report (Dissertation Susanne Scheibe).

When introducing a new concept into the literature, it is crucial to show its uniqueness in comparison to an already existing well-articulated concept. Therefore, one goal of our research has been to investigate commonalities and differences with concepts, such as goals, regrets, or ideal selves. A second goal has been to study possible functions of life longings for development. Third, we tested the applicability of our theory of life longings to cultural contexts other than Germany, such as the United States.

Delineating Life Longings From Other Concepts

The most notable concept related to life longings is that of personal goals. Like life longings, goals are directed at positive outcomes and give directionality to life. Goals operate primarily at the behavioral level: People strive at attaining their goals by formulating specific implementation intentions and by engaging in goal-relevant behaviors. Life longings, in contrast, are utopian and unattainable; they work mainly at the level of imagination and fantasy (Boesch, 1998). Confirming this view, we found that personal goals were reported to be more concrete, controllable, and more closely linked to everyday behavior than life longings. Personal life longings, in contrast, were rated as more emotionally bittersweet than goals (e.g., as simultaneously painful and pleasurable; Diploma Thesis Sabine Mayser).

We further differentiated life longings from regret, goals, and the conception of one's ideal self by examining people's beliefs about the typical states and traits associated with their activation. Table 2 lists the most typical states and traits assigned to the four concepts. Consistent with the defining characteristic of emotional ambivalence, life longings were rated equally high on both positive

Key References

Baltes, P. B. (in press). Entwurf einer Lebensspannen-Psychologie der Sehnsucht: Utopie eines vollkommenen und perfekten Lebens. *Psychologische Rundschau.*

Scheibe, S., Freund, A. M., & **Baltes, P. B.** (2007). Toward a developmental psychology of Sehnsucht (life-longings): The optimal (utopian) life. *Developmental Psychology, 43,* 778–795.

Baltes, P. B. (1997). On the incomplete architecture of human ontogeny: Selection, optimization, and compensation as foundation of developmental theory. *American Psychologist, 52,* 366–380.

Table 1
A Family of Six Characteristics to Capture the Structure of Life Longings: Explanations and Sample Items From Questionnaire Designed to Measure Life Longings

Structural characteristics of life longings	*Explanation*	*Sample items from questionnaire*
Unrealizable personal utopia	Consistent with the idea that individuals hold subjective beliefs about their own optimal development, life longings involve personal utopias of ideal life realities and optimal life courses. These are unattainable in principle.	I am longing for something that is too perfect to be true.
Feeling of incompleteness	Life longings involve feelings of incompleteness and imperfection of life. They reflect the notion that development is a lifelong process that never reaches completion.	My longing means that something essential is missing in my life.
Ontogenetic tritime focus	Life longings focus on the life course as a whole, that is, on the personal past, present, and future.	In my longing, memories of my past and fantasies about my future are connected.
Ambivalent emotions	Life longings reflect the conception that development always entails both gains and losses: They have an ambivalent, bittersweet, emotional quality.	My feeling of longing is both painful and pleasurable.
Life reflection and evaluation	Life longings elicit reflections and evaluations of life and one's standing relative to ideals or to others who serve as guideposts for optimal development.	My longing makes me think a lot about the meaning and sense of my life.
Symbolic richness	Life longings comprise representations that are rich in symbolic meaning. Specific targets of life longings are linked to encompassing mental-emotional representations for which they stand.	What I am longing for is heavily filled with meaning.

In collaboration with Alexandra Freund, University of Zurich

and negative states, and were linked with positive (e.g., openness, agreeableness, having a sense of purpose and directedness) and negative personality traits (e.g., introversion, lack of environmental mastery, low self-acceptance). Goals and the ideal self were rated higher on positive than negative states, and were linked with a well-adjusted personality profile. In contrast, regret was rated higher on negative than positive adjectives, and was linked to a maladaptive personality profile (with the exception that people often having regrets were judged to have a sense of purpose and directedness). These findings support the divergent validity of life longings, demonstrating its uniqueness in relation to other already existing concepts.

The Regulative Function of Life Longings in Adult Development and Aging

What is the role of life longings in planning, managing, and experiencing one's life? Do they give direction or help to cope with loss and unattainability? Are they indicators of positive or negative states and outcomes? Answers to such questions require analysis of antecedent-consequent relationships, considerations of different outcome measures, and the recognition that such associations and causal connections may be nonlinear.

In a first project, we found that life longings are perceived as functional (facilitative) in development (Dissertation Susanne Scheibe; Scheibe, Freund, & Baltes, 2007). Participants reported that their life longings (1) provided

Table 2
Most Typical States and Traits Assigned to Life Longings and Other Concepts of Developmental Regulation (N = 109 younger and older adults)

Life longings	*Goals*	*Regrets*	*Ideal self*
Five most typical states *A person whose thoughts and feelings CURRENTLY revolve around life longings/ goals/regrets/his or her ideal self, typically feels …*			
dreamy sensual empathic sad silent	ambitious creative energetic powerful persistent	sad depressed frustrated silent helpless	ambitious creative persistent inspired energetic
Three most typical traits *A person whose thoughts and feelings OFTEN revolve around life longings/ goals/ regrets/ his or her ideal self, typically is …*			
someone who has an active imagination	someone who has an active imagination	someone who feels that the demands of everyday life often get him/her down	someone who finds it important to have new experiences that challenge how he/she thinks about him-/herself and the world
someone who feels disappointed about his/ her achievements in life	someone who does a thorough job	someone who feels disappointed about his/ her achievements in life	someone who has an active imagination
someone who feels that the demands of everyday life often get him/her down	someone who feels in charge of the situation in which he/she lives	someone who gets nervous easily	someone who does a thorough job

a sense of directionality for development and (2) helped in regulating losses and unattainable aspects of life. Seemingly contrary to this finding was a negative relationship between life longings and overall well-being (e.g., positive emotions, life satisfaction). Individuals with high-level expressions of life longings reported lower well-being. However, when persons also reported a strong sense of control over the experience of life longings, the negative relationship was reduced. It can be speculated that life longings are linked with critical self-reflection about the developmental progression toward personal ideals of life. As such, strong life longings may lead to lower well-being, but possibly promote personal growth (Scheibe, Kunzmann, & Baltes, 2007, in press).

A second project investigated whether life longings develop from unattainable goals, and whether this transformation represents a regulatory strategy to manage the nonfulfillment of important life goals (Dissertation Dana Kotter-Grühn). Here, we focused on the widely shared goal to have children. Childless women aged 35 to 55 years rated the extent to which their wish for children fulfilled the six structural characteristics of life longings as well as typical characteristics of goals (e.g., intention to pursue the wish actively). Results were consistent with the idea that women were at different points in the transformation process from goals to life longings. The first group (22 % of the sample) described their wish for children as a strong goal, but only as a weak life longing. Another group (30 %) reported a strong goal *and* a strong life longing to have children. A third group (20 %) reported a strong life longing, but only a weak goal. The remaining women reported a weak goal and life longing.

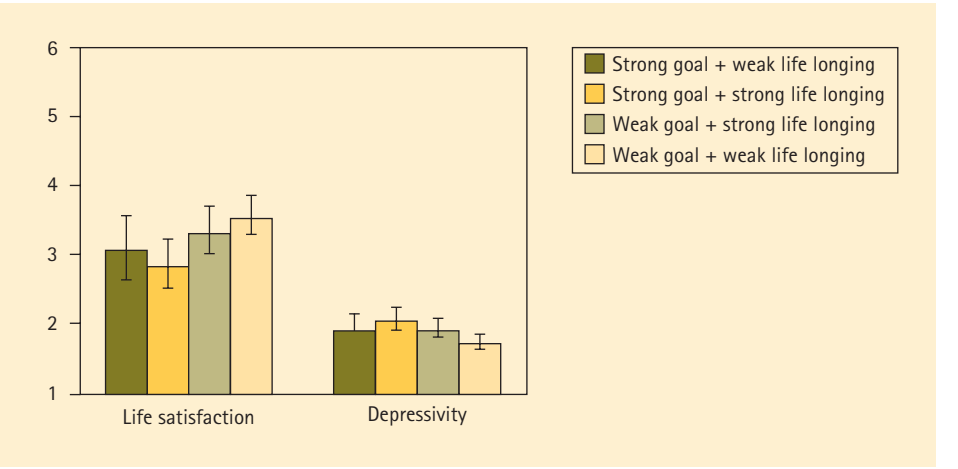


Figure 1. Life satisfaction and depressivity in groups of women with either a strong or weak goal to have children, combined with either a strong or weak life longing to have children. Women with a weak goal and life longing to have children had the highest life satisfaction and lowest depressivity, whereas women with a strong goal and life longing to have children had the lowest life satisfaction and highest depressivity. The differences between these two groups were statistically reliable.

Does this transformation process lead to positive outcomes? Replicating our earlier study, a stronger expression of life longing was related to lower well-being. However, women with a strong expression of life longing to have children reported high well-being if they used additional self-regulatory strategies, such as reengagement in alternative life goals. Looking at the groups specified above, women with a strong goal *and* life longing to have children had lower well-being than women with neither a goal nor life longing to have children (Figure 1). Women with a strong life longing, but a weak goal, did not differ from the other groups. Together, these results suggest that pursuing an unattainable goal as a life longing may have positive outcomes. However, this positive effect emerges only under certain conditions, and therefore needs to be investigated in more detail.

In cooperation with Fredda Blanchard-Fields, Georgia Institute of Technology, Atlanta

Going Beyond Germany: Sehnsucht in the American Culture

In German culture, the concept of "Sehnsucht" is salient, and its core connotations have evolved during the cultural era of Romanticism. The German word "Sehnsucht" is difficult to translate into English. Its basic characteristics, however, have been derived on the basis of lifespan theory, and are thought to reflect basic universal aspects of lifespan development.

To inquire the generality and cultural specificity of life longings, we developed an English-language version of our questionnaire that is suitable for assessing life longings in English-speaking samples. Initial evidence from an internet questionnaire study with German and American participants (Diploma Thesis Maja Wiest) and from a laboratory study in Atlanta, undertaken in collaboration with Fredda Blanchard-Fields, support the view that life longings can be assessed in cultural contexts outside Germany. The reliabilities of the scales and the statistical fit of the six-dimensional structure of life longings were satisfactory in the North American samples, and factor loadings were similar across the two cultural contexts. At the level of latent constructs, low correlations between personal utopia and the remaining five characteristics in the North American sample suggest that unattainability may not be linked to life longing experiences to the same degree as it is in Germany. Also, relative to the German sample, participants in the North American sample reported fewer life longings, and were more likely to report that the concept of life longings is difficult to understand and not often used in everyday life. At the same time, the two samples did not differ in the self-reported ease with which they were able to identify their personal life longings nor in their salience (intensity, frequency).

Anokhin, A. P., **Müller, V., Lindenberger, U.,** Heath, A. C., & Myers, E. (2006). Genetic influences on dynamic complexity of brain oscillations. *Neuroscience Letters, 397,* 93–98.

Bäckman, L., & Farde, L. (2005). The role of dopamine systems in cognitive aging. In R. Cabeza, L. Nyberg, & D. C. Park (Eds.), *Cognitive neuroscience of aging: Linking cognitive and cerebral aging* (pp. 58–84). New York: Oxford University Press.

Bäckman, L., Jones, S., Berger, A.-K., Jonsson Laukka, E., & Small, B. J. (2005). Cognitive impairment in preclinical Alzheimer's disease: A meta-analysis. *Neuropsychology, 19,* 520–531.

Bäckman, L., Nyberg, L., & Farde, L. (in press). Dopamine and cognitive aging: State-of-the-art and future directions. In Q. Jing & H. Zhang (Eds.), *Proceedings from the 28th International Congress of Psychology.* London: Psychology Press.

Bäckman, L., Nyberg, L., & Farde, L. (2007). Dopamine and cognitive aging: A strong relationship. In Q. Jing, M. R. Rosenzweig, G. d'Ydewalle, H. Zhang, H.-C. Chen, & K. Zhang (Eds.), *Progress in psychological science around the world: Congress proceedings. XVIII International Congress of Psychology, Beijing, 2004: Vol. 1. Neural cognitive and developmental issues* (pp. 455–469). Hove: Psychology Press.

Bäckman, L., Nyberg, L., **Lindenberger, U., Li, S.-C.,** & Farde, L. (2006). The correlative triad among aging, dopamine, and cognition: Current status and future prospects. *Neuroscience & Biobehavioral Reviews, 30,* 791–807.

Bäckman, L., & Small, B. J. (in press). Cognitive deficits in preclinical Alzheimer's disease and vascular dementia: Patterns of findings from the Kungsholmen Projekt. *Physiology & Behavior.*

Baltes, P. B. (in press). Entwurf einer Lebensspannen-Psychologie der Sehnsucht: Utopie eines vollkommenen und perfekten Lebens. *Psychologische Rundschau.*

Baltes, P. B. (2007). Alter(n) als Balanceakt: Im Schnittpunkt von Fortschritt und Würde. In P. Gruss (Ed.), *Die Zukunft des Alterns: Die Antwort der Wissenschaft* (pp. 15–34). München: Beck.

Baltes, P. B. (2006a). Alter(n) als Balanceakt im Schnittpunkt von Fortschritt und Würde: Vortrag gehalten anlässlich der Öffentlichen Jahrestagung des Nationalen Ethikrates. Berlin, 27. Oktober 2005. In E. Loewy (Ed.), *Schwerpunkt: Selbstbestimmtes Sterben* (pp. 210–225). Nürnberg: Gesellschaft für kritische Philosophie (Aufklärung und Kritik, Sonderheft 11).

Baltes, P. B. (2006b). Facing our limits: Human dignity in the very old. *Daedalus, 135,* 32–39.

Baltes, P. B. (Ed.). (2005). Theoretical approaches to lifespan development: Interdisciplinary perspectives [Special Issue]. *Research in Human Development, 2* (1–2). Mahwah, NJ: Erlbaum.

Baltes, P. B., Freund, A. M., & **Li, S.-C.** (2005). The psychological science of human ageing. In M. Johnson, V. L. Bengston, P. G. Coleman, & T. B. L. Kirkwood (Eds.), *The Cambridge handbook of age and ageing* (pp. 47–71). Cambridge, UK: Cambridge University Press.

Baltes, P. B., & Kunzmann, U. (in press). Wisdom and aging: The road toward excellence in mind and character. In D. C. Park & N. Schwarz (Eds.), *Cognitive aging: A primer.* Hove: Psychology Press.

Baltes, P. B., Lindenberger, U., & Staudinger, U. M. (2006). Life span theory in developmental psychology. In W. Damon & R. M. Lerner (Eds.), *Handbook of child psychology: Vol. 1. Theoretical models of human development* (pp. 569–664). New York: Wiley.

Baltes, P. B., Reuter-Lorenz, P. A., & Rösler, F. (Eds.). (2006a). *Lifespan development and the brain: The perspective of biocultural co-constructivism.* Cambridge, UK: Cambridge University Press.

Baltes, P. B., Reuter-Lorenz, P. A., & Rösler, F. (2006). Preface and acknowledgments. In P. B. Baltes, P. A. Reuter-Lorenz, & F. Rösler (Eds.), *Lifespan development and the brain: The perspective of biocultural co-constructivism* (pp. XIII–XIV). Cambridge, UK: Cambridge University Press.

Baltes, P. B., Rösler, F., & Reuter-Lorenz, P. A. (2006). Prologue: Biocultural co-constructivism as a theoretical metascript. In P. B. Baltes, P. A. Reuter-Lorenz, & F. Rösler (Eds.), *Lifespan development and the brain: The perspective of biocultural co-constructivism* (pp. 3–39). Cambridge, UK: Cambridge University Press.

Baltes, P. B., & **Smith, J.** (in press). The fascination of wisdom: Its nature, ontogeny, and function. *Perspectives on Psychological Science.*

Brandtstädter, J., & **Lindenberger, U.** (Eds.). (in press). *Entwicklungspsychologie der Lebensspanne: Ein Lehrbuch.* Stuttgart: Kohlhammer.

Brehmer, Y., Li, S.-C., Müller, V., von Oertzen, T., & **Lindenberger, U.** (2007). Memory plasticity across the lifespan: Uncovering children's latent potential. *Developmental Psychology, 43,* 465–478.

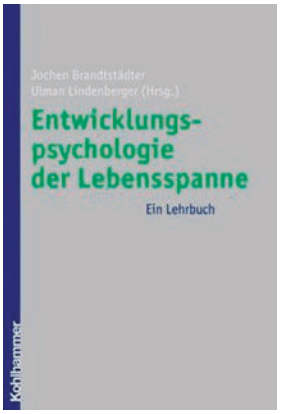
Brehmer, Y., & **Lindenberger, U.** (in press-a). Intraindividuelle Variabilität und Plastizität. In M. Hasselhorn & W. Schneider (Eds.), *Handbuch der Psychologie: Vol. Entwicklungspsychologie.* Göttingen: Hogrefe.

Brehmer, Y., & **Lindenberger, U.** (in press). Kognitive Leistungsreserven im höheren Erwachsenenalter: Befunde der Interventionsforschung. In F. Petermann & W. Schneider (Eds.), *Enzyklopädie der Psychologie, Vol. 7. Entwicklungspsychologie.* Göttingen: Hogrefe.

Charness, N., Tuffiash, M., Krampe, R. T., Reingold, E., & Vasyukova, E. (2005). The role of deliberate practice in chess expertise. *Applied Cognitive Psychology, 19,* 151–165.

Delius, J. A. M., & von Hammerstein, N. (2005). International Max Planck Research Schools: Neue Wege der Graduiertenausbildung. In U. Teichler & R. Tippelt (Eds.), *Hochschullandschaft im Wandel* (pp. 170–185). Weinheim: Beltz (Zeitschrift für Pädagogik, Beiheft 50).

Delius, J. D., & **Delius, J. A. M.** (2006). Intelligences and brains: An evolutionary bird's eye view. In E. A. Wasserman & T. R. Zentall (Eds.), *Comparative cognition: Experimental explorations of animal intelligence* (pp. 555–579). New York: Oxford University Press.



Derwinger, A., Stigsdotter Neely, A., MacDonald, S., & **Bäckman, L.** (2005). Forgetting numbers in old

age: Strategy and learning speed matter. *Gerontology, 51,* 277–284.

Drewing, K., Aschersleben, G., & **Li, S.-C.** (2006). Sensorimotor synchronization across the life span. *International Journal of Behavioral Development, 30,* 280–287.

Ebner, N. C., & Freund, A. M. (in press). Annäherungs- vs. Vermeidungsmotivation. In V. Brandstätter & J. H. Otto (Eds.), *Handbuch der Allgemeinen Psychologie: Motivation und Emotion.* Göttingen: Hogrefe.

Ebner, N. C., & Freund, A. M. (2007). Personality theories of successful aging. In J. A. Blackburn & C. N. Dulmus (Eds.), *Handbook of gerontology: Evidence-based approaches to theory, practice, and policy* (pp. 87–116). Haboken, NJ: Wiley.

Ebner, N. C., Freund, A. M., & **Baltes, P. B.** (2006). Developmental changes in personal goal orientation from young to late adulthood: From striving for gains to maintenance and prevention of losses. *Psychology and Aging, 21,* 664–678.

Erixon-Lindroth, N., Farde, L., Robins-Wahlin, T.-B., Sovago, J., Halldin, C., & **Bäckman, L.** (2005). The role of the striatal dopamine transporter in cognitive aging. *Psychiatry Research: Neuroimaging, 138,* 1–12.

Fiedler, K., Kliegl, R., **Lindenberger, U.,** Mausfeld, R., Mummendey, A., & Prinz, W. (2005). Psychologie im 21. Jahrhundert: Führende deutsche Psychologen über Lage und Zukunft ihres Fachs und die Rolle der psychologischen Grundlagenforschung. *Gehirn & Geist* (7–8), 56–60.

Fischer, H., Sandblom, J., Gavazzeni, J., Fransson, P., Wright, C. I., & **Bäckman, L.** (2005). Age-differential patterns of brain activation during perception of angry faces. *Neuroscience Letters, 386,* 99–104.

Freund, A. M. (2006). Age-differential motivational consequences of optimization versus compensation focus in younger and older adults. *Psychology and Aging, 21,* 240–252.

Freund, A. M., & **Baltes, P. B.** (2005). Entwicklungsaufgaben als Organisationsstrukturen von Entwicklung und Entwicklungsoptimierung. In N. Birbaumer et al. (Series Eds.), S.-H. Filipp & U. M. Staudinger (Vol. Eds.), *Enzyklopädie der Psychologie: Vol. C, V, 6. Entwicklungspsychologie des mittleren und höheren Erwachsenenalters* (pp. 35–78). Göttingen: Hogrefe.

Freund, A. M., & **Ebner, N. C.** (2005). The aging self: Shifting from promoting gains to balancing losses. In W. Greve, K. Rothermund, & D. Wentura (Eds.), *The adaptive self: Personal continuity and intentional self-development* (pp. 185–202). Göttingen: Hogrefe.

Freund, A. M., & **Riediger, M.** (2006). Goals as building blocks of personality and development in adulthood. In D. K. Mroczek & T. D. Little (Eds.), *Handbook of personality development* (pp. 353–372). Mahwah, NJ: Erlbaum.

Freund, A. M., & **Riediger, M.** (2005). Gerontopsychologie: Erfolgreiches Altern. In J. Bengel et al. (Series Eds.), H. Weber & T. Rammsayer (Vol. Eds.), *Handbuch der Psychologie: Vol. 2. Handbuch der Persönlichkeitspsychologie und differentiellen Psychologie* (pp. 564–571). Göttingen: Hogrefe.

de Frias, C. M., **Lövdén, M., Lindenberger, U.,** & Nilsson, L.-G. (2007). Revisiting the dedifferentiation hypothesis with longitudinal multi-cohort data. *Intelligence, 35,* 381–392.

Gerstorf, D., Herlitz, A., & **Smith, J.** (2006). Stability of sex differences in cognition in advanced old age: The role of education and attrition. *Journal of Gerontology: Psychological Sciences, 61B,* P245–P249.

Gerstorf, D., & **Lindenberger, U.** (2006). Vergessen [Forgetting]. In J. Bengel et al. (Series Eds.), J. Funke & P. A. Frensch (Vol. Eds.), *Handbuch der Psychologie: Vol. 5. Handbuch der allgemeinen Psychologie: Kognition* (pp. 371–378). Göttingen: Hogrefe.

Gerstorf, D., Lövdén, M., Röcke, C., Smith, J., & **Lindenberger, U.** (2007). Well-being affects changes in perceptual speed in advanced old age: Longitudinal evidence for a dynamic link. *Developmental Psychology, 43,* 705–718.

Gerstorf, D., Ram, N., Röcke, C., Lindenberger, U., & Smith, J. (in press). Decline in life satisfaction in old age: Longitudinal evidence for links to distance-to-death. *Psychology and Aging.*

Gerstorf, D., Smith, J., & **Baltes, P. B.** (2006). A systemic-wholistic approach to differential aging: Longitudinal findings from the Berlin Aging Study. *Psychology and Aging, 21,* 645–663.

Ghisletta, P., Bickel, J.-F., & **Lövdén, M.** (2006). Does activity engagement protect against cognitive decline in old age? Methodological and analytical considerations. *Journal of Gerontology: Psychological Sciences, 61B,* P253–P261.

Ghisletta, P., & **Lindenberger, U.** (2005). Exploring structural dynamics within and between sensory and intellectual functioning in old and very old age: Longitudinal evidence from the Berlin Aging Study. *Intelligence, 33,* 555–587.

Ghisletta, P., McArdle, J. J., & **Lindenberger, U.** (2006). Longitudinal cognition-survival relations in old and very old age: 13-year data from the Berlin Aging Study. *European Psychologist, 11,* 204–223.

Glück, J., & **Baltes, P. B.** (2006). Using the concept of wisdom to enhance the expression of wisdom knowledge: Not the philosopher's dream but differential effects of developmental preparedness. *Psychology and Aging, 21,* 679–690.

Greve, W., & **Ebner, N. C.** (2007). Intentional self-development—genetically framed. *European Journal of Developmental Sciences, 1,* 82–94.

Grühn, D., Scheibe, S., & **Baltes, P. B.** (in press). Reduced negativity effect in older adults? Memory for emotional pictures: The heterogeneity–homogeneity list paradigm? *Psychology and Aging.*

Grühn, D., Smith, J., & **Baltes, P. B.** (2005). No aging bias favoring memory for positive material: Evidence from a heterogeneity-homogeneity list paradigm using emotionally toned words. *Psychology and Aging, 20,* 579–588.

Herlitz, A., & Kabir, Z. A. (2006). Sex differences in cognition among illiterate Bangladeshis: A comparison with literate Bangladeshis and Swedes. *Scandinavian Journal of Psychology, 47,* 441–447.

Hertzog, C., Lindenberger, U., Ghisletta, P., & **von Oertzen, T.** (2006). On the power of multivariate latent growth curve models to detect correlated change. *Psychological Methods, 11,* 244–252.

Hoppmann, C., **Gerstorf, D., Smith, J.,** & Klumb, P. L. (2007). Linking possible selves and behavior: Do domain-specific hopes and fears translate into daily activities in very old age? *Journal of Gerontology: Psychological Sciences, 62B,* P104–P111.

Hoppmann, C., & **Smith, J.** (2007). Life-history related differences in possible selves in very old age. *International Journal of Aging and Human Development, 64,* 109–127.

Huxhold, O., Li, S.-C., Schmiedek, F., & **Lindenberger, U.** (2006). Dual-tasking postural control: Aging and the effects of cognitive demand in conjunction with focus of attention. *Brain Research Bulletin, 69,* 294–305.

Jones, S., Jonssn Laukka, E., & **Bäckman, L.** (2006). Differential verbal fluency impairment in the preclinical stages of Alzheimer's disease and vascular dementia. *Cortex, 42,* 347–355.

Jones, S., Livner, A., & **Bäckman, L.** (2006). Patterns of prospective and retrospective memory impairment in preclinical Alzheimer's disease. *Neuropsychology, 20,* 144–152.

Jones, S., Nyberg, L., Sandblom, J., Stigsdotter Neely, A., Ingvar, M.,

Petersson, K. M., & **Bäckman, L.** (2006). Cognitive and neural plasticity in aging: General and task-specific limitations. *Neuroscience & Biobehavioral Reviews, 30,* 864–871.

Jopp, D., & **Smith, J.** (2006). Resources and life-management strategies as determinants of successful aging: On the protective effect of selection, optimization, and compensation. *Psychology and Aging, 21,* 253–265.

Krampe, R. T. (2006). Musical expertise from a lifespan perspective. In H. Gembris (Ed.), *Musical development from a lifespan perspective* (pp. 91–105). Frankfurt a. M.: Lang.

Kray, J., & **Lindenberger, U.** (in press). Fluide Intelligenz. In J. Brandtstädter & U. Lindenberger (Eds.), *Entwicklungspsychologie der Lebensspanne: Ein Lehrbuch.* Stuttgart: Kohlhammer.

Kreppner, K. (2005a). Analyzing family interaction patterns from videotapes over time. In V. L. Bengtson, A. C. Acock, K. R. Allen, P. Dilworth-Anderson, & D. M. Klein (Eds.), *Sourcebook of family theory & research* (pp. 80–82). Thousand Oaks, CA: Sage.

Kreppner, K. (2005b). Erleben von Veränderung: Pubertät in der Familie. In U. Lehmkuhl (Ed.), *Die Bedeutung der Zeit: Zeiterleben und Zeiterfahrung aus Sicht der Individualpsychologie* (pp. 95–131). Göttingen: Vandenhoeck & Ruprecht (Beiträge zur Individualpsychologie 30).

Kreppner, K. (2005c). Family assessment and methodological issues: Discussion. *European Journal of Psychological Assessment, 21,* 249–254.

Kreppner, K. (2005d). Heinz Werner and the Psychological Institute in Hamburg. In J. Valsiner (Ed.), *Heinz Werner and developmental science* (pp. 55–74). New York: Kluwer Academic/ Plenum Publishers.

Kreppner, K. (2005e). Persönlichkeitsentwicklung in sozialen Beziehungen. In N. Birbaumer et al. (Series Eds.), J. B. Asendorpf (Vol. Ed.), *Enzyklopädie der Psychologie: Vol. C, V, 3. Soziale, emotionale und Persönlichkeitsentwicklung* (pp. 617–675). Göttingen: Hogrefe.

Kreppner, K. (2005f). [Review of the book Väter und Kinder: Langzeitstudien über väterliche Fürsorge und die sozioemotionale Entwicklung von Kindern]. *Zeitschrift für Pädagogik, 51,* 300–304.

Kreppner, K. (2005g). Wilhelm T. Preyer (1841–1897). In B. Hopkins (Ed.), *The Cambridge Encyclopedia of child development* (pp. 523–524). Cambridge, UK: Cambridge University Press.

Kruse, I. (in press-a). Driven from the outside: The EU's impact on Albanian immigration and asylum policies. In T. Faist & A. Ette (Eds.), *The europeanization of national immigration policies and politics.* New York: Palgrave Macmillan.

Kruse, I. (in press-b). Immigration reform in Germany: The domestic debate under the red-green government. In O. Schmidtke (Ed.), *Governing migration in an age of denationalization.* London: Routledge.

Kunzmann, U., & **Baltes, P. B.** (2005). The psychology of wisdom: Theoretical and empirical challenges. In R. J. Sternberg & J. Jordan (Eds.), *A handbook of wisdom: Psychological perspectives* (pp. 110–135). Cambridge, UK: Cambridge University Press.

Kunzmann, U., & **Grühn, D.** (2005). Age differences in emotional reactivity: The sample case of sadness. *Psychology and Aging, 20,* 47–59.

Kunzmann, U., Kupperbusch, C. S., & Levenson, R. W. (2005). Behavioral inhibition and amplification during emotional arousal: A comparison of two age groups. *Psychology and Aging, 20,* 144–158.

Kunzmann, U., & Stange, A. (2006). Wisdom as a classical human strength: Psychological conceptualizations and empirical inquiry. In A. D. Ong & M. H. M. van Dulmen (Eds.), *Oxford handbook of methods in positive psychology* (pp. 306–322). Oxford: Oxford University Press.

Kunzmann, U., Stange, A., & Jordan, J. (2005). Positive affectivity and lifestyle in adulthood: Do you do what you feel? *Personality and Social Psychology Bulletin, 31,* 574–588.

Li, K. Z. H., Krampe, R. T., & Bondar, A. (2005). An ecological approach to studying aging and dual-task performance. In R. W. Engle, G. Sedek, U. von Hecker, & D. N. McIntosh (Eds.), *Cognitive limitations in aging and psychopathology* (pp. 190–218). Cambridge, UK: Cambridge University Press.

Li, S.-C. (2006). Biocultural coconstruction of lifespan development. In P. B. Baltes, P. A. Reuter-Lorenz, & F. Rösler (Eds.), *Lifespan development and the brain: The perspective of biocultural coconstructivism* (pp. 40–57). Cambridge, UK: Cambridge University Press.

Li, S.-C. (2005). Neurocomputational perspectives linking neuromodulation, processing noise, representational distinctiveness, and cognitive aging. In R. Cabeza, L. Nyberg, & D. Park (Eds.), *Cognitive neuroscience of aging: Linking cognitive and cerebral aging* (pp. 354–379). Oxford: Oxford University Press.

Li, S.-C., & **Baltes, P. B.** (2006). Cognitive developmental research from lifespan perspectives: The challenge of integration. In E. Bialystok & F. I. M. Craik (Eds.), *Lifespan cognition: Mechanisms of change* (pp. 344–363). Oxford: Oxford University Press.

Li, S.-C., Brehmer, Y., Shing, Y.-L., Werkle-Bergner, M., & **Lindenberger, U.** (2006). Neuromodulation of associative and organizational plasticity across the life span: Empirical evidence and neurocomputational modeling. *Neuroscience and Biobehavioral Reviews, 30,* 775–790.

Li, S.-C., & Freund, A. M. (2005). Advances in lifespan psychology: A focus on biocultural and personal influences. *Research in Human Development, 2,* 1–23.

Li, S.-C., & **Lindenberger, U.** (2006). Ageing deficit in neuromodulation of representational distinctiveness and conjunctive binding: Computational explorations of possible links. In H. D. Zimmer, A. Mecklinger, & U. Lindenberger (Eds.), *Handbook of binding and memory: Perspectives from cognitive neuroscience* (pp. 291–312). Oxford: Oxford University Press.

Li, S.-C., Naveh-Benjamin, M., & **Lindenberger, U.** (2005). Aging neuromodulation impairs associative binding: A neurocomputational account. *Psychological Science, 16,* 445–450.

Li, S.-C., von Oertzen, T., & **Lindenberger, U.** (2006). A neurocomputational model of stochastic resonance and aging. *Neurocomputing, 69,* 1553–1560.

Lindenberger, U. (in press). Historische Grundlagen: Johann Nicolaus Tetens als Wegbereiter des Lebensspannen-Ansatzes in der Entwicklungspsychologie. In J. Brandtstädter & U. Lindenberger (Eds.), *Entwicklungspsychologie der Lebensspanne: Ein Lehrbuch.* Stuttgart: Kohlhammer.

Lindenberger, U. (2007). Technologie im Alter: Chancen aus Sicht der Verhaltenswissenschaften. In P. Gruss (Ed.), *Die Zukunft des Alterns: Die Antwort der Wissenschaft* (pp. 221–239). München: Beck.

Lindenberger, U., & **Brehmer, Y.,** Kliegl, R., & **Baltes, P. B.** (in press). Benefits of graphic design expertise in old age. In C. Lange-Küttner & A. A. Winter (Eds.), *Drawing and non-verbal intelligence.* Cambridge: Cambridge University Press.

Lindenberger, U., & **Chicherio, C.** (in press). Développement intellectuel au cours du cycle de vie: Sources de variabilité et niveaux d'analyse. *L'Année Pschologique.*

Lindenberger, U., & Kray, J. (2005). Kognitive Entwicklung. In N. Birbaumer et al. (Series Eds.), S.-H. Filipp & U. M. Staudinger (Vol. Eds.), *Enzyklopädie der Psychologie: Vol. C, V, 6. Entwicklungspsychologie des mittleren und höheren Erwachsenenalters* (pp. 299–341). Göttingen: Hogrefe.

Lindenberger, U., Li, S.-C., & **Bäckman, L.** (2006a). Delineating brain-behavior mappings across the lifespan: Substantive and methodological advances in developmental neuroscience. Editorial. *Neuroscience & Biobehavioral Reviews, 30,* 713–717.

Lindenberger, U., Li, S.-C., & **Bäckman, L.** (Eds.). (2006b). *Methodological and conceptual advances in the study of brain-behavior dynamics: A multivariate lifespan perspective* [Special Issue]. Neuroscience & Biobehavioral Reviews, 30. Amsterdam: Elsevier.

Lindenberger, U., Li, S.-C., Lövdén, M., & **Schmiedek, F.** (in press). The Center for Lifespan Psychology at the Max Planck Institute for Human Development: Overview of conceptual agenda and illustration of research activities. *International Journal of Psychology.*

Lindenberger, U., & **Lövdén, M.** (2006). Co-constructing human engineering technologies in old age: Lifespan psychology as a conceptual foundation. In P. B. Baltes, P. A. Reuter-Lorenz, & F. Rösler (Eds.), *Lifespan development and the brain: The perspective of biocultural co-constructivism* (pp. 350–375). Cambridge, UK: Cambridge University Press.

Lindenberger, U., & **von Oertzen, T.** (2006). Variability in cognitive aging: From taxonomy to theory. In E. Bialystok & F. I. M. Craik (Eds.), *Lifespan cognition: Mechanisms of change* (pp. 297–314). Oxford: Oxford University Press.

Lindenberger, U., & **Schäfer, S.** (in press). Erwachsenenalter und Alter. In R. Oerter & L. Montada (Eds.), *Entwicklungspsychologie.* Weinheim: Beltz.

Lindenberger, U., & **Werkle-Bergner, M.** (2005). [Review of the article Reward-related fMRI activation of dopaminergic midbrain is associated with enhanced hippocampus-dependent long-term memory formation]. *Neuroforum, 11* (2), 67–69.

Lövdén, M., Bergman, L., Adolfsson, R., **Lindenberger, U.,** & Nilsson, L.-G. (2005). Studying individual aging in an interindividual context: Typical paths of age-related, dementia-related, and mortality-related cognitive development in old age. *Psychology and Aging, 20,* 303–316.

Lövdén, M., Ghisletta, P., & **Lindenberger, U.** (2005). Social participation attenuates decline in perceptual speed in old and very old age. *Psychology and Aging, 20,* 423–434.

Lövdén, M., Herlitz, A., Schellenbach, M., Grossman-Hutter, B., Krüger, A., & **Lindenberger, U.** (in press). Quantitative and qualitative sex differences in spatial navigation. *Scandinavian Journal of Psychology.*

Lövdén, M., Li, S.-C., Shing, Y.-L., & Lindenberger, U. (in press). Trial-to-trial variability precedes and predicts decline in cognitive performance in old age: Longitudinal data from the Berlin Aging Study. *Neuropsychologia.*

Lövdén, M., & **Lindenberger, U.** (2007). Intelligence. In J. E. Birren (Ed.), *Encyclopedia of gerontology: Age, aging and the aged* (2nd ed., Vol. 1, pp. 763–770). Amsterdam: Elsevier.

Lövdén, M., & **Lindenberger, U.** (2005). Development of intellectual abilities in old age: From age gradients to individuals. In O. Wilhelm & R. W. Engle (Eds.), *Handbook of understanding and measuring intelligence* (pp. 203–221). Thousand Oaks, CA: Sage.

Lövdén, M., Schellenbach, M., Grossman-Hutter, B., Krüger, A., & **Lindenberger, U.** (2005). Environmental topography and postural control demands shape aging-associated decrements in spatial navigation performance. *Psychology and Aging, 20,* 683–694.

Lövdén, M., & Wahlin, A. (2005). The sensory-cognition association in adulthood: Different magnitudes for processing speed, inhibition, episodic memory, and false memory? *Scandinavian Journal of Psychology, 46,* 253–262.

MacDonald, S. W. S., Stigsdotter Neely, A., Derwinger, A., & **Bäckman, L.** (2006). Rate of acquisition, adult age, and basic cognitive abilities predict forgetting: New views on a classic problem. *Journal of Experimental Psychology: General, 135,* 368–390.

Marcus, B., Höft, S., & **Riediger, M.** (2006). Integrity tests and the five-factor model of personality: A review and empirical test of two alternative positions. *International Journal of Selection and Assessment, 14,* 113–130.

McArdle, J. J., Small, B. J., **Bäckman, L.,** & Fratiglioni, L. (2005). Longitudinal models of growth and survival applied to the early detection of Alzheimer's disease. *Journal of Geriatric Psychiatry and Neurology, 18,* 234–241.

Nagel, I. E., Werkle-Bergner, M., Li, S.-C., & **Lindenberger, U.** (2007). Perception. In J. E. Birren (Ed.), *Encyclopedia of gerontology: Age, aging and the aged* (2nd ed., Vol. 2, pp. 334–342). Amsterdam: Elsevier.

Nilsson, L.-G., Adolfsson, R., **Bäckman, L.,** Cruts, M., Nyberg, L., Small, B. J., & Van Broeckoven, C. (2006). The influence of APOE status on episodic and semantic memory: Data from a population-based study. *Neuropsychology, 20,* 645–657.

Oberauer, K., Wilhelm, O., & **Schmiedek, F.** (2005). Experimental strategies in multivariate research. In A. Beauducel, B. Biehl, M. Bosniak, W. Conrad, G. Schönberger, & D. Wagener (Eds.), *Multivariate research strategies: Festschrift in Honor of Werner W. Wittmann* (pp. 119–149). Aachen: Shaker.

von Oertzen, T. (2006). Exact computation of polynomial zeros expressible by square roots. *Algorithmica, 46,* 119–136.

Rapp, M. A., Krampe, R. T., & **Baltes, P. B.** (2006). Adaptive task prioritization in aging: Selective resource allocation to postural control is preserved in Alzheimer's disease. *American Journal of Geriatric Psychiatry, 14,* 52–61.

Ratcliff, R., **Schmiedek, F.,** & McKoon, G. (in press). A diffusion model explanation of the worst performance rule for reaction time and IQ. *Intelligence.*

Raz, N., Lindenberger, U., Ghisletta, P., Rodrigue, K. M., Kennedy, K. M., & Acker, J. D. (in press). Neuroanatomical correlates of fluid intelligence in healthy adults and persons with vascular risk factors. *Cerebral Cortex.*

Raz, N., Lindenberger, U., Rodrigue, K. M., Kennedy, K. M., Head, D., Williamson, A. et al. (2005). Regional brain changes in aging healthy adults: General trends, individual differences and modifiers. *Cerebral Cortex, 15,* unpaginated.

Raz, N., & **Nagel, I. E.** (in press). Der Einfluss des Hirnalterungsprozesses auf die Kognition: Eine Integration struktureller und funktioneller Forschungsergebnisse. In J. Brandtstädter & U. Lindenberger (Eds.), *Entwicklungspsychologie der Lebensspanne: Ein Lehrbuch.* Stuttgart: Kohlhammer.

Rehnman, J., & **Herlitz, A.** (2007). Women remember more faces than men do. *Acta Psychologica, 124,* 344–355.

Rehnman, J., & **Herlitz, A.** (2006). Higher face recognition ability in girls: Magnified by own-sex and own-ethnicity bias. *Memory, 14,* 289–296.

Riediger, M. (2007). Interference and facilitation among personal goals: Age differences and associations with well-being and behavior. In B. R. Little, K. Salmela-Aro, & S. D. Philipps (Eds.), *Personal project pursuit: Goals, action, and human flourishing* (pp. 119–143). Mahwah, NJ: Erlbaum.

Riediger, M., & **Ebner, N. C.** (in press). A broader perspective on three lifespan theories: Comment to Boerner and Jopp. *Human Development.*

Riediger, M., & Freund, A. M. (2006). Focusing and restricting: Two aspects of motivational selectivity in adulthood. *Psychology and Aging, 21,* 173–185.

Riediger, M., Freund, A. M., & **Baltes, P. B.** (2005). Managing life through personal goals: Intergoal facilitation and intensity of goal pursuit in younger and older adulthood. *Journal of Gerontology: Psychological Sciences, 60B,* P84–P91.

Riediger, M., Li, S.-C., & **Lindenberger, U.** (2006). Selection, optimization, and compensation as developmental mechanisms of adaptive resource allocation: Review and preview. In J. E. Birren & K. W. Schaie (Eds.), *The handbooks of aging: Vol. 2. Handbook of the psychology of aging* (6th ed., pp. 289–313). Amsterdam: Elsevier.

Rönnlund, M., Nyberg, L., **Bäckman, L.,** & Nilsson, L.-G. (2005). Stability, growth, and decline in adult life span development of declarative memory: Cross-sectional and longitudinal data from a population-based study. *Psychology and Aging, 20,* 3–18.

Schäfer, S., & **Bäckman, L.** (in press). Normales und pathologisches kognitives Altern. In J. Brandtstädter & U. Lindenberger (Eds.), *Entwicklungspsychologie der Lebensspanne: Ein Lehrbuch.* Stuttgart: Kohlhammer.

Schäfer, S., Huxhold, O., & **Lindenberger, U.** (2006). Healthy mind in healthy body? A review of sensorimotor-cognitive interdependencies in old age. *European Review of Aging and Physical Activity, 3,* 45–54.

Scheibe, S., Freund, A. M., & **Baltes, P. B.** (2007). Toward a developmental psychology of Sehnsucht (life-longings): The optimal (utopian) life. *Developmental Psychology, 43,* 778–795.

Scheibe, S., Kunzmann, U., & **Baltes, P. B.** (in press). New territories of positive lifespan development: Wisdom and life longings. In C. R. Snyder & S. J. Lopez (Eds.), *Handbook of positive psychology.* New York: Oxford University Press.

Scheibe, S., Kunzmann, U., & **Baltes, P. B.** (2007). Wisdom, life longing, and optimal development. In J. A. Blackburn & C. N. Dulmus (Eds.), *Handbook of gerontology: Evidence-based approaches to theory, practice, and policy* (pp. 117–142). New York: Wiley.

Schmiedek, F. (2005). Item response theory and the measurement of cognitive processes. In O. Wilhelm & R. W. Engle (Eds.), *Handbook of understanding and measuring intelligence* (pp. 265–277). Thousand Oaks, CA: Sage.

Schmiedek, F., & **Li, S.-C.** (2006). Die Lernkurve. In J. Bengel et al. (Series Eds.), J. Funke & P. A. Frensch (Vol. Eds.), *Handbuch der Psychologie: Vol. 5. Handbuch der allgemeinen Psychologie: Kognition* (pp. 213–219). Göttingen: Hogrefe.

Schmiedek, F., & **Lindenberger, U.** (in press). Methodologische Grundlagen. In J. Brandtstädter & U. Lindenberger (Eds.), *Entwicklungspsychologie der Lebensspanne: Ein Lehrbuch.* Stuttgart: Kohlhammer.

Schmiedek, F., Oberauer, K., Wilhelm, O., Süß, H.-M., & Wittmann, W. W. (in press). Individual differences in components of reaction time distributions and their relations to working memory and intelligence. *Journal of Experimental Psychology: General.*

Smith, J. (2006a). Berlin Aging Study. In R. Schulz, L. S. Noelker, K. Rockwood, & R. L. Sprott (Eds.), *Encyclopedia of aging: A comprehensive resource in gerontology and geriatrics* (4th ed., Vol. 1, pp. 110–112). New York: Springer.

Smith, J. (2006b). Developmental psychology. In R. Schulz, L. S. Noelker, K. Rockwood, & R. L. Sprott (Eds.), *Encyclopedia of aging: A comprehensive resource in gerontology and geriatrics* (4th ed., Vol. 1, pp. 306–308). New York: Springer.

Smith, J., & **Baltes, P. B.** (in press). Healthy aging from 70 to 100+ in Germany: Lessons from the Berlin Aging Study. In M. Robinson, W. Novelli, & C. E. Pearson (Eds.), *Global health and global aging.* New York: Jossey-Bass/Wiley.

Smith, J., & **Delius, J. A. M.** (2006). BASE: Die Berliner Alterstudie. In W. D. Oswald, U. Lehr, C. Sieber, & J. Kornhuber (Eds.), *Gerontologie: Medizinische, psychologische und sozialwissenschaftliche Grundbegriffe* (3rd, complete rev. ed., pp. 114–119). Stuttgart: Kohlhammer.

Smith, J., & **Delius, J. A. M.** (2005). Psychologische Funktionsfähigkeit im Alter: Potenziale und Grenzen. *Quintessenz, 56 (2),* 159–169.

Smith, J., & Jopp, D. (2005). Geschlechterdifferenzen im Alter(n) [Gender differences in old age and aging]. In N. Birbaumer et al. (Series Eds.), S.-H. Filipp & U. M. Staudinger (Vol. Eds.), *Enzyklopädie der Psychologie: Vol. C, V, 6. Entwicklungspsychologie des mittleren und höheren Erwachsenenalters* (pp. 501–524). Göttingen: Hogrefe.

Staudinger, U. M., & **Lindenberger, U.** (2007). Nachruf auf Paul B. Baltes. *Psychologische Rundschau, 58,* 149–151.

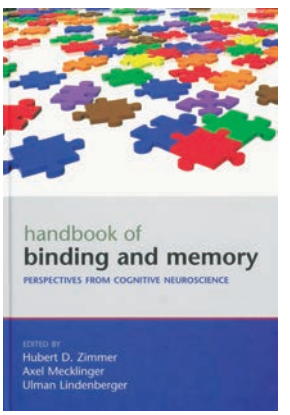
Striano, T., **Kopp, F.,** Grossmann, T., & Reid, V. M. (2006). Eye contact influences neural processing of emotional expressions in 4-month-old infants. *Social Cognitive and Affective Neuroscience, 1,* 87–94.

Thilers, P. P., MacDonald, S. W. S., & **Herlitz, A.** (2006). The association between endogenous free testosterone and cognitive performance: A population-based study in 35 to 90 year-old men and women. *Psychoneuroendocrinology, 31,* 565–576.

Werkle-Bergner, M., Müller, V., Li, S.-C., & **Lindenberger, U.** (2006). Cortical EEG correlates of successful memory encoding: Implications for lifespan comparisons. *Neuroscience & Biobehavioral Reviews, 30,* 839–854.

Yang, L., Krampe, R. T., & **Baltes, P. B.** (2006). Basic forms of cognitive plasticity extended into the oldest-old: Retest learning, age, and cognitive functioning. *Psychology and Aging, 21,* 372–378.

Zimmer, H. D., Mecklinger, A., & **Lindenberger, U.** (Eds.). (2006a). *Handbook of binding and memory: Perspectives from cognitive neuroscience.* Oxford: Oxford University Press.



Zimmer, H. D., Mecklinger, A., & **Lindenberger, U.** (2006b). Levels of binding: Types, mechanisms, and functions of binding in remembering. In H. D. Zimmer, A. Mecklinger, & U. Lindenberger (Eds.), *Handbook of binding and memory: Perspectives from cognitive neuroscience* (pp. 3–22). Oxford: Oxford University Press.

Independent Junior Research Group

Neurocognition of Decision Making

Contents

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Research Agenda: Multimodal Approach to the Neurocognition of Decision Making

Decision making can be defined as the process of choosing a preferred option or course of action from among a set of alternatives. There is a long history of decision-making research in psychology and economics that has resulted in the development of formal models of behavior, which are inspired by behavioral data or the computational demands of a task. An example for the former are sequential sampling models of decison making, an example for the latter are reinforcement learning models for repeated choice tasks. However, cognitive functions, such as decision making, cannot be completely understood on the basis of mathematical models and behavioral data alone; we have to investigate how mental (cognitive) and neuronal processes map onto each other (cf. Schall, 2004). Therefore, a central goal of the independent junior research group "Neurocognition of Decision Making" is to explicitly link brain function and behavior using formal models of decision-making behavior.

In pursuit of this goal, we investigate decision making in different domains. First, at the basis of a number of different decisions we are facing in everyday life stands *perceptual decision making:* the process of translating sensory input into some kind of motor output (cf. Figure 1). Many of our decisions are influenced by the potential outcomes associated with different options, hence, *reward-based decision making* is another important topic for our group. *Decision making in social contexts* relies not only on perceptual and reward-related processes but also includes more complex cognitive processes and emotional aspects and the interaction between the two.

We believe that the investigation of the neurocognition of decision making requires a multimodal methodological approach that integrates information from an array of methods ranging from cognitive modeling based on behavioral data to simultaneous *functional Magnetic Resonance Imaging* (fMRI) and EEG experiments (cf. Figure 1). On the following pages, we briefly describe research on the three topics in some more detail. Each section begins with a brief introduction, which is followed by short descriptions of individual projects.

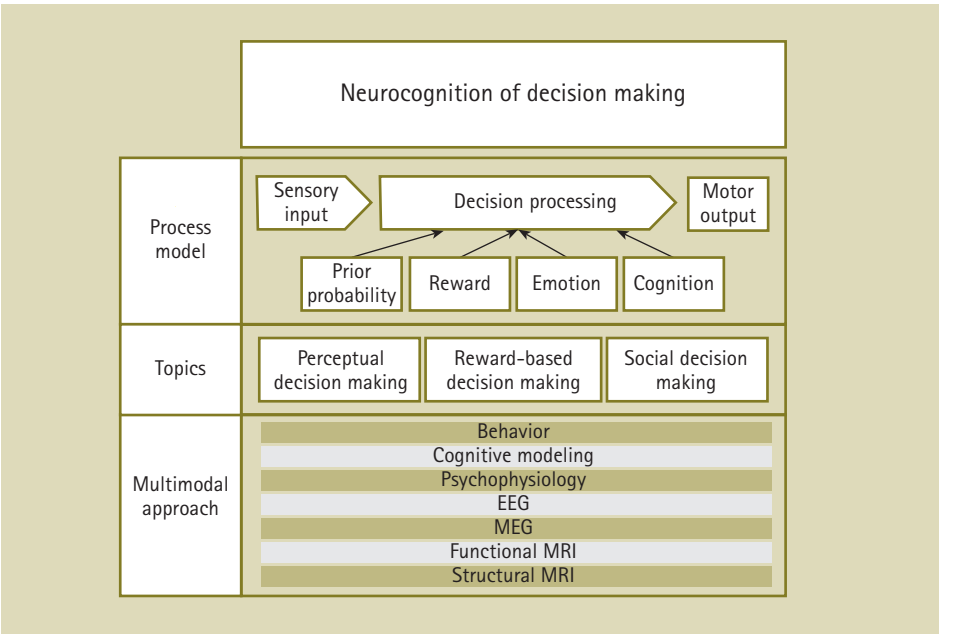


Figure 1. A multimodal approach to the neurocognition of decision making.

Neurocognition of Perceptual Decision Making

Perceptual decision making entails processing of sensory signals, formation of a decision, and the planning and execution of a motor response. For example, in a motion-direction discrimination task, motion signals need to be interpreted and translated into a saccadic eye movement. In a face-house discrimination task, degraded images of faces and houses have to be interpreted and translated into a button press with the right or the left hand.

Over the last 40 years, decision-making research in mathematical psychology has resulted in detailed mathematical models of the assumed underlying cognitive processes. Sequential sampling models are particularly successful in explaining response time data and accuracy in two-choice reaction time tasks, such as the ones described above. A prominent version of sequential sampling models are diffusion models, which assume that decisions are formed by continuously accumulating sensory information until one of the two response criteria is reached (e. g., Smith & Ratcliff, 2004; cf. Figure 2).

Given the well-described nature of perceptual decision-making tasks, such as face-house discrimination and the relatively well-known functional neuroanatomy of the subsystems involved, perceptual decision making has recently been used as paradigm to study simple decision processes in the brain of human and nonhuman primates.

Single-unit recordings in monkeys, and more recently neuroimaging studies in humans, have begun to investigate the neural mechanisms involved in these processes (e. g., Heekeren, Marrett, Bandettini, & Ungerleider, 2004, 2006; Mazurek et al., 2003; Romo & Salinas, 2003) and to model not only psychophysical data but also neurophysiological data as a diffusion-to-barrier process (e. g., Gold & Shadlen, 2002; Philiastides et al., 2006). Thus, perceptual decision-making tasks provide an ideal paradigm to pursue our goal to explicitly link brain function and behavior using formal models.

Studies in monkeys and humans performing sensory discrimination tasks suggest that perceptual decisions are made by integrating the sensory evidence represented by lower level sensory neurons (Gold & Shadlen, 2002; Heekeren et al., 2004). For example, when monkeys must decide whether a noisy field of dots is moving upward or downward, a decision can be formed by computing the difference in responses between lower level neurons sensitive to upward motion and those sensitive to downward motion. In this model, higher level brain regions computing decision variables thus have to accumulate evidence over time. The dynamics that are involved in the formation of these higher level representations are of core interest to systems and cognitive neuroscience. In ongoing projects, we build on our previous work and investigate how sensory systems infer the identity of real-world objects from their noisy neural representations, and how the outcome of such a process is signaled to the motor system. Furthermore, we want to elucidate how the brain uses contextual information (in particular prior probabilities about possible alternatives) that is integrated with stimulus

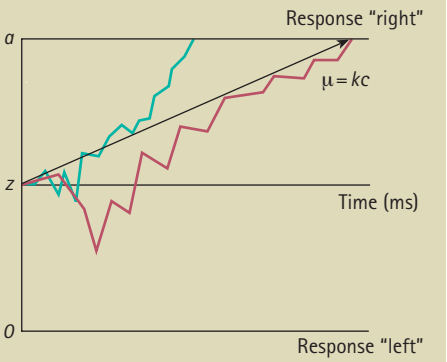


Figure 2. Stochastic diffusion models assume that a decision is the result of continuously accumulating noisy stimulus information from a starting point *z* until one of two response criteria, *a* and *0*, is reached. Once the boundary is reached, the decision process is concluded and a response is elicited. Moment-by-moment fluctuations in the sample path reflect noise in the decision process. The drift rate (μ) is related to the efficacy of information processing. μ is dependent on the ncrease in the decision variable (accumulation rate, *k*) quantifying how much evidence is accumulated per time interval as well as on the strength of the sensory signal *(c)* (e. g., Smith & Ratcliff, 2004).

inherent information, and thereby conveys additional information to improve decision making.

Perceptual Decision Making in the Somatosensory Domain

The project "Tactile Decision Making" investigates how sensory information is processed to make categorical judgments and aims at revealing the neural processes behind the accumulation of sensory evidence.

To date, it is unclear whether the accumulation of evidence by a diffusion process as found in the visual domain (see above) generalizes to other sensory modalities and stimulus materials with only brief exposure. Furthermore, the precise neuronal mechanisms behind such accumulation of evidence remain unclear. In a first study, we therefore investigated whether there is evidence for temporal integration in the somatosensory system using a tactile decision task. Previous research from Bauer, Oostenveld, Peeters, and Fries (2006) has shown that in a two-alternative decision task, very brief exposure (35 ms) to tactile pattern stimuli leads to *sustained* high-frequency oscillations in primary somatosensory cortex when subjects have to report the identity of these patterns. On the contrary, when stimuli are presented, but subjects are not required to make a decision, only a brief burst of oscillatory activity occurs. These sustained oscillatory responses are accompanied by rather long reaction times (~500 ms) suggesting that time-enduring internal computational processes are necessary to distinguish between the two patterns to make a decision. A central question inherent to the project presented here will be whether these sustained oscillations are instrumental to the decision process and reflect the accumulation of evidence.

In a recent experiment, three pattern pairs were presented varying in difficulty level operationalized by the spatial separability of the patterns of a pair. Subjects had to discriminate between two tactile stimuli of a pair. Response times as well as error rates increased with increasing difficulty, indicating that temporal integration (accumulation) of evidence seems to occur (see Figure 3).

In ongoing studies, we are investigating whether, similar to neurophysiological studies in monkeys, human EEG and MEG data provide neurophysiological evidence for a "diffusion to boundary process" determining the elicitation of a response.

Future directions of this project will include simultaneous EEG and fMRI experiments to study the interactions between higher level cortical structures, such as the *DorsoLateral PreFrontal Cortex* (DLPFC; which is known to

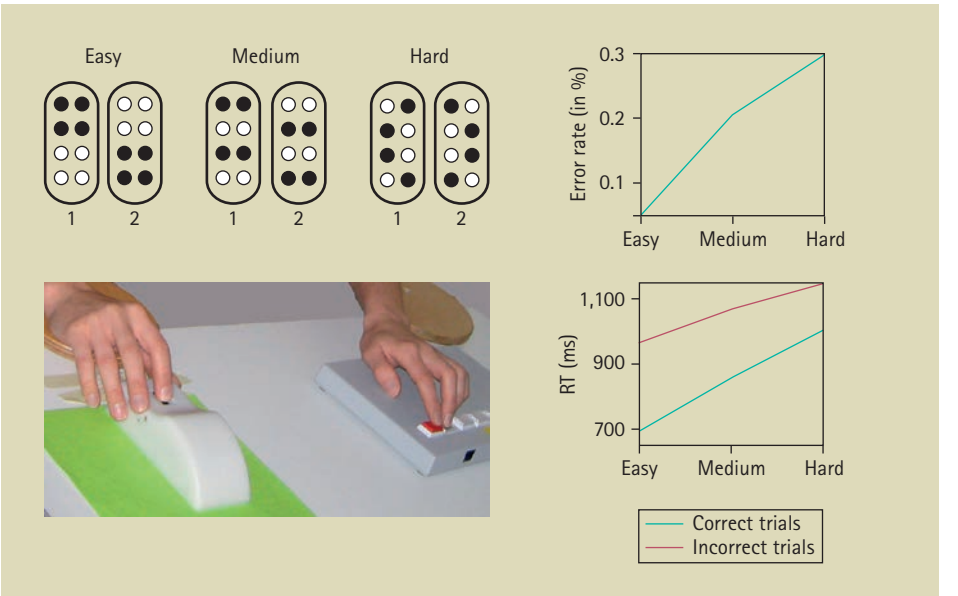


Figure 3. Three different Braille pairs (varying in spatial similarity) were presented to subjects' right index fingers (left). Discrimination of these pairs resulted not only in substantially different performance levels, but also longer reaction times (right).

Key Reference

Scheibe, C., Ullsperger, M., Sommer, W., & **Heekeren, H. R.** (2007). *Spatiotemporal dynamics munderlying the integration of prior probability information in decision making.* Conference of Cognitive Neuroscience, New York. Abstract.

be involved in somatosensory decision making, cf. Preuschhof, Heekeren, Taskin, Schubert, & Villringer, 2006, but difficult to map with EEG/MEG) and sensory cortices (which are more easily localizable with EEG/MEG, cf. e. g., Bauer et al., 2006). Furthermore, it will be of interest to show how information from different sensory modalities is combined to make decisions about external objects. Parts of this project are realized in collaboration with Driver (Institute of Cognitive Neuroscience/Wellcome Trust Centre for Neuroimaging, UCL, London) as well as von Oertzen (Center for Lifespan Psychology at MPI for Human Development).

The Influence of Prior Probability on Decision Making

The prior probability of the occurrence of an event is a critical variable in decision-making processes. The response time in two-alternative forced choice tasks is speeded by prior probability. Single cell recordings in monkeys revealed a modulation of the firing rate of motor-related neurons by prior probability. Furthermore, modeling studies suggest that the motor system is an integral component of decision-making processes. However, it is unclear at which stage of the decision-making process in the human brain prior probability is integrated. In a recent experiment, we used *Event-Related Potential* (ERP) components as proxies for different processing stages of the decision-making process. In this context, the *Contingent Negative Variation* (CNV) reflects higher level response selection and abstract motor programming at a more central level while the *Lateralized Readiness Potential* (LRP) is an index for lower level motor preparatory processes. To investigate the influence of prior probability, we used a number comparison task as a modified precue paradigm. Our data revealed that the CNV during the foreperiod is parametrically modulated by prior probability, indicating an integration of prior probability at an early stage of response selection and premotor preparation (cf. Figure 4) (Scheibe, Schubert, Sommer, & Heekeren, 2006). In contrast, the LRP was modulated in a binary fashion, that is, it only distinguished between certain (100 % prior probability) and uncertain information (<100 % prior probability).

Based on these results, we recently conducted an fMRI experiment with simultaneous EEG recordings (in cooperation with Ullsperger and von Cramon, MPI for Human Cognitive and Brain Science, Leipzig) to examine the neural correlates of the integration of prior probability in the decision process. Despite the EEG-adverse environment in the scanner, we replicated the increasing CNV amplitude with increasing prior probability. The fMRI data revealed that areas in the prefrontal cortex, particularly the dorsolateral and frontomedial regions, seem to play a crucial role in preparatory processes based on prior probability (Scheibe et al., 2007). In a further EEG-informed analysis, we will relate the CNV amplitude and *Blood Oxy-*

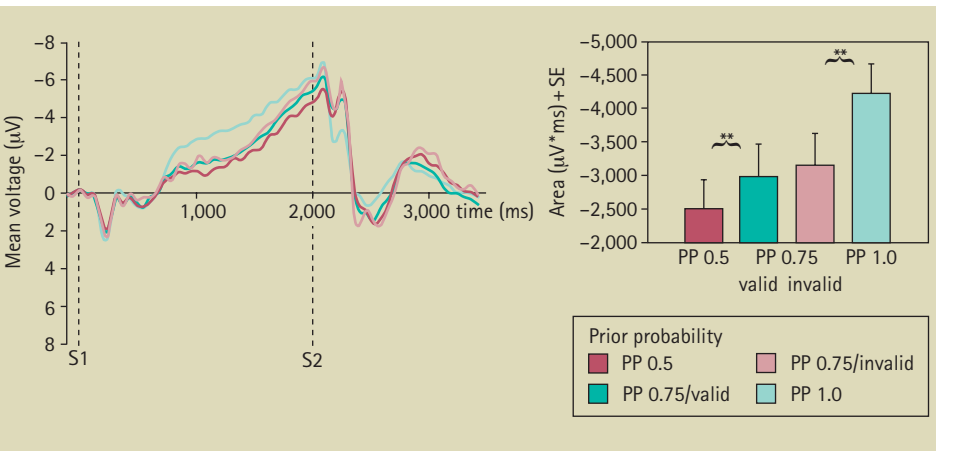


Figure 4. EEG component at the electrode position Cz for the different conditions. The CNV between S1 and S2 (foreperiod) increases parametrically with increasing prior probability.

genation Level Dependent (BOLD) correlates at a single-trial level. Thereby, we want to identify brain regions that are associated with the development of the CNV and the integration of prior probability into the decision process.

Reward-Based Decision Making

Many of our decisions are influenced by the potential outcomes associated with different options. For instance, consumers test different brands of a particular product to identify their favored brand, or investors first learn about the past performance of investments and then decide about the allocation of their funds. The project "reward-based decision making" examines how people use information to achieve rewarding outcomes.

To examine reward-based decision making, we abstract basic features from real-life decisions, such as the type of information and feedback available, and implement them in simpler tasks, which are amenable for the application in an fMRI environment and to precise modeling. Conducting fMRI experiments allows us to test models and theories with variables, such as the prediction error in temporal difference learning models that are usually not accessible with exclusively behavioral experiments.

Reward-based decision making has been tackled by different disciplines, therefore, our theoretical approach combines elements from these: *Economics and Machine Learning* describe procedures which aim to maximize the decision maker's outcome (Markowitz, 1952; Sutton & Barto, 1998), psychological theories describe how people learn from feedback (Erev & Barron, 2005), and neuroscientific research describes which kind of information is represented, and how it is manipulated to reach a decision (e. g., Frank & Claus, 2006). While it is a challenging endeavor to examine reward-based decision making across these different levels, we believe that a solid understanding of reward-based decision making needs to describe and understand decision making on different theoretical levels (Marr, 1982). Understanding how goals can be achieved in an optimal way allows deriving hypotheses about the information that needs to be represented and manipulated to make good decisions. Knowledge about how the brain represents information, and about the type of connections between different brain regions, constrains theories about which information is used, and how it is manipulated.

Guided by this general approach, a typical project starts with one or several behavioral theories of reward-based decision making, which are compared in their ability to predict behavioral data. In a second step, the theories are tested on the neuronal level. Testing theories on a neuronal level amounts, for instance, to investigating if a representation of information that is essential to that theory can be found on the neuronal level, or if a representation of a behaviorally unobservable variable predicted by a theory can be identified. Due to our multilevel approach to reward-based decision making, the projects are usually interdisciplinary, and involve cooperation with other research institutions. The remainder will introduce some ongoing projects.

Neural Representation of Decision Thresholds

One question that is particularly interesting for the fields of both perceptual decision making and reward-based decision making is how decision makers adjust their decision criterion to obtain optimal rewards. One kind of model addressing this question are sequential sampling models because they successfully explain response times and percentage of correct decisions in tasks as different as perceptual decision making and short-term memory tasks (Ratcliff & Smith, 2004). The common idea of sequential sampling models is that the decision maker accumulates information in favor of the different decision options, and that the decision is made in favor of the option for which the accumulated evidence first exceeds a decision threshold (see above). Recent research attempted to test sequential sampling models by identifying neurons that accumulate evidence over time, and by correlating EEG parameters with the accumulation gradient in sequential sampling models. From a reward-based learning perspective, the decision

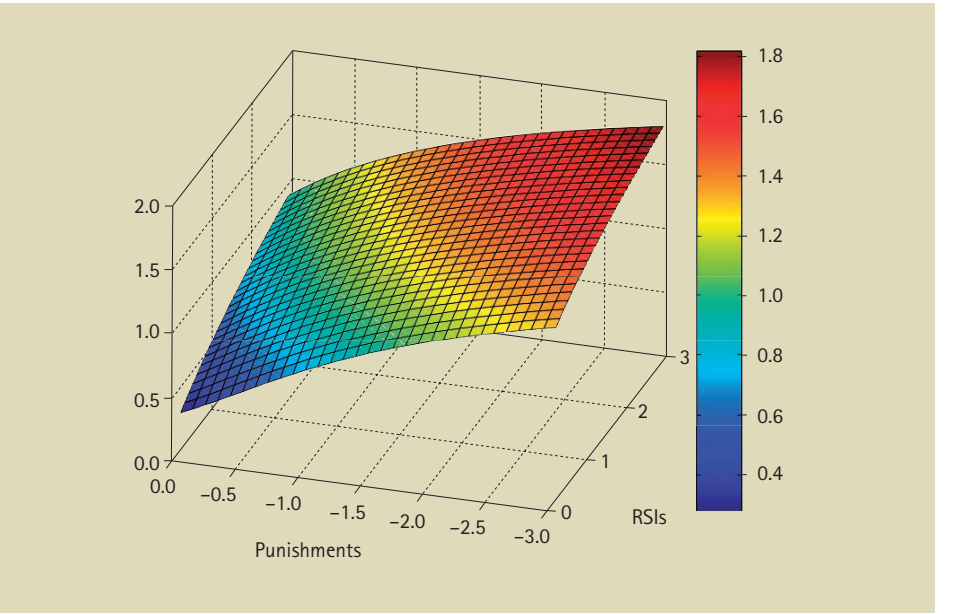


Figure 5. Decision thresholds: Speed-accuracy trade-off can be manipulated by the *Response Stimulus Interval* (RSI) and by punishment for incorrect decisions. The figure depicts optimal thresholds (Y-axis) for a sequential sampling decision model. The payoff for a correct decision is fixed to 1, the parameter for the drift rate is .5, the residual decision time is set to empirically realistic 0.4.

threshold is an especially interesting parameter because it is under the influence of the decision maker. Therefore, in this project, we investigate the neural correlates of the decision threshold. Specifically, we plan to conduct experiments on perceptual (visual) decision making, in which we systematically modify payoffs, so that participants have a strong incentive to adjust their decision threshold. For instance, increasing the punishment for a wrong decision for one alternative in a two-alternative forced choice task should increase the decision threshold for that alternative (Figure 5). In a first behavioral study, we investigate how people respond to changing payoff structures. The first goal of the behavioral study is to identify payoff matrices leading to different thresholds. The second goal is to evaluate which sequential sampling model explains the data best. In an fMRI study, we will then record brain activation during perceptual decision making under different payoff conditions identified in the behavioral study. Here, the objective is to identify how the decision threshold parameter of the best sequential sampling model is represented in connectivity between different brain regions. This project is realized in collaboration with Galesic and Olsson from the Center for Adaptive Behavior and Cognition (ABC) at the MPI for Human Development.

Is Ambiguity Aversion Caused by Pessimism or Dislike?

An observation of considerable interest to economists and psychologists alike is that people prefer risky situations over ambiguous situations with the same expected outcome. For example, most subjects would prefer a gamble with a 50 % chance to win 10 Euros and to win nothing otherwise, over a gamble with unknown probabilities to win either 10 Euros or nothing. The aim of this experiment is to test the hypothesis that ambiguity aversion can be explained by a pessimistic attitude toward ambiguous situations, that is, that people assign the worse outcome a higher likelihood than justified by the available information (Gilboa & Schmeidler, 1989). To test this hypothesis, we use a new variant of the monetary incentive delay task, which has previously been used to elicit representations of event probabilities (Knutson et al., 2005). During the task, participants first receive information about the difficulty of a shortly following face-house discrimination task (see Figure 6). Crucially, the participants' payment depends on the performance in this task, where the correct response needs to be

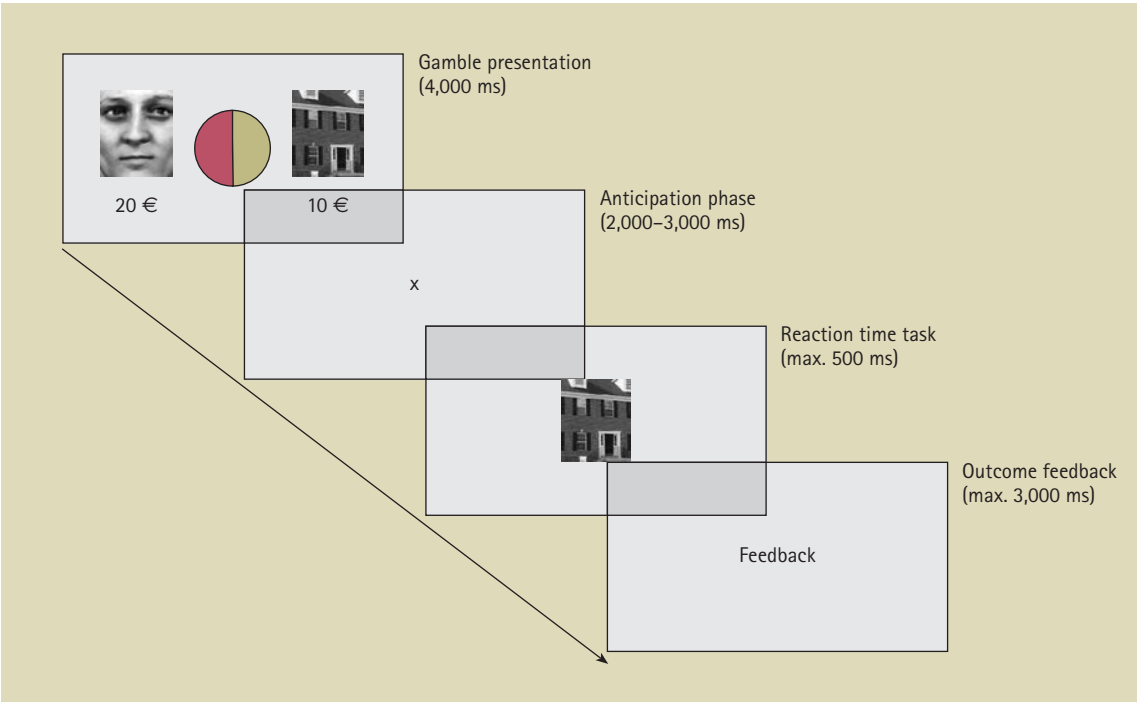


Figure 6. Modified delayed incentive task. Participants are first presented with a gamble, which also predicts the probability of a house-target or a face-target in the reaction time task. If participants are ambiguity averse due to pessimism, this increases their expected probability to react fast enough after presentation of an ambiguous lottery, compared to an 50 %-50 % lottery. Neural corralates of this expected probability, measured in the anticipation phase, have been identified in earlier studies.

made in limited time. After a brief delay (2,000-3,000 ms), participants perform the reaction time task, and finally receive feedback about their success. Previous studies showed that activation in the medial prefrontal cortex correlates with the success probability in the reaction time task. We modified the task so that participants first receive probabilistic or ambiguous information about which of two different stimuli (i. e., face or house) they will see in the face-house discrimination task. The two pictures represent the two possible outcomes of a gamble (high and low), which is only paid out to the participants if they make the correct response fast enough. The ambiguity aversion from pessimism hypothesis predicts on the behavioral level that reaction times for the low-outcome picture are slower in the 50 %-50 % condition compared to the ambiguous condition. On the neuronal level, the medial prefrontal cortex should signal a higher likelihood of success in the ambiguous decision compared to the 50 %-50 % condition because pessimistic participants will expect the low-outcome object with a high certainty. This likelihood of success is a direct function of the probability with which a participant expects a specific face, importantly, the paticipant's expectation is difficult to assess in a purely behavioral experiment.
This project is a collaboration with Rieskamp from the ABC group at MPI for Human Development, Gerhardt from the Humboldt University Berlin, and Mechtenberg from the Technical University Berlin.

Integration of Possible Gains and Losses in a Go-No-Go Task

How do people integrate possible gains and losses when they decide for or against a particular action? So far, this seemingly simple but also important question has stimulated little research in the field of neuroscience. While extensive research has examined the representation of experienced rewards and punishments, or anticipated reward, less is known about how potential gains and losses

are represented and integrated before a decision is reached. Simple weighted additive models, which are often used to describe multiattribute choices, predict that benefits and costs of a particular action are weighted to generate a final evaluation. Translated into a hypothesis for an fMRI experiment, the weighted additive model suggests that people represent gains and losses in two different neural populations, whereas a third population might integrate this information. To gain insight in the neuronal processes of gain-loss integration, we designed an experiment in which participants first learn cues that signal monetary gains and losses of different amounts. After the learning phase, a decision condition follows in which people are confronted simultaneously with two cues representing possible losses and gains, and then have to decide if they want to receive the outcome of this gamble or not. The main goal of the study is to investigate which regions represent the gains and losses signaled by the cues. Whereas the *OrbitoFrontal Cortex* (OFC) is a natural candidate for this (Kringelbach, 2005), recent results about the function of the OFC are still so diverse that this hypothesis deserves empirical examination. A second goal consists in identifying the neuronal processes that generate the final evaluation of the gamble, for example, by integrating information from brain regions representing reward and punishment, respectively. This project is realized in collaboration with Basten and Fiebach (University of Heidelberg).

Neural Correlates of Risk-Value Models for Financial Investment Decisions

When people can choose between different choice options, the option with the highest expected value is often also the riskiest option. One domain in which this is particularly true is financial decision making, where investments with higher expected returns are usually also more volatile. Economic theory suggests that people should trade off expected return and risk in such cases, that is, they should subtract some measure of risk from the expected return to generate an integrated evaluation of an option (Markowitz, 1952). The aims of this project are (a) to model how people evaluate the expected return and the risk of an investment, (b) to identify the neural representations of these attributes, and, crucially, (c) to test if the representations are also present when people have to choose between two investments. In the experiment used to investigate these questions, participants first see a sequence of ten past returns of a risky investment and then have to either predict the expected return, judge the subjective risk, or choose between the presented investment and an investment with a known fixed return of 5 %. On the behavioral level, we test if risk-value models predict choices better than alternative models, like simple decision heuristics (Brandstätter, Gigerenzer, & Hertwig, 2006) or sequential sampling models (Busemeyer & Townsend, 1993). On the neuronal level, we will use fMRI to test if representations for both expected return *and* risk (see Figure 7) can be found when people choose between two investments, or if dif-

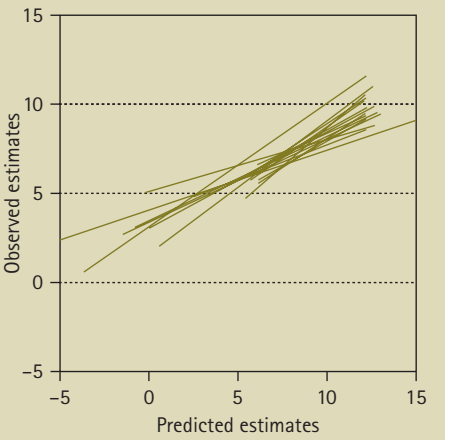


Figure 7. Modeling estimates of expected return. We selected for each participant the model that best predicts his/her estimates in the estimation trials. Most participants were best described by a model calculating the mean of the presented returns while putting higher weights on returns below 5 %. The figure shows the regression lines for estimated and modeled estimations of the expected return, indicating a good agreement of both (n = 16). It therefore seems justified to use modeled estimates as predictors of expected returns in the decision trials.

ferent kinds of information are represented. Finally, we aim to validate the behavioral tests of the models by investigating if the integrated evaluation of the risky option, as predicted by the best model, is also represented in the brain.

The Influence of Advice on Reinforcement Learning

The final project in this section makes the link between reward-based decision making and decision in social contexts. Starting point for the project is the observation that people often do not learn based on experienced rewards alone but also receive advice from other people. For example, when moving for a new job to a new city, one will probably get some advice about the best way to get to the office but also experiment with other alternatives. To examine the influence of advice on reinforcement learning, a first behavioral study by Biele, Rieskamp, and Gonzalez compared different computational models describing the integration of advice and own experience. The main result was that one model, which assumed that people evaluate payoffs from the recommended option more positively than the same payoff from alternative options, described people's behavior best. The current fMRI project examines in more detail how the evaluation of payoffs differs. One hypothesis is that people are not only rewarded by the monetary payoffs but also intrinsically for following advice. This hypothesis can be derived from early theoretical work on the development of imitative capacities (Miller & Dollard, 1941) and from more recent work highlighting the rewarding capacity of cooperative behavior (Decety et al., 2004). The fMRI prediction derived from the intrinsic reward hypothesis is that reward from the recommended options leads to greater activation in the OFC than reward from an alternative option. To test this and alternative hypotheses, we have collected fMRI and behavioral data from participants who first received a recommendation about which deck to choose from in a multiple-armed bandit task. We employed an event related design, which allows to separately examine the decision, the anticipation, and the feedback phases. First results indicate that outcomes from recommended options might indeed be evaluated differently than outcomes from alternative options (Biele, Krugel, Rieskamp, & Heekeren, 2007).

Decision Making in Social Contexts

Decision making processes during social interactions are highly complex, unstructured, and often intuitive. For example, when we have to make a decision about the trustworthiness of a stranger, a variety of information, such as facial expression, tone of voice, and the pragmatics of language, have to be interpreted simultaneously. Although part of those interpretations are accomplished through cognitive (i. e., conscious and analytical) processes, given the velocity with which social decisions have to be made, the faster and mostly unconscious emotional processes (e. g., intuition) are likely to be involved as well (Adolphs, 2006). Thus, any social decision will be the result of social cognitive as well as socioemotional processes. The common goal of our subprojects within the topic of decisions in social contexts is to elucidate the unique as well as combined contributions that these cognitive and emotional processes have on social decision making. Given the complexity of social interactions, identification of brain correlates for social decisions poses a great challenge. By putting emphasis on the development of psychological paradigms that focus on subcomponents of social decisions, we are trying to reduce this complexity, and to make it more controllable for research settings while aiming for ecological validity at the same time. Using structural and functional MRI as well as psychophysiological measures, such as skin conductance and pupillometry, our group is trying to elucidate how and where in the brain of healthy individuals social decisions are processed. Moreover, to complement our understanding of the "social brain," we are studying neuropsychiatric patients with socioaffective impairments, such as Borderline personality disorder and autism. We expect that, in turn, our studies will inform future research and intervention efforts in these and other conditions with deficient decision making.

Sociotopy of the Posterior Superior Temporal Sulcus

Social tasks, such as judging another person's movements (*biological motion*, BM), mental states (*theory-of-mind*, ToM), and norm-congruency of behavior (*normative judgment*, NJ), lead to the recruitment of a network of brain areas that consistently includes the *posterior superior temporal sulcus* (pSTS). The goal of the present fMRI study was to elucidate the specific function of the pSTS region within the social cognitive network. Based on a meta-analysis of previous imaging studies, we hypothesized that subregions within the pSTS would be differentially activated by the three different tasks (BM, ToM, NJ). For our fMRI study, we developed a new set of animated stimuli, which depicts two persons in social interactions (Figure 8).

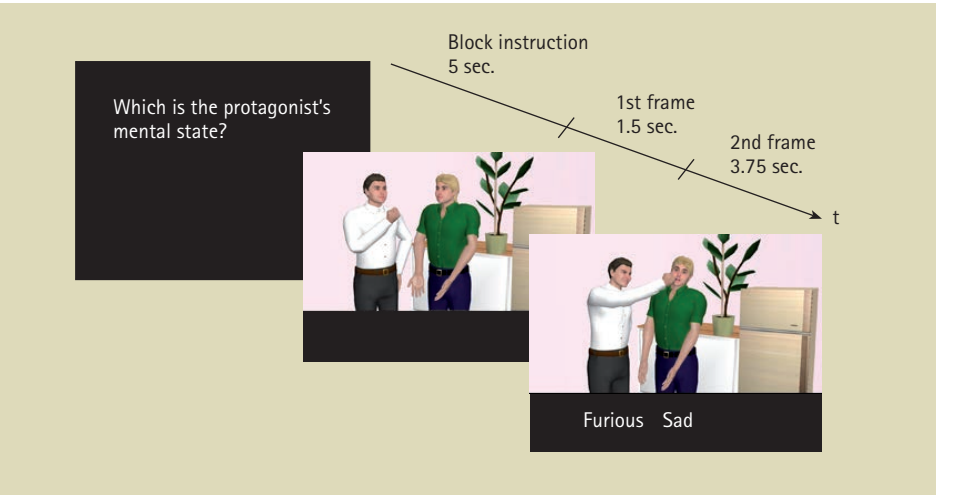


Figure 8. Sample stimulus for the ToM condition with timeline of presentation. The protagonist was marked by the white shirt. The same two frames were used for the BM and NJ conditions, only the block instruction and the response choice pair were adapted accordingly. BM: In which direction is the protagonist moving? (left or right). NJ: Is the protagonist committing a norm violation? (yes or no).

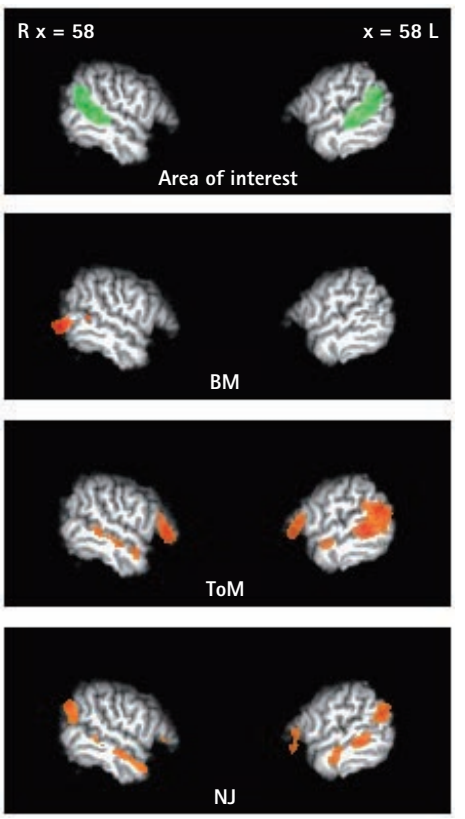


Figure 9. Sagittal view of the pSTS in the right and left hemisphere for BM, ToM, and NJ, $p < 0.001$, uncorrected. The area of interest is highlighted in green in the uppermost panel.

Each stimulus includes the display of a person's movements and mental states, and the depicted behavior could clearly be judged concerning a possible violation of social norms. Importantly, the material was kept constant for all three conditions, and only task instructions were manipulated. The fMRI results reproduced task-specific activation patterns for each task, as reported by previous studies ($Z = 3.1$, uncorrected) (e.g., Allison et al., 2000; Gallagher & Frith, 2003; Goodenough & Prehn, 2004; Heekeren, Wartenburger, Schmidt, Schwintowski, & Villringer, 2003; Heekeren et al., 2005). With respect to the pSTS, the activity evoked by the BM task was strongly right-lateralized, while that evoked by the ToM task was left-lateralized. The NJ task led to bilateral activation. There was a significant overlap of activity of the ToM and NJ tasks (Figure 9). The distinctive pattern of activation during the BM task in relation to the ToM and NJ

tasks suggests the involvement of different cognitive processes. In contrast, the considerable overlap between activations evoked by the ToM and NJ tasks indicates that the two functions engage a common cognitive process, such as an automated inference of thoughts/feelings or intentions, even if not explicitly demanded by the task. Currently, we are preparing the adaptation of the paradigm for use with *Near InfraRed Spectroscopy* (NIRS) and its use in a study with subjects with Asperger Syndrom.

Interaction of Emotional and Cognitive Processing in Decision Making

To address the question, how emotional and conceptual processes interact in decision making, we developed an analogical reasoning task. In this task, word pairs were presented simultaneously, and participants had

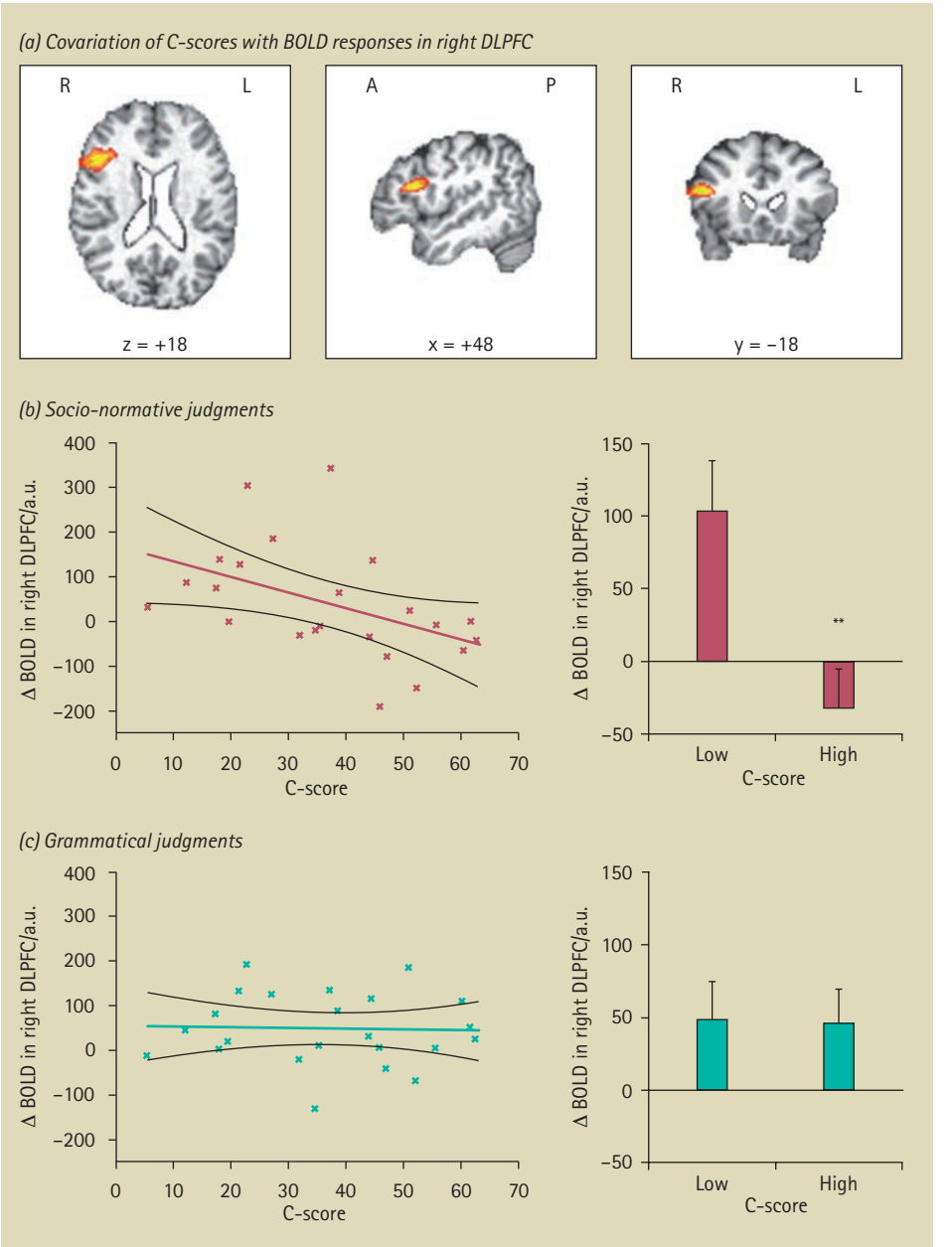


Figure 10. Neural correlate of individual differences in moral judgment competence.

to decide whether they corresponded in their emotional as well as in their conceptual relations. Response times, error rates, and pupillary responses were recorded. Response time data showed that emotional processing is faster than conceptual processing. Pupillary responses as a proxy for the processing load, however, clearly indicated that semantic processing is consuming as many cognitive resources as emotional processing. This result suggests that both cognitive and emotional aspects are processed in parallel (Prehn et al., 2005). In a next step, we will identify the network of brain regions that mediates emotional and conceptual processing using fMRI and concurrent psychophysiological monitoring. In another project, we continue our previous work on the neural correlates of moral judgment processes (Goodenough & Prehn, 2004; Heekeren et al., 2003, 2005). Moral judgment as a higher cognitive function entails a number of processes implemented by a network of brain regions that are involved in cognitive as well as in emotional processing. People differ with respect to their competence to make moral judgments. We used fMRI and skin conductance recording to investigate how individual differences in this domain modulate neural correlates of normative judgments. We found that individual moral judgment competence (assessed with the Moral Judgment Test; Lind, 2005) was reflected in BOLD activity in right DLPFC during socio-normative judgments relative to grammatical judgments. Participants with lower moral judgment competence recruited the right DLPFC more than those with higher competence in this domain (Figure 10), indicating higher processing demands (Prehn et al., 2006).

Neural Correlates of Individual Differences in Cognitive Processing of Emotions

People differ in the extent to which they experience emotions. These individual differences affect even simple perceptual decisions, and influence the psychophysiological and neural correlates of emotion processing. In a first fMRI study, we investigated how individual differences in cognitive processing of emotions influence perceptual decisions on the gender or the emotional expression of faces (Figure 11). We found that those individual differences were associated with increased activity of the left dorsal anterior cingulate cortex and altered connectivity of this region with prefrontal areas (cognitive processing) and limbic regions (emotional processing). We argue that differences in functional integration of this neural network

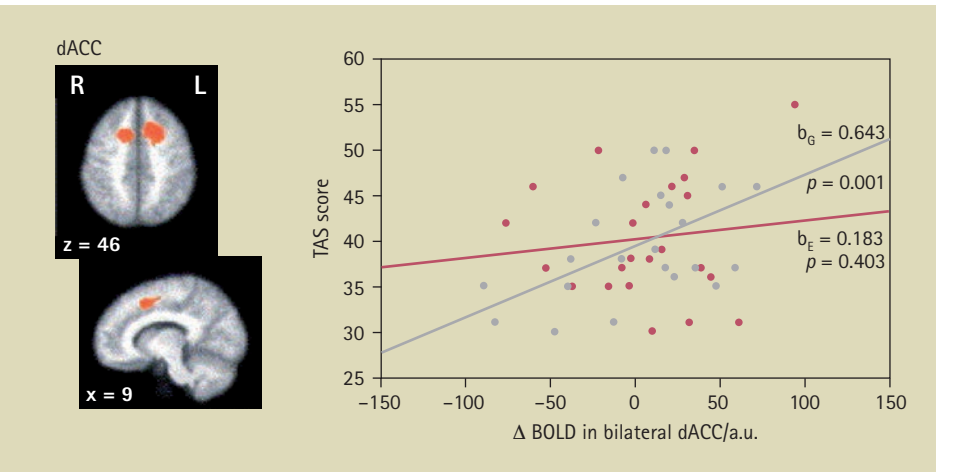


Figure 11. Covariation of BOLD responses with TAS score. Left panel: TAS score covaried significantly with BOLD responses in the bilateral dACC during gender decisions. The figure shows activations from higher level analysis thresholded at $Z > 3.1$, corresponding to $p = 0.001$, uncorrected, that were used as a mask for subsequent PPI analyses. Right panel: Covariation of TAS score and BOLD responses (*arbitrary units*, a.u.) during emotion decisions (red dots) and gender decisions (grey dots) (b_E and b_G represent regression slopes for emotion decisions and gender decisions, respectively; p = p value).

may give rise to individual differences in the ability to cognitively process emotions. Moreover, we present neurophysiological evidence for a theoretical model which posits that discommunication of the neocortex with limbic areas impairs cognitive processing of emotions (Mériau, Wartenburger et al., 2006). In another study, we combined psychophysiological and fMRI measurements to investigate how individual differences in *negative affect* (NA) are reflected in changes in BOLD responses and *Skin Conductance Level* (SCL) during passive viewing of emotional stimuli. Our data show differential insular activity as a function of individual differences in NA when passively viewing aversive stimuli. Furthermore, this finding was independent of autonomic arousal.

The insula has been implicated in interoceptive processes and in the integration of sensory, visceral, and affective information, thus contributing to subjective emotional experience. Therefore, the greater recruitment of the insula in response to aversive stimuli in subjects with high NA may indicate increased interoceptive sensitivity to internal changes independent of autonomic arousal, and may contribute to greater self-reported NA (Mériau, Kazzer et al., 2006).

Social Cognition and Cortical Thickness in Asperger Syndrome

Asperger Syndrome (AS) represents the cognitively higher functioning end of the autism spectrum with selective deficits in social perception and cognition. Thus, brain imaging research in AS can provide important information on the neuronal structures, which are crucially involved in social cognitive processes in healthy individuals. In a previous study, we have found some evidence for amygdala abnormalities and impaired social cognitive functions in adults with AS (Dziobek, Rogers, Fleck, Wolf, & Convit, 2006). In the present study, in collaboration with researchers from the New York University School of Medicine, we investigated whether social cognitive impairments in AS are selective, and how they are related to neuroanatomical differences. We compared a group of individuals with AS (n = 27) with a group of well-matched *Normal Controls* (NC) (n = 29) in tests of social cognition, memory, attention, executive functioning, and cortical thickness measures. Neuropsychological results showed that differences between the diagnostic groups were restricted to social perception and cognition (facial emotion recognition and theory of mind [as assessed using the *Movie for the Assessment of Social Cognition*, MASC; Dziobek, Fleck et al., 2006]). Imaging analyses revealed that the AS group had thicker cerebral cortex in the left fusiform gyrus and the right *Temporo-Parietal Junction* (TPJ). Interestingly, there was a negative association between cortical thickness of the fusiform *Region of Interest* (ROI) and facial emotion recognition in the AS, but not in the NC group (due to later inclusion in the study, data on facial emotion recognition was available only for a subset of study participants [*n:* AS = 18; NC = 13]), (Figure 12).

One of the most consistent findings in autism spectrum conditions is increased head and brain size (e. g., Redcay & Courchesne, 2005). In addition, both the fusiform gyrus and the TPJ have previously been identified as crucial for face processing and social cognitive functions in typically developed individuals, as has also been shown by our previous research (see Bahnemann, Dziobek, Prehn, Wolf, & Heekeren, 2007; Prehn et al., 2006). Thus, our data represent convergent neuroanatomical and neuropsychological evidence for specific social perceptive and social cognitive impairments in AS. The results may be important in the understanding of yet unknown brain behavior relationships in autism spectrum conditions.

Differentiating Cognitive and Emotional Empathy in Asperger Syndrome

Empathy is a multidimensional construct entailing cognitive (understanding others' mental states, theory of mind) and affective (emotional reaction to the observed experiences of another) components. Despite a lack of research, deficient empathy is considered a central characteristic of AS. In a preliminary study, we profiled empathy multidimensionally in individuals with AS using question-

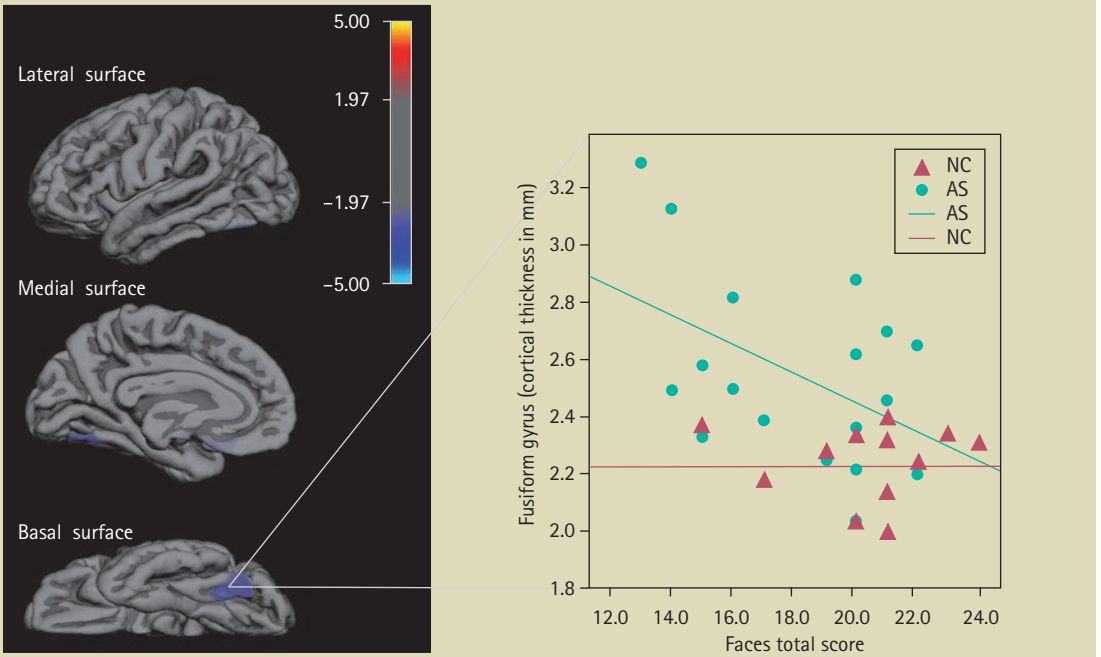


Figure 12. Left: Areas of increased cortical thickness of the AS group were restricted to the fusiform gyrus ($p < 0.001$). Right: Associations between fusiform gyrus cortical thickness and facial emotion recognition for the AS ($r = -.47$, $p = 0.048$) and NC ($r = .00$, $p = 0.99$) groups.

naires (Rogers, Dziobek, Hassenstab, Wolf, & Convit, 2006). In a next step, to further characterize empathic abilities, we used in-house developed empathy paradigms that allow separate assessment of emotional and cognitive components, while also aiming at ecological validity. The MASC (Dziobek, Fleck et al., 2006) is a video-based measure of cognitive empathy that requires a subject to infer mental states of movie characters. The *Multifaceted Empathy Test* (MET) (Dziobek, Rogers, Fleck, Bahnemann et al., 2006) allows simultaneous assessment of cognitive and affective empathy, asking study participants to rate their emotional reaction to social picture stimuli (Figure 13).

Our data showed that while individuals with AS seem to have impairments in inferring others' mental states (cognitive empathy), they are as empathically concerned for others (emotional empathy) as control subjects. In a next step, we will test the hypothesis that

Figure 13. MET example item depicting the various conditions.

healthy controls and individuals with AS recruit dissociable brain networks during cognitive, but not emotional empathy tasks. We developed fMRI compatible adaptations of the MASC and MET and will be using them with a combination of structural (brain volumetrics) and fMRI measures.
An important goal of our work is to make it applicable for clinical cognitive neuroscience questions. In pursuit of this goal, we started investigating empathic abilities in clinical populations: In collaboration with the Department of Psychiatry and Psychotherapy of the Charité—University Medicine, Campus Benjamin Franklin in Berlin (Prof. Heuser), we are evaluating patients with narcissistic and Borderline personality disorder. In collaboration with the Department of Social Pedagogy of the Free University Berlin (Prof. Körner), we are currently examining delinquent adolescents and school children with behavioral deviances.

The Independent Research Group in March 2007

From left to right: Sonali Beckmann, Philipp Kazzer, Markus Bauer, Hauke Heekeren, Isabel Dziobek, Christina Scheibe, Katja Mériau, Nikos Green, Jenny Kirchner, Kristin Prehn, Guido Biele, Hermine Wenzlaff, Peter Mohr, Sandra Preißler, Janine Bayer, Ulrich Reinacher, Lea Krugel, Markus Bahnemann, Flora von Randow, Ingo Wolf.

Publications 2005–2006

(last update: May 2007)

Bahnemann, M., Dziobek, I., Prehn, K., Wolf, I., & **Heekeren, H. R.** (2007). Sociotopy of the superior temporal sulcus: Searching for dissociable representations of judgments on movements, mental states and norm-congruency of behavior. *Human Brain Mapping.* Abstract.

Bauer, M., Oostenveld, R., Peeters, M., & Fries, P. (2006). Tactile spatial attention enhances gamma-band activity in somatosensory cortex and reduces low-frequency activity in parieto-occipital areas. *Journal of Neuroscience, 26* (2), 490–501.

Biele, G., Krugel, L., Rieskamp, J., & **Heekeren, H. R.,** (2007). The influence of advice on reward based decision-making and learning. *Human Brain Mapping.* Abstract.

Dziobek, I., Gold, S., Wolf, O. T., & Convit, A. (2007). Hypercholesterolemia in Asperger syndrome: Independence from lifestyle, obsessive-compulsive behavior, and social anxiety. *Psychiatry Research, 149* (1–3), 321–324.

Dziobek, I., Wolf, I., **Preißler, S.,** Kirchner, J., **Bahnemann, M.,** Convit, A., & **Heekeren H. R.** (2007). Neuropsychological and neuroanatomical evidence for social perceptive and social cognitive impairments in adults with Asperger syndrome. *Human Brain Mapping.* Abstract.

Dziobek, I., Fleck, S., Kalbe, E., Rogers, K., Hassenstab, J., Brand, M., Kessler, J., Woike, J., Wolf, O. T., & Convit, A. (2006). Introducing MASC: A movie for the assessment of social cognition. *Journal of Autism and Developmental Disorders, 36* (5), 623–636.

Dziobek, I., Rogers, K., Fleck, S., **Bahnemann, M., Heekeren, H. R.,** Wolf, O. T., & Convit, A. (2006). Differenzierung kognitiver und affektiver Empathie bei Menschen mit Asperger Syndrom: erste Ergebnisse des Multifaceted Empathy Test (MET). Kongress der Deutschen Gesellschaft für Psychiatrie, Psychotherapie und Nervenheilkunde (DGPPN), Berlin November 2006. *Der Nervenarzt, 77* (Suppl. 3), S343:0095.

Dziobek, I., Rogers, K., Fleck, S., Wolf, O. T., & Convit, A. (2006). The amygdala theory of autism revisited: Linking structure to behaviors. *Neuropsychologia, 44* (10), 1891–1899.

Dziobek, I., Rogers, K., Fleck, S., Hassenstab, J., Gold, S., Wolf, O. T., & Convit, A. (2005). In search of "master mindreaders": Are psychics superior in reading the language of the eyes? *Brain and Cognition, 58* (2), 240–244.

Gold, S. M., **Dziobek, I.,** Rogers, K., Bayoumy, A., McHugh, P. F., & Convit, A. (2005). Hypertension and hypothalamo-pituitary-adrenal axis hyperactivity affect frontal lobe integrity. *Journal of Clinical Endocrinolgy and Metabolism, 90* (6), 3262–3267.

Goodenough, O. R, & **Prehn, K.** (2004). A neuroscientific approach to normative judgment in law and justice. *Philosophical Transactions of the Royal Society of London, Series B: Biological Sciences, 359,* 1709–1726.

Hassenstab, J., **Dziobek, I.,** Rogers, K., Wolf, O. T., & Convit, A. (2007). Knowing what others know, feeling what others feel: A controlled study of cognitive and affective empathy in psychotherapists. *Journal of Nervous and Mental Disease*, *195,* 277–281.

Heekeren, H. R., Wartenburger, I., Mell, T., Marschner, A., Villringer, A., & Reischies, F. M. (in press). Role of ventral striatum during reward-based decision-making. *NeuroReport.*

Heekeren, H. R., Marrett, S., Bandettini, P. A., Ungerleider, L. G. (2006.) Involvement of human left dorsolateral prefrontal cortex in perceptual decision-making is independent of response modality. *Proceedings of the National Academy of Sciences of the United States of America, 103* (26), 10023–10028.

Heekeren, H. R., Wartenburger, I., Schmidt, H., **Prehn, K.,** Schwintowski, H. P., & Villringer, A. (2005). Influence of bodily harm on neural correlates of semantic and moral decision-making. *NeuroImage, 24* (3), 887–897.

Heekeren, H. R., Marrett, S., Bandettini, P. A., Ungerleider, L. G. (2004). A general mechanism for perceptual decision-making in the human brain. *Nature, 431*, 859–861.

Marschner, A., Mell, T., Wartenburger, I., Villringer, A., Reischies, F. M., & **Heekeren, H. R.** (2005). Reward-based decision-making and aging. *Brain Research Bulletin, 67* (5), 382–390.

Mell, T., **Heekeren, H. R.,** Marschner, A., Wartenburger, I., Villringer, A., & Reischies, F. M. (2005). Effect of aging on stimulus-reward association learning. *Neuropsychologia, 43* (4), 554–563.

Mériau, K., Kazzer, P., Wartenburger, I., **Prehn, K.,** Villringer, A., van der Meer, E., & **Heekeren, H. R.** (2006). Insular activity reflects individual differences in negative affect independent of autonomic arousal. *Human Brain Mapping.* Abstract.

Mériau, K., Wartenburger, I., Kazzer, P., **Prehn, K.,** Lammers, C.-H., van der Meer, E., Villringer, A., & **Heekeren, H. R.** (2006). A neural network reflecting individual differences in cognitive processing of emotions during perceptual decision-making. *NeuroImage, 33*, 1016–1027.

Pachur, T., & **Biele, G.** (2007). Forecasting from ignorance: The use and usefulness of recognition in lay predictions of sports events. *Acta Psychologica, 125,* 99–116.

Prehn, K., Heekeren, H. R., Raisig, S., Schiemann, T., Villringer, A., & van der Meer, E. (2005). Integration of emotional and conceptual processing in decision-making: Evidence from pupillometry. *Journal of Cognitive Neuroscience* (Suppl.), 169–169.

Prehn, K., Wartenburger, I., **Mériau, K., Scheibe, C.,** Goodenough, O .R., Villringer, A., van der Meer, E., & **Heekeren, H. R.** (2006). Influence of individual differences in moral judgment competence on neural correlates of normative judgments. *Human Brain Mapping.* Abstract.

Preuschhof, C., **Heekeren, H. R.,** Taskin, B., Schubert, T., & Villringer, A. (2006). Neural correlates of vibrotactile working memory in the human brain. *The Journal of Neuroscience, 26,* 13231–13239.

Rogers, K., **Dziobek, I.,** Hassenstab, J., Wolf, O. T., & Convit, A. (2006). Who cares? Revisiting empathy in Asperger syndrome. *Journal of Autism and Developmental Disorders,* Aug. 12 [Epub ahead of print].

Scheibe, C., Ullsperger, M., Sommer, W., & **Heekeren, H. R.** (2007). *Spatiotemporal dynamics munderlying the integration of prior probability information in decision making.* Conference of Cognitive Neuroscience, New York. Abstract.

Scheibe, C., Schubert, R., Sommer, W., & **Heekeren, H. R.** (2006). *Integration of prior probability in the process of decision making.* Human Brain Mapping Conference, Florence. Abstract.

Scheibe, C., Wartenburger, I., Wüstenberg, T., Villringer, A., & **Heekeren, H. R.** (2005). Neural correlates of the interaction between transient and sustained processes—A mixed blocked/

event-related fMRI study. *Human Brain Mapping,* Sep. 2 [Epub ahead of print].

de Wit, T. C., **Bauer, M.,** Oostenveld, R., Fries, P., & van Lier, R. (2006). Cortical responses to contextual influences in amodal completion. *NeuroImage, 32* (4), 1815–1825.

Wolf, O. T., **Dziobek, I.,** McHugh, P. F., Sweat, V., Javier, E., de Leon, M. J., & Convit, A. (2005). Subjective memory complaints in aging are associated with elevated cortisol levels. *Neurobiology of Aging, 26,* 1357–1363.

Service Units

Contents

Scientific and Professional Staff (2005–2006)

Library and Research Information: Nicole Engelhardt, **Ursula Flitner**

Information Processing Center: Wolfgang Assmann

Library and Research Information

Rapid access to printed and digital information is a decisive prerequisite for successful studies and for internationally renowned research.
The Library and Research Information Unit of the Max Planck Institute for Human Development aims to anticipate, determine, and respond to the Institute's needs for information in the areas of education, sociology, psychology, and neighboring disciplines.
To support the research, teaching, and publishing activities of the Institute's researchers, the Library seeks to provide an environment and facilities conducive to efficient and independent use and dissemination of information.

The Library's collection currently comprises around 200,000 volumes, 520 printed periodicals, several thousand electronic journals, and an extensive selection of electronic resources. It offers easy and fast access to our own materials and information worldwide. Comprehensive intranet services include, among other things, online access to major bibliographic and abstract databases, to portals and e-books, to document delivery services, and listings of new acquisitions.
In 2005 and 2006, the range of electronic full texts available within the context of the Max Planck Society's basic provision (Grundversorgung) was expanded to include a total of more than 15,000 journals on all fields of science, thus offering a sound basis for interdisciplinary research.
The collection of centrally and locally licenced electronic resources, accessible from every office desk in the Institute, is growing steadily.

Among the new electronic resources added to the Library's services are:
- *CogNet,* the brain sciences portal maintained by the Massachusetts Institute of Technology;
- *The Cochrane Library,* a collection of databases to inform health-care decision making;
- the *International Bibliography of Periodical Literature (IBZ),* containing almost 2.8 million journal articles from about 11,000 journals mainly from the Humanities, Social Sciences, and Arts;
- the *International Bibliography of Book Reviews (IBR),* containing over 1 million entries on book reviews from the year 1985 onwards, published in approximately 6,600 academic journals mainly on the Humanities and Social Sciences;
- *SocINDEX with Full Text,* a sociological database containing full text for several hundred journals, for more than 700 books

and monographs, as well as conference papers;
- *SourceOECD* organizes the OECD's authoritative research output into a full-text online library that consists of more than 20 periodicals, 24 statistical databases, reference titles, thematic book collections, and working papers;
- *Periodicals Index Online,* currently indexing more than 15 million articles from the Humanities reaching back to the year 1665.

In addition, the Institute profits from the National Licences, a program financed by the German Research Foundation (DFG), offering free access on a national level to a vast number of databases, digital full-text collections, and e-journals.

The staff of the Library continue to offer regular training in the use of databases.

Additional funds were raised to satisfy the information needs of the new Independent Junior Research Group "Neurocognition of Decision Making."

To enhance the visibility of the Institute's scientific output, the Library took up digitalization in 2004 and launched its first electronic full-text collection in spring 2005: the Institute's Serials—*Studien und Berichte,* since 1965, and *Materialien aus der Bildungsforschung,* since 1972—with a total of 173 volumes are now available online in formats allowing smooth access both from inside and outside high-performance networks.

A moving wall of 5 years was deemed an appropriate provision to secure interest in the ongoing publication of the printed volumes. Usage reports show that this offer is in high demand.

In 2005, the Library also addressed the issue of catalog enrichment.

The idea is to enhance library catalog browsing by adding content to help users make more informed decisions on the applicability of a resource from the catalog record.

This seems all the more desirable given the closed-stack shelving of most of our Library's collections.

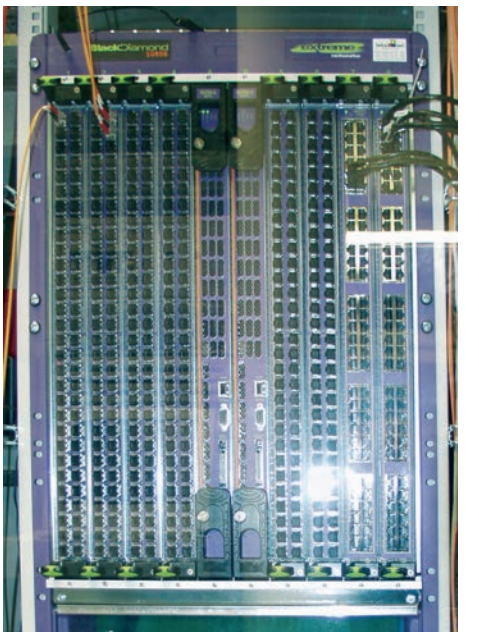
Thus, in fall 2005, the Library started to digitize tables of content of newly acquired books to be included in the library catalog.

Since 2005, we have been training an apprentice in Library and Information Science.

Information Processing Center

The Information Processing Center supports projects and other service units in the Institute through its central facilities. Central servers are installed with Windows 2000/2003 or LINUX for dedicated purposes: internet/intranet servers, software server, etc. Five Windows 2000 cluster systems with large RAID storage installations provide the capacity (more than 10 TByte) for the central data management. Several powerful terminal servers establish a CITRIX server farm. They allow the user to run programs (SPSS, SAS, MAT-Lab, EQS, etc.) on the server CPUs from their own workstations (Windows or Apple PC) or the Internet. "Server-based computing" helps to overcome the constraints of the different workstations concerning CPU power and local storage. There has been a paradigm shift from the classical RAID system to a SAN solution on the central servers in 2005. Thereby, 80 TByte has been created in the last 2 years.

The decentralized personal computing capacity comprises about 300 Intel PCs and 150 Apple computers. The Apple computers are running MacOS X and the Intel PCs are operating on Microsoft Windows 2000 or Windows XP. A central backup service is provided for all data on cluster and SAN disks. A wide array of software is available for the desktop systems.
To provide the necessary security, a Cisco-PIX firewall system was installed which allows for the failure of certain modules without causing a complete breakdown. Central virus scanner software—continuously updated via the internet—monitor all Intel and Apple workstations to avoid data loss caused by viruses.
The Local Area Network (LAN) integration of all desktop computers provides access to central resources and cluster capacity. At the end of 2004, the previous "fiber-to-desktop" solution of 10 Mbit/s was replaced by the "fiber-to-office" concept. Each office is now connected with 1,000 Mbit/s, and here the changeover from fiber to four copper ports takes place by using a small Gigabit Ethernet Switch.
To provide notebook users with a wireless connection to the internet, the Institute has installed WLAN.
The Institute's connectivity to Wide Area Networks (internet, etc.) is provided via the Research Network (WIN) of German Telekom and the German Research Network Association (Deutsches Forschungsnetz [DFN]). Late in the year 2000, the GIGA-WIN (1 Gbit/s) was installed, allowing the Institute to increase the use of high-speed connectivity.



The Center's services include:
- operating, optimizing, and developing the devices of the central cluster and network equipment;
- maintenance and updating Windows 2000, XP, and Linux operating systems;
- centralized printing capacity, including high-speed and color printers;
- LAN integration of desktop computers, and the continuous enhancement of LAN facilities;
- national and international connectivity (Wide Area Network);
- internet services: E-mail, WWW, NEWS, FTP, and Telnet;

– maintenance and webmaster tasks of the Institute's internet and intranet servers;
– security measures;
– management of the central telephone system, including the voice-mail server;
– user support and trouble-shooting for Intel PCs and Apple computers;
– coordination and technical support for desktop computers and software;
– software acquisition.

The Center provides:
– general design and coordination of the Institute's information technology equipment;
– the documentation of data concerning the existing computer and network equipment;
– an overview of market developments;
– advice for the Institute's boards and departments;
– the promotion of new concepts for state-of-the-art computer equipment.

Appendix

Contents

Last update: May 2007

1. Research Colloquia 2005–2006

2006

Kaarin J. Anstey
Australian National University:
The Relationship Between Weekly Alcohol Consumption, Cognitive Function and Brain Structure in Young, Middle, and Older Adulthood
September 5

Jean Decety
University of Chicago:
A Developmental and Cognitive Neuroscience View of Human Empathy
June 13

Hartmut Ditton
Ludwig Maximilians University Munich:
Übergänge auf weiterführende Schulen nach der Grundschule: primäre und sekundäre Effekte
September 27

Jon Driver
Institute of Cognitive Neuroscience at University College London:
Crossmodal Links in Human Spatial Attention
October 26

Jutta Heckhausen
University of California, Irvine:
Developmental Regulation Across the Life Span
October 24

Alumit Ishai
University of Zurich:
fMRI Studies of Face Perception: Effects of Memory, Emotion & Sexual Preference
March 9

Richard M. Lerner
Tufts University, Medford, MA:
The Handbook of Child Psychology, 6th ed. (2006): An Editor's Perspective
June 16

Ulrich Mayr
University of Bonn:
Navigating Through Task Space: The Role of Cues and Inhibition
June 20

Günther Palm
University of Ulm:
Neuroinformatik: Experiment, Theorie und Praxis
February 24

Tenko Raykov
Michigan State University:
Change Measurement and Program Evaluation Using Latent Variable Modeling
October 31

Neal Roese
University of Illinois:
The Functional Basis of Counterfactual Thinking
May 9

Michael Schäfer
National Institute for Neurological Disorders and Stroke, Bethesda, MA:
Social Neuroscience: From Body Perception Over Mirror Neurons to Culture
January 18

Glenn Schellenberg
University of Toronto at Mississauga:
Does Music Make You Smarter?
April 8

Wolfgang Schneider
University of Würzburg:
Die Entwicklung von Metakognition bei Kindern und Jugendlichen
November 28

Lee S. Shulman
Carnegie Foundation for the Advancement of Teaching, Stanford:
"Signature Pedagogies" in the Professions: Their Characteristics and Lessons Learned for the Power of Professional Eduation
September 7

Martin Sliwinski
Syracuse University, New York:
Intraindividual Variability and Change in Affect, Stress and Health
May 23

Piotr Winkielman
University of California, San Diego:
Preferences With and Without Inferences
May 8

Marjorie H. Woollacott
University of Oregon:
Attentional Factors Contributing to Balance Constraints During Gait in Older Adults: Can These be Reduced With Training?
November 21

Zhou Xiaolin
Beijing University China:
The Automaticity and Flexibility of the Mental Number Line
February 24

2005

Uschi Backes-Gellner
University of Zurich:
Incentives and Research Productivity in Universities: A Business Economist's Analysis and Empirical Evidence
May 3

Lars Bäckman
Karolinska Institute, Stockholm:
Dopamine and Cognitive Aging
May 31

Fredda Blanchard-Fields
Georgia Institute of Technology, Atlanta:
Aging, Affective Processing, and Social Cognition
August 9

Hans-Peter Blossfeld
University of Bamberg:
Educational Systems as Marriage Markets
January 5

Marlis Buchmann
University of Zurich/ETH:
New Challenges in Life Course Research: Persistent Gaps and Promising Avenues
February 1

Hannah Brückner
Yale University:
Capitalizing on the Life Course
March 7

2005

Lynn Prince Cooke
Nuffield College, Oxford University:
What Does "Doing" Gender Do for Marriage? Household Bargaining and Risk of Divorce in Germany and the United States
May 30

Thomas DiPrete
Columbia University:
Life Course Destandardization, Social Polarization, and Social Interaction: A Reflection on Recent American Trends and a Proposal for Research
April 22

Ido Erev
Technion—Israel Institute of Technology, Haifa:
On Adaption, Maximization, and Reinforcement Learning Among Cognitive Strategies
November 28

Ute Frevert
Yale University:
Europeanizing German History
April 28

Yoav Ganzach
Tel Aviv University:
On the Perception of Financial Risk (and Return)
May 2

Adam Gamoran
University of Wisconsin-Madison:
Racial Gaps and School Effects during School Re-Segregation
April 1

Theodore P. Gerber
University of Wisconsin-Madison:
Economic Crisis or Second Demographic Transition? Trends and Correlates of Union Formation in Russia, 1985–2001
April 26

David Grusky
Stanford University:
Measuring Inequality: The Heavy Weight of Convention, the Case for Overcoming it, and Why a New Social Indicators Framework Must be Developed
April 18

Agneta Herlitz
Karolinska Institute, Stockholm:
Sex Differences in Cognition
April 26

Christopher Hertzog
Georgia Institute of Technology, Atlanta:
Individual Differences in Strategy Use for Associative Learning
May 3

Hachiro Iwai
Kyoto University:
The Japanese Life Course After the Postwar Economic Growth
January 28

Douglas M. Jones
University of Utah, Salt Lake City:
Universals of Language and Kinship: A Perspective From Evolutionary Psychology
December 12

Michael Kahana
University of Pennsylvania:
Human Memory and its Neural Mechanisms
June 28

Vered Kraus
University of Haifa:
Secondary Breadwinner: Israeli Women in the Labor Force, January 21

John McArdle
University of Southern California:
Recent Developments in Latent Growth Curve Modeling
September 16

Earl K. Miller
Massachusetts Institute of Technology:
The Prefrontal Cortex: Categories, Concepts, and Cognitive Control
May 24

Peter Molenaar
University of Amsterdam:
Idiographic Psychology: The Necessary and Principled Psychometric Answer to the Uniqueness of Human Persons and its Theoretical and Practical Implications
March 15

Roger Ratcliff
Ohio State University:
Applications of Diffusion Models in Cognitive Aging and in Analyses of Single-Neuron Recording Data
April 19

Henry L. Roediger, III
Washington University, St. Louis
Illusory Memories: Remembering Events That Never Happened
May 9

André A. Rupp
University of Iowa:
Hunting the Ghost in the Machine: General and Cognitive Psychometric Methodologies for Modeling and Understanding Response Processes for Language Tests
February 24

Robert J. Sampson
Harvard University:
Delinquent Boys Grown Up: Trajectories of Crime from Childhood to Age 70
January 7

David P. Schmitt
Bradley University, Illinois:
The Many Cultures of Short-Term Mating: How Gender, Personality, and Local Ecology Relate to High-Risk Sexual Behavior in Humans
December 8

Brent Small
University of South Florida:
Growth Mixture Models of Cognitive Impairment and Cancer-Related Fatigue
June 14

Stephen M. Stigler
University of Chicago:
The History of Maximum Likelihood From Lagrange to Fisher
July 19

Nikolaus Troje
Queen's University:
Local and Global Information in Animate Motion Patterns, June 21

Duncan Watts
Columbia University:
Networks, Collective Dynamics, and the Small-World Problem, January 11

2. Visiting Scientists 2005–2006

2006

Kaarin Anstey
Australian National University, Canberra
September 2006

Nathan Berg
University of Texas, Dallas
June–August 2006

Martin Bischoff
University of Erlangen-Nuremberg
April 2006

Fredda Blanchard-Fields
Georgia Institute of Technology, Atlanta
June–July 2006

Steven Boker
University of Notre Dame, Indiana
June–July 2006

Eduard Brandstätter
Johannes Kepler University Linz
August 2006

Ruth Butler
Hebrew University of Jerusalem, School of Education, Jerusalem
February 2006

Sy-Miin Chow
University of Notre Dame, Indiana
June–July 2006

Hartmut Ditton
Ludwig Maximilians University Munich
September 2006

Daniel Goldstein
London Business School
January 2006

Ed Elbers
University of Utrecht
February 2006

Daniel Frey
Massachusetts Institute of Technology
September–October 2006

Brit Grosskopf
Texas A&M University
June 2006

Kenneth Hammond
University of Colorado at Boulder
September 2006

Werner Helsper
Martin Luther University Halle-Wittenberg
April 2006

Christopher Hertzog
Georgia Institute of Technology, Atlanta
June–July 2006

Floris Heukelom
University of Amsterdam
January–June 2006

Richard Hwang
Academia Sinica, Taiwan
November–December 2006

Thomas Joseph
Indian Institute of Management, Bangalore
May 2006

Linnea Karlsson
Umea University
September–October 2006

Daniel Koretz
Harvard Graduate School of Education
December 2006

Joachim Krüger
Brown University, Providence
May 2006

Erno Lehtinen
University of Turku, Finnland
May 2006

Dan McGrath
Education Statistics Services Institute, American Institutes for Researach, Washington, DC
January–February 2006

Mary McLaughlin
Education Statistics Services Institute, American Institutes for Researach, Washington, DC
January–February 2006

John McNamara
University of Bristol
October 2006

Kevin Miller
Department of Educational Studies and Psychology, Center for Human Growth and Development, University of Michigan
April–May 2006

Bruce Moulton
University of Technology, Sydney
September–October 2006

Shabnam Mousavi
Pennsylvania State University
August 2006

Nilan Ram
Pennsylvania State University
June–July 2006

Rajiv Sarin
Texas A&M University
June 2006

Lee S. Shulman
Carnegie Foundation for the Advancement of Teaching, Stanford
September 2006

Nandan Sudarsanam
Massachusetts Institute of Technology
September–October 2006

Peter M. Todd
University of Indiana, Bloomington
June–August 2006

2005

Morris Altman
University of Saskatchewan
September 2005

Lars Bäckman
Karolinska Institute, Stockholm
July 2004–July 2005

Fredda Blanchard-Fields
Georgia Institute of Technology, Atlanta
January–July 2005

Gary Bornstein
Hebrew University of Jerusalem
September 2005

Arndt Bröder
University of Bonn
March–September 2005

Gayle Christensen
Urban Institute, Washington, DC
January–August 2005

Ido Erev
Technion—Israel Institute of Technology
November 2005

Claudia Gonzalez-Vallejo
Ohio University, Athens
January–August 2005

Agneta Herlitz
Karolinska Institute, Stockholm
July 2004–July 2005

Christopher Hertzog
Georgia Institute of Technology, Atlanta
January–July 2005

Douglas M. Jones
University of Utah, Salt Lake City
December 2005

Yongfang Liu
East China Normal University, Shanghai
July–September 2005

Kathleen B. McDermott
Washington University, St. Louis
May 2005

Leo Montada
University of Trier
September 2005

Thad Polk
University of Michigan, Ann Arbor
May–June 2005

Richard M. Ryan
University of Rochester
June–July 2005

Naftali Raz
Wayne State University, Detroit
June–August 2005

Henry L. Roediger, III
Washington University, St. Louis
May 2005

David P. Schmitt
Bradley University
December 2005

Stephen M. Stigler
University of Chicago
July 2005

Helen M. G. Watt
School of Education, University of Michigan, Ann Arbor
September–October 2005

Christoph Weidemann
University of Indiana, Bloomington
July 2005

3. Other Professional Activities 2005–2006

Paul B. Baltes

- Academia Europaea (Election Committee, Section on Psychology and Behavioral Sciences; Member of Trust).
- Berlin-Brandenburgische Akademie der Wissenschaften (Vice-Chair, Working Group on Science History and Psychology History).
- US National Academy of Sciences and National Research Council (Member of Committee on Future Research in Cognitive Aging, 2002–2003, and of Committee on Assessing Behavioral and Social Science Research on Aging, 2004–2006).
- International University of Bremen (Member of Board of Governors).
- Jacobs Foundation (Member of Board of Trustees and Jacobs Family Council).
- Deutsche Akademie der Naturforscher Leopoldina (Vice-President).
- IPSEN Foundation, IPSEN Longevity Award (Member of Jury Selection).
- University of Konstanz, Center for Junior Research Fellows (Member of Kuratorium).

Jürgen Baumert

- Max Planck Society (Vice-President, Human Sciences Section).
- Jacobs Foundation, Zurich, Switzerland (Member of Board of Trustees).
- Institute for Educational Progress, Humboldt University Berlin (Member of Board of Trustees).
- Research Program "Professional Minds of Teachers: On the Development of Standards for Vocational Teachers", University of Fribourg, Switzerland (Member of Advisory Board).
- Quality Agency of the State Institute of School Education and Educational Research (ISB), Munich (Member of Board of Scientific Advisers).
- University of Twente, Institute for Behavioral Research (IBR) (Member of Board of Trustees).
- Action Program "New Paths in Teacher Training", Founders' Association of German Science, Bonn (Member of Board of Scientific Advisers).
- Leibniz Association (Member of Senate and Evaluation Committee).
- Internationale Grundschul-Lese-Untersuchung (IGLU)/Progress in International Reading Literacy Study (PIRLS) (Member of Advisory Board).
- Center for Research on Learning and Instruction, University of Erfurt (Member of Advisory Board).
- Psychologie in Erziehung und Unterricht (Member of Advisory Board).
- Schweizerische Zeitschrift für Bildungswissenschaften (Member of Advisory Board).
- Zeitschrift für Erziehungswissenschaft (Coeditor).
- Zeitschrift für Pädagogische Psychologie (Member of Advisory Board).
- Center for School Research and Questions of Teacher Education, Martin Luther University Halle-Wittenberg (Member of Advisory Board).
- Waxmann Verlag, Reihe Pädagogische Psychologie und Entwicklungspsychologie (Member of Advisory Board).
- Zeitschrift für Unterrichtswissenschaft (Coeditor).
- Jacobs Center of Lifelong Learning and Institutional Development (JCLL), International University Bremen (Member of Advisory Board).
- European Science Foundation, Strasbourg (Member of Pedagogical and Educational Research Expert Panel).
- University of Kassel (Member of University Council).
- "Bürgernetzwerk Bildung" (Member of Advisory Board).
- State Institute for School Quality in Berlin und Brandenburg (ISQ) (Member of Advisory Board).
- Expert Committee to Assess Teacher Training in North Rhine-Westphalia (Chair).
- International Academy of Education (Fellow).
- Carnegie Foundation for the Advancement of Teaching (Member of Board of Trustees).
- "Haus der kleinen Forscher" (McKinsey) (Member of Advisory Board).
- "School Reform and Beyond" (David L. Featherman) (Member of Advisory Board).
- Dahlem Conferences (Member of Advisory Board).

Nathan Berg

- Journal of Socio-Economics (Editorial Board).
- Global Business Economics Review (Member of Advisory Board).
- Society for the Advancement of Behavioral Economics (Member of Board).
- European Science Foundation (Member of Program Review Committee).

Henry Brighton
- The First Conference on Artificial General Intelligence (AGI-08) (Member of Program Committee).

Wolfgang Edelstein
- Institut für angewandte Familien-, Kindheits- und Jugendforschung e.V., Potsdam (Member of Board of Scientific Advisers).
- BLK-Program "Demokratie lernen und leben" (Learning and Living Democracy) (Member of Steering Committee).
- Irmgard-Coninx-Stiftung (Member of Advisory Council).
- Kulturstiftung der Länder, Program "Kinder zum Olymp" (Member of Board of Trustees).
- Yehudi Menuhin Stiftung Deutschland (Member of Board of Trustees).
- Deutsche Gesellschaft für Demokratiepädagogik (German Association for Democratic Education) (President).
- Social Justice Research, New York (Member of Editorial Board).
- New Directions for Youth Development, New York (Member of Editorial Board).
- Entwicklungswissenschaft. Biopsychosoziale Forschung und Anwendung", Verlag Vandenhoeck & Ruprecht, Göttingen (Member of Board of Advisers).

Ursula Flitner
- German Special Library Association (ASpB), Section 5 of the German Library Association (DBV) (Deputy Chair).
- German Library Association (DBV) (Board Member of Berlin Division).
- Scopus Content Selection & Advisory Board.

Gerd Gigerenzer
- Berlin-Brandenburgische Akademie der Wissenschaften (Member).
- Deutsche Akademie der Naturforscher Leopoldina (Fellow).
- Theory and Psychology (Coeditor).
- Journal of Behavioral Decision Making (Editorial Board).
- Evolution and Human Behavior (Editorial Board).
- Summer Institute on Bounded Rationality in Psychology and Economics (Codirector).
- British Medical Journal (Member of Advisory Committee).
- Organizational Behavior and Human Decision Process (Editorial Board).
- Bundesinstitut für Risikobewertung, Germany (Advisory Board).
- European Society for Philosophy and Psychology ESPP (Advisory Board).
- Psychological Inquiry (Editorial Board).
- Frankfurt Institute for Advanced Studies Forum (Advisory Board).

Hauke Heekeren
- Acta Neuropsychiatrica (Editorial Board).

John M. C. Hutchinson
- Animal Behavior (Consulting Editor).
- Folia Malacologica (Advisory Board).

Konstantinos V.Katsikopoulos
- IEEE Transactions on Systems, Man and Cybernetics (Associate Editor).

Monika Keller
- Erwägen, Wissen, Ethik (Editorial Board).
- European Developmental Science (Editorial Board).
- Jean Piaget Society (ex-officio Member of Board of Directors).

Shu-Chen Li
- Neuroscience and Biobehavioral Reviews (Board of Consulting Editors).
- Psychology and Aging (Board of Consulting Editors).
- Brain Research Center, School of Computer Science, National Chiao-Tung University, Taiwan (International Collaborative Faculty).
- International Max Planck Research Network on Aging (Deputy Director).
- Max Planck Society (Institute Scientific Staff Representative in the Human Sciences Section).

Ulman Lindenberger

- European Journal of Developmental Science (Member of Editorial Board).
- Centre for Population Studies (CPS), Umea University, Sweden (Member of the Board of Ageing and Living Conditions Programme, ALC)
- Margret M. and Paul B. Baltes Foundation for the Advancement of Research in Developmental Psychology and Gerontology (Member of the Board)
- Nordic Centre in Cognitive Control (Member of the Scientific Advisory Board)
- Gerontological Society of America (Fellow)
- Wilhelm-Wundt-Gesellschaft (Member).
- Alexander von Humboldt-Stiftung (Member and Selection Committee for Humboldt Research Awards).
- Deutsche Akademie der Naturforscher Leopoldina (Fellow).
- AG LeoTech Alter: Opportunities and Problems of an Aging Society: The World of Work and Lifelong Learning, launched together by the German Academy of Sciences Leopoldina and acatech-Council for Engineering Sciences at the Union of the German Academies of Science and Humanities (Member of Working Group).
- Psychology and Aging (Member of Editorial Board).
- Aging, Neuropsychology, and Cognition (Member of Editorial Board).
- International Journal of Behavioral Development (Member of Editorial Board).

Lael J. Schooler

- 19th International Congress of Psychology. Organizing a series of controvertial debates for the ICP (Member of Scientific Committee).
- Frankfurt Institute for Advanced Studies Forum (Member of Program Advisory Committee).
- Berlin Graduate School of Mind and Brain (Member of Curriculum Committee).
- International Conference on Cognitive Modeling (Member of Program Committee).

Jacqui Smith

- Academia Europaea (Member).
- Journal of Gerontology: Psychological Sciences (Member of Editorial Board).
- English Longitudinal Study (ELSA) (Member of Advisory Board).
- Survey of Older Adults in Germany (Member of Advisory Board).
- China Healthy Longevity Study (Research Consultant).
- Norwegian Longitudinal and Cohort Study of Aging (Research Consultant).
- Max Planck International Research Network on Aging (Deputy Director).

Elsbeth Stern

- Mind, Brain, and Education (Associate Editor).
- Science (Board of Reviewing Editors).
- Academy of Finland (Board of Reviewers for Educational Research).
- Zeitschrift für Pädagogische Psychologie (Member of Editorial Board).
- Deutsches Institut für Internationale Pädagogische Forschung (Member of Evaluation Group).
- Microsoft-Stiftung "Wissenswert" (Member of Scientific Board).
- Max Planck Society, Working Committee for the Advancement of Women in Science (Vice-Chair).

4. Academic Degrees 2005–2006

Habilitations

Artelt, C. (2005). Lesekompetenz und Selbstreguliertes Lernen. University of Postdam.

Kunzmann, U. (2006). Die differentielle Entwicklung lebenspragmatischer Kompetenz im Erwachsenenalter und Alter. Free University Berlin.

Li, S.-C. (2006). The ontogeny of the shared and personalized brain: Contextualized lifelong development of adaptive neurocognitive representations. Free University Berlin.

Stanat, P. (2005). Disparitäten im schulischen Erfolg: Analysen zur Rolle von Migrationshintergrund und Geschlecht. Free University Berlin.

Trautwein, U. (2005). Hausaufgabenvergabe und Hausaufgabenerledigung: Entwicklung und Überprüfung eines pädagogisch-psychologischen Mehrebenenmodells. Free University Berlin.

Watermann, R. (2005). Soziale Disparitäten der Bildungsbeteiligung und des Kompetenzerwerbs. Free University Berlin.

Doctoral Dissertations

Biele, G. (2006). No man is an island: Cooperation in groups and social learning. Free University Berlin.

Brehmer, Y. (2006). Episodic memory plasticity across the lifespan. Humboldt University Berlin.

Brunner, M. (2006). Mathematische Schülerleistung: Struktur, Schulformunterschiede und Validität. Humboldt University Berlin.

Dieckmann, A. (2005). The ecological rationality of heuristics and their building blocks: The making of adaptive decisions. Free University Berlin.

Dziobek, I. (2006). Biopsychological markers and neural correlates of Asperger syndrome: Social cognition, lipid profiles, and magnetic resonance imaging findings. University of Bielefeld.

Ebner, N. C. (2005). Striving for gains and preventing losses: Multi-method evidence on the differences in personal goal orientation in early and late adulthood. Free University Berlin.

Felbrich, A. (2005). Kontrastierungen als effektive Lerngelegenheiten zur Vermittlung von Wissen über Repräsentationsformen am Beispiel des Graphen einer linearen Funktion. Technical University Berlin.

Gaissmaier, W. (2007). The mnemonic decision maker: How search in memory shapes decision making. Free University Berlin.

Gummerum, M. (2005). The development of prosocial behavior: Integrating psychological, economic, and evolutionary perspectives. Free University Berlin.

Gundert, S. (2006). Befristete Beschäftigung bei Berufsanfängern und älteren Arbeitnehmern. Free University Berlin.

Grühn, D. (2006). Aging and emotional memory: Evidence from a heterogeneity-homogeneity list paradigm using emotionally-toned words. Free University Berlin.

Höhne, A. (2005). Soziale Unterstützung in Partnerschaften: Individuelle Beschäftigungschancen und -risiken im ostdeutschen Transformationsprozess unter Berücksichtigung des Partnerschaftskontexts. Free University Berlin.

Huxhold, O. (2007). Processing fluctuations in postural control: Relations to adult age and fluctuations in cognition. Free University Berlin.

Kopp, F. (2006). Rehearsal-Prozesse im Arbeitsgedächtnis und EEG-Kohärenz. University of Leipzig.

Limbird, C. (2006). Phonological processing, verbal abilities, and second language literacy development among bilingual turkish children in Germany. Free University Berlin.

Maaz, K. (2006). Primäre und sekundäre Disparitäten des Hochschulzugangs. Free University Berlin.

Mata, R. (2006). The aging decision maker: Cognitive aging and the use of decision strategies. Free University Berlin.

McElvany, N. (2006). Förderung von Lesekompetenz im Kontext der Familie. Free University Berlin.

Müller, A. G. (2007). Aspekte schulbezogener Sprache als Barriere für schulischen Erfolg von Schülerinnen und Schülern deutscher und nichtdeutscher Herkunftssprache. Free University Berlin.

Nagy, G. (2006). Berufliche Interessen, kognitive und fachgebundene Kompetenzen: Ihre Bedeutung für die Studienfachwahl und die Bewährung im Studium. Free University Berlin.

Pachur, T. (2006). Ecological rationality: Do samples in memory reflect the world? Free University Berlin.

Röcke, C. (2006). Intraindividual variability in positive and negative affect: Age-related and individual differences in magnitude and coupling with cognitive performance. Free University Berlin.

Saalbach, H. (2006). The cognitive influence of a classifier system. Technical University Berlin.

Schäfer, S. (2005). Concurrent cognitive and sensorimotor performance: A comparison of children and young adults. Free University Berlin.

Scheibe, S. (2005). Longing ("Sehnsucht") as a new lifespan concept: A developmental conceptualization and its measurement in adulthood. Free University Berlin.

Schneider, M. (2006). Konzeptuelles und prozedurales Wissen als latente Variablen: Ihre Interaktion beim Lernen mit Dezimalbrüchen. Technical University Berlin.

Stange, A. (2005). The social dimension of wisdom: Conditions for perceiving advice-giving persons as wise. Free University Berlin.

Wilke, A. (2006). Evolved responses to an uncertain world. Free University Berlin.

Master's and Diploma Theses

Blumenthal, A. (2006). The development of perceived control in old age: A longitudinal and multidimensional approach. Free University Berlin.

Brose, A. (2005). Eine experimentelle Induktion von Sehnsucht: Untersuchung von Wirksamkeit und Korrelaten. Free University Berlin.

Diffendaffer, B. (2005). Die Entwicklung grafischen Verständnisses bei Grundschulkindern: Einfluss der Aufgabenform auf den Lernzuwachs. Technical University Berlin.

Grube, A. (2005). Dynamics of the motivational system: The role of age, performance evaluation, self-efficacy, and achievement motivation. Free University Berlin.

Herbrich, I. (2006). Positiver und negativer Affekt im hohen Alter – ein längsschnittlicher Ansatz. Technical University Berlin

Ibrahimbegovic, S. (2006). Lebensziele junger Erwachsener aus personenorientierter Sicht: Eine Anwendung der Mischverteilungsverfahren. Technical University Darmstadt.

Kampa, N. N. (2006). Eine Studie zum Zusammenhang zwischen sozioökonomischer Herkunft von Lehrkräften und deren Berufslaufbahn sowie berufsbezogenen Überzeugungen. Free University Berlin.

Kropf, M. (2005). Hausaufgabenverhalten und Hausaufgabenmotivation von Schülerinnen und Schülern: Die Rolle der Eltern. University of Erfurt.

Lörz, M. (2005). Primäre und sekundäre Effekte bei tertiären Bildungsentscheidungen nach Geschlecht und sozialer Herkunft. University of Mannheim.

Mayser, S. (2005). (Un)Erreichbar fern: Ein Vergleich persönlicher Ziele und Sehnsüchte. Humboldt University Berlin.

Neumann, M. (2006). Der Einfluss schulischer Kontextbedingungen auf die Leistungsentwicklung in Französisch als Fremdsprache: Eine mehrebenenanalytische Untersuchung in der deutschsprachigen Schweiz. Humboldt University Berlin.

Paetsch, J. (2006). Mentale Zahlenrepräsentation als Determinante kindlicher Diagrammkompetenz. Technical University Berlin.

Pereira Kastens, C. (2005). Lernen zu Hause vs. im Unterricht: Wie situationsspezifisch sind das Erleben, die Motivation und das Verhalten von Schülerinnen und Schülern? Technical University Braunschweig.

Pohlmeyer, A. (2006). Adult age differences in intra-individual variability of spatio-temporal gait parameters are shaped by working memory load. Humboldt University Berlin.

Sameiske, S. (2006). Lehrerbeanspruchung und schulischer Unterricht: Zur Rolle von Unterrichtsüberzeugungen und Merkmalen der Unterrichtsgestaltung. Free University Berlin.

Schalk, L. (2006). Ist die Giraffe ein Mama-Tier? Grammatikalisches Geschlecht und Induktives Schließen bei Kindern. Technical University Berlin.

Wieckhorst, B. (2006). Concurrent cognitive and sensorimotor performance in children and young adults: Does working memory benefit from simultaneous walking? Free University Berlin.

Wiest, M. (2006). Sehnsucht – ein typisch deutsches Phänomen? Ein interkultureller Vergleich zwischen Deutschland und den USA. Free University Berlin.

5. Scientific and Professional Staff 2005–2006

Artelt, Cordula (Dr. phil. in Psychology, 1999, University of Potsdam; Habilitation, 2005, University of Potsdam): Research in learning (learning strategies and metacognition); reading; cognitive development (as of 2005: University of Bamberg).

Assmann, Wolfgang (Head of Information Processing Center): Service management in research institutions; information technology in the social and behavioral sciences.

Baltes, Paul B. (Dr. phil. in Psychology, 1967, Saarland University; Fellow of the Max Planck Society; Co-director of the Institute; as of July 2004: Director, MaxnetAging; Professor of Psychology, Free University Berlin; as of November 2004: Distinguished Professor of Psychology, and Permanent Fellow at the Shannon Center for Advanced Study, University of Virginia [part-time]): Lifespan human development: Evolution and ontogenesis; aging of the mind (intelligence, memory, personality, wisdom); theory of successful development; science policy: interdisciplinarity, history, and internationality (deceased 7 November 2006).

Baumert, Jürgen (State Examination for Teachers, 1968, Hamburg; Dr. phil., 1968, University of Tübingen; Habilitation in Educational Sciences, 1982, Free University Berlin; Fellow of the Max Planck Society; Co-director of the Institute; Professor of Educational Sciences, Free University Berlin and Humboldt University Berlin; Vice President of the Max Planck Society): Research in teaching and learning; cultural comparisons, large-scale assessment, cognitive and motivational development in adolescence.

Baumgarten, Jürgen (Dr. phil. in German Language and Literature, 1973, Free University Berlin; Head of Editorial and Public Relations Department): Prehistory of the Middle East; neolithization; nomadic cultures.

Berg, Nathan (B.A. in American Studies, 1995, University of Kansas; M.A. in Mathematics, 2001, University of Kansas; PhD in Economics, 2001, University of Kansa): Behavioral economics; demographic economics; less-is-more effects in decision making and estimation; social heuristics.

Brighton, Henry (PhD Cognitive Science, 2003, The University of Edinburgh, UK; M.Sc. Cognitive Science, 1997, The University of Edinburgh, UK; B.Sc. (Hons) Artificial Intelligence and Computer Science, 1996, The University of Edinburgh, UK): Cognition-inspired approaches to artificial intelligence and machine learning; inductive inference, information theory, and MDL; ecological rationality and adaptive decision making; computational evolutionary linguistics and cultural computation.

Brunner, Martin (Diploma in Psychology, 2002, University of Mannheim; Dr. phil. in Educational Science, 2006, Humboldt University Berlin): Research in instruction and learning; structural equation modeling and item response theory; mathematics achievement; cognitive abilities (as of 2006: University of Luxemburg).

Czienskowski, Uwe (Dr. phil. in Psychology, 1995, Free University Berlin; Scientific Programmer): Scientific software development (resource distribution in social networks; feature-pattern-analysis; computer-based scientific research); modeling and simulation; self-reference effect; meta-analysis; experimental design and analysis; philosophy of psychology (mind & consciousness).

Delius, Julia A. M. (Dr. med. in Medicine, 1993, University of Frankfurt a.M.): Interdisciplinary gerontology in the context of the Berlin Aging Study (BASE); BASE Website design and management; editorial projects.

Flitner, Ursula (M.A. in American Studies and German Literature, 1991, Free University Berlin; State Examination in Library and Information Science, 1995, Senatsverwaltung für Kulturelle Angelegenheiten Berlin/Cologne; Head of the Library and Information Research Unit): Information management; electronic resources and networked information systems; human resources development.

Gigerenzer, Gerd (Dr. phil. in Psychology, 1977, University of Munich; Habilitation in Psychology, 1982, University of Munich; Fellow of the Max Planck Society; Co-director of the Institute; Professor of Psychology, Free University Berlin): Models of bounded rationality; social intelligence; ecological rationality; heuristics of scientific discovery; philosophy, history, and methodology of social sciences.

Grabbe, Yvonne (Diploma in Psychology, 2001, University of Münster; Dr. phil. in Psychology, 2003, University of Münster): Research in instruction and learning; teacher-based assessment of student achievement; effective pre-school education and educational outcomes; job demands and stress of teachers.

Hardy, Ilonca (PhD in Educational Psychology, 1998, University of Iowa): Learning environments incorporating the social character of cognition (emphasis: collaborative learning); the role of language in problem solving; effects and uses of external representations.

Heekeren, Hauke (PhD, 2000, Humboldt University Berlin; License for the practice of medicine, 2002; Head of Independent Junior Research Group): Neurobiology of perceptual and reward-based decision making; influence of cognition and emotion on decision making in social contexts; multimodal neuroimaging.

Hutchinson, John M. C. (DPhil in Biology, 1990, University of York): Behavioral ecology and optimality modeling; rules of thumb in animals and plants (e.g., weather prediction); spatial decisions in biology and the social sciences; daily routines: the dawn chorus of birds; skylark behavior and morphology; sexual selection of slug genitalia; theoretical morphology.

Katsikopoulos, Konstantinos V. (PhD in Industrial Engineering, 1999, University of Massachusetts, Amherst): Theory: Development, analysis, and testing of simple

models of bounded rationality; applications: Decision analysis, medical decision making, transportation.

Keller, Monika (Dr. phil. in Psychology, 1974, University of Heidelberg; Habilitation in Psychology, 1996, Free University Berlin, Professor of Psychology, Free University Berlin): Understanding of relationships, moral development and moral emotions in cultural context; social rationality: Interconnecting moral psychology with behavioral game theory; social perspective taking, theory of mind, and domains of social and moral reasoning; social and moral copetence in education.

Krauss, Stefan (First State Examination in Mathematics and Physics, 1995, University of Erlangen-Nuremberg; Dr. phil. in Psychology, 2001, Free University Berlin): Research on teaching and learning; didactics of mathematics, especially didactics of statistics; probabilistic reasoning (Bayesian inferences).

Kruse, Imke (Dr. phil. in Political Science, 2005, Free University Berlin): International relations; institutional theory; asylum and migration policies; aging policy for elderly migrants in Europe.

Kunter, Mareike (Diploma in Psychology, 1999, Julius Maximilians University Würzburg; Dr. phil. in Psychology, 2004, Free University Berlin): Research in instruction and learning; teacher research; multiple educational objectives; motivational processes in the classroom; assessment of instructional processes.

Li, Shu-Chen (PhD in Psychology, 1994, University of Oklahoma; Habilitation in Psychology, 2006, Free University Berlin): Behavioral and neurocognitive development across the lifespan; neuromodulation of cognition; neurocomputational and formal modeling of lifespan cognition; ontogeny of Brain-Body-World interactive dynamics; neuroeconomics and aging; biocultural co-construction of development.

Lindenberger, Ulman (Dr. phil. in Psychology, 1990, Free University Berlin; Habilitation in Psychology, 1998, Free University Berlin; Fellow of the Max Planck Society; Co-director of the Institute; Professor of Psychology, Saarland University; Professor of Psychology, Free University Berlin; Professor of Psychology, Humboldt University Berlin): Lifespan psychology: Theories and methods; behavioral plasticity and its neural correlates in childhood and old age; sensorimotor and cognitive development; multivariate measurement of change and variability.

Lövdén, Martin (B.A. in Psychology, 1998, Lund University, Sweden; PhD in Psychology, 2002, Stockholm University, Sweden): Lifespan development; cognitive neuroscience of aging; behavioral and neural plasticity; cognitive control; episodic memory; spatial navigation; sensorimotor-cognition couplings; methods for studying individual change (as of 2006: Karolinska Institute, Stockholm).

Lüdtke, Oliver (Diploma in Psychology, 2000, Free University Berlin; Dr. phil. in Psychology, 2004, Free University Berlin): Research in teaching and learning; quantitative methods in empirical research; personal goals.

Maaz, Kai (Diploma in Education [FH], 1998, Catholic University of Applied Sciences Berlin; Diploma in Social Sciences, 2002, Humboldt University Berlin; Dr. phil. in Educational Science, 2006, Free University Berlin): Transition from school to university and work; social background and educational and vocational chances; social inequality and educational decisions.

Mayer, Karl Ulrich (Dr. rer. soc., 1973, University of Konstanz; Habilitation in Sociology, 1977, University of Mannheim; Fellow of the Max Planck Society; Co-director of the Institute; Professor of Sociology, Free University Berlin): Social stratification and mobility; comparative analysis of social structure; sociology of the life course; occupational structures and labor market processes (as of July 2005: Yale University).

McElvany, Nele (Diploma in Psychology, 2001, Free University Berlin; Dr. phil. in Psychology, 2006, Free University Berlin): Research in instruction and learning; reading literacy; self-regulated learning; socialization in the family.

Müller, Viktor (Dr. rer. soc., 1996, Eberhard Karls University Tübingen): Lifespan psychology and aging mechanisms; psychophysiology of social interactions; complexity and brain dynamics; cortical synchronization: local and global networks.

Nagy, Gabriel (Diploma in Psychology, 2002, Free University Berlin; Dr. phil. in Psychology, 2006, Free University Berlin): Research in teaching and learning; developmental regulation across the life span; transition from school to vocational training; quantitative methods of empirical social research.

von Oertzen, Timo (Diploma in Computer Science, 1999, Saarland University; PhD in Computer Science, 2003, Saarland University): Mathematical psychology; algorithms in psychology; statistical modeling; formal modeling.

Oesterreich, Detlef (Diploma in Psychology, 1968, Free University Berlin; Dr. phil. in Psychology, 1975, Free University Berlin): Theory of authoritarianism, authoritarianism and political consciousness; civic education of adolescents (November 2006 retired).

Olsson, Henrik (PhD in Psychology, 2000, Uppsala University, Uppsala, Sweden): Computational modeling; judgment and decision making; categorization, estimation, and causal learning; adaptiveness of cognitive mechanisms to environmental structures; working memory capacity.

Riediger, Michaela (Diploma in Psychology, 1997, Humboldt University Berlin; Dr. phil. 2001, Free University Berlin): Lifespan changes in the interplay of motivation, affect, and social cognition; future-orientation, motivation, and volition; emotion and emotion regulation; social aspects of motivational and affective processes.

Rieskamp, Jörg (Diploma in Psychology, 1998, Technical University Berlin; Dr. phil. in Psychology, 2001, Free University Berlin): Cognitive modeling of judgment and decision making; the role of learning in

decision making; experimental examinations and evolutionary simulations of simple strategies for social interactions.

Schmiedek, Florian (Diploma in Psychology, 2000, University of Mannheim; Dr. phil. in Psychology, 2003, Free University Berlin): Cognitive lifespan psychology; intraindividual variability; model-based analyses of reaction time distributions; multivariate modeling of cognitive developmental processes; typical intellectual engagement; structural equation modeling, latent growth modeling, time series analysis; item response theory (as of 2006: Humboldt University Berlin).

Schooler, Lael, J. (PhD in Cognitive Psychology, 1993, Carnegie Mellon University): Adaptation of human memory to the statistical structure of past and present environments; computational models of human memory; memory's role in judgment and prediction tasks.

Schümer, Gundel (First and Second State Examination for Teachers, 1962, Stuttgart; 1970, Tübingen; Dr. phil. in Educational Sciences, 1977, University of Hamburg): School systems and instruction; theories of instruction and methods of instructional research; comparative research on schools and instruction; the language of the classroom. (June 2006 retired).

Smith, Jacqui (PhD in Psychology, 1984, Macquarie University, Sydney; Habilitation in Psychology, 1999, Free University Berlin; Honorary Professor of Psychology, 2003, Free University Berlin; Deputy Director, MaxnetAging; Senior Research Scientist): Profiles of psychological functioning in the old and oldest-old; psychological predictors of longevity; potentials and risks for development and successful aging; application of intelligence and life knowledge during adulthood (as of 2006: University of Michigan, Ann Arbor).

Stanat, Petra (Diploma in Psychology, 1992, Free University Berlin; PhD in Psychology, 1998, University of Massachusetts at Amherst; Habilitation in Educational Science, 2005, Free University Berlin): Conditions of immigrant students' school success; international and comparative educational research; gender differences in school performance; social competence (as of 2005: University of Erlangen-Nuremberg).

Stern, Elsbeth (Diploma in Psychology, 1982, University of Hamburg; Dr. phil. in Psychology, 1986, University of Hamburg; Habilitation in Psychology, 1994, University of Munich; University Professor, 1994, University of Leipzig): Cognitive development; intelligence and knowledge; research in teaching and learning (as of 2006: Swiss Federal Institute of Technology [ETH], Zurich).

Stevens, Jeffrey (PhD in Ecology, Evolution, and Behavior, 2002, University of Minnesota): Cognitive constraints on cooperative behavior; evolution of decision making (particularly temporal discounting); comparative aspects of decision making in humans and nonhuman animals; the role of ecological and social context on choice.

Todd, Peter M. (PhD in Psychology, 1992, Stanford University): Evolution of behavior (including computer simulations of populations of simple organisms adapting to and creating different environmental structures, both physical and social); ecological rationality (characterizing environment structure-decision mechanism interactions); simple heuristics for sequential search (including mate choice, job search, foraging among patches, looking for cues, and seeking parking places) and other types of decisions; mechanisms for food choice (and other aspects of consumer behavior); rhythmic and time-based behavior (including music, sequence learning/production, and evolution of song) (as of 2005: Indiana University, School of Informatics).

Trautwein, Ulrich (Diploma in Psychology, 1999, University of Göttingen; Dr. phil. in Psychology, 2002, Free University Berlin; Habilitation in Psychology, 2005, Free University Berlin): Development of self-related cognitions in educational settings; school development and management; effects of homework assignment on academic achievement.

Watermann, Rainer (Diploma in Education, 1996, University of Munster; Dr. phil. in Educational Science, 2002, Free University Berlin; Habilitation in Educational Science, 2005, Free University Berlin): International and comparative educational research; quantitative methods of social research; political socialization (as of 2005: University of Göttingen).

Emeritus Members of the Max Planck Society

Edelstein, Wolfgang (Dr. phil. in Medieval Studies, 1962, University of Heidelberg; Fellow of the Max Planck Society; until 1997 Co-director of the Institute; Honorary Doctorate in Social Science, University of Iceland; Honorary Professor of Educational Science, Free University 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.

Roeder, Peter M. (Dr. phil., 1960, University of Marburg; Habilitation in Educational Science, 1966, University of Marburg; Fellow of the Max Planck Society; until 1995 Co-director of the Institute; Special Professor of Educational Science, Free University Berlin): Educational science; school research; history of educational science.

Postdoctoral Research Fellows

Bauer, Markus (Diploma in Psychology, 2002, Humboldt University Berlin, PhD research, F. C. Donders Centre for Cognitive Neuroimaging): Neuronal mechanisms of perceptual decision processes; functional relevance of sychronized oscillatory neural activity; methods of human electrophysiology.

Biele, Guido (Diploma in Psychology, 1999, Free University Berlin, Dr. phil in Psychology, 2006, Free University Berlin): Reward based decision making; computational modeling; neural correlate of reinforcement learning models.

Chicherio, Christian (PhD in Psychology, 2006, University of Geneva): Developmental and differential approaches to the study of cognitive aging; working memory, executive functioning and attentional resources across the lifespan; individual differences and variability; gene-behavior interactions; age-related changes in brain functioning (plasticity/reorganization) using SPECT/PET, EEG, fMRI; connectivity and dynamics in brain functioning; linking behavioral performance to cerebral signal; multivariate methodology.

Conlin, Juliet (PhD in Psychology, 2006, University of Durham): Working memory and 'executive' processes; decision making across the lifespan; navigational heuristics.

Dziobek, Isabel (Diploma in Psychology, 2000, Ruhr University Bochum, PhD, 2006, University of Bielefeld): Social cognitive neuroscience; autism spectrum conditions; neuroanatomy.

Ebner, Natalie C. (Diploma in Psychology, 2001, Free University Berlin; Dr. phil. in Psychology, 2005, Free University Berlin): Multi-method approach to processes of developmental regulation; lifespan changes in the interplay of motivation, affect, and (social) cognition; approach and avoidance motivation across the lifespan; facial expressions across the lifespan.

Galesic, Mirta (PhD in Psychology, 2004, University of Zagreb; M.Sc. in Survey Methodology, 2005, Joint Program in Survey Methodology, University of Maryland & University of Michigan): Risk communication; sampling approaches to cognition; judgment and decision making models; cognitive aspects of survey response.

Garcia-Retamero, Rocio (as of 2006: University of Granada): Causal learning; compound cue processing; leadership and gender; social learning and imitation; threat perception.

Kopp, Franziska (Diploma in Psychology, 1999, University of Leipzig; Dr. rer. nat. in Psychology, 2006, University of Leipzig): Cognitive and social development during infancy; synchronized brain activity during cognition in infants and adults.

Luan, Shenghua (PhD in Psychology, 2004, University of Florida): Applied signal detection theory; information integration and advice-taking behaviors; group decision processes; simple heuristics for individual and group decision making (as of 2006: Singapore Management University).

Mata, Rui (Diploma in Psychology, 2002, FPCE University of Lisbon; Dr. phil. 2006, Free University Berlin): Adaptation of human memory to the statistical structure of the environment; social cognition (the discipline, not ToM) (LIFE) (as of 2006: University of Michigan at Ann Arbor).

Pachur, Thorsten (Diploma in Psychology, 2002, Free University Berlin; M.Sc. in Health Psychology, 2002, Sussex; Dr. phil. 2006, Free University Berlin): Role of recognition in decision making; sampling based simple heuristics; ecological rationality; process models of decision under uncertainty; risk perception and communication (as of 2006: University of Basel).

Persson, Magnus (PhD in Psychology, 2004, Uppsala University): Decision making under uncertainty; bounded rationality; exemplar models; computer go.

Qian, Jing (PhD in Cognitive Psychology, 2006, University of Warwick): Economic psychophysics: How do sampling, loss aversion, and the distribution of contextual information affect our judgement of economic quantities; GEMS model: A generalized exemplar model of sampling; statistical structure of the world and the distributions of social-economic quantities: Power-laws and the pareto law; ecological rationality: An adaptive sampling approach; social rationality and models of social comparison; the origins of the probability weighting function; price perception and pay satisfaction.

Reimer, Torsten (Dr. phil. in Psychology, 1996, Free University Berlin): Cognitive aspects of group decision making and problem solving (as of 2006: University of Maryland).

Schäfer, Sabine (Diploma in Psychology, 2001, Free University Berlin; Dr. phil., 2005, Free University Berlin): Cognitive-sensorimotor coordination across the life span; age differences in the regulation of sequential action; spatial navigation; behavioral and neural plasticity; ontogenetic changes in behavior regulation.

Scheibe, Susanne (Diploma in Psychology, 2001, Humboldt University Berlin; Dr. phil., 2005, Free University Berlin): Strategies of life management and successful development across the lifespan; developmental psychology of Sehnsucht (life-longings); emotions and emotion regulation across the lifespan; the role of interindividual differences in psychopathology; structural equation modeling and questionnaire development.

Schooler, Julia (PhD in Psychology, 1996, University of Pittsburgh): Cues determining portion size; memory for enjoyed food; understanding and remembering health claims on packages.

Takezawa, Masanori (M.A. in Social Psychology, 1997, Hokkaido University, Japan; PhD in Social Psychology, 2001, Hokkaido University, Japan): Adaptive heuristic approach in distributive bargaining under incomplete information; development and emergence of social preferences—altruism, reciprocity, egalitarianism and moral punishment; social intelligence in cooperative/ competitive situations; human experiments and computer simulations (as of 2006: Tilburg University).

Wegwarth, Odette (Diploma in Psychology, 2003, University of Potsdam; Dr. rer. nat. in Psychology, 2007, Humboldt University Berlin): Medical decision-making; choice modeling; risk communication and understanding of risk; phenomenon of too much choice.

Wilke, Andreas (Diploma in Psychology, 2002, Free University Berlin; Dr. phil., 2006, Free University Berlin): Emotions; evolutionary psychology; judgment and decision making (LIFE) (as of 2006: University of California, Los Angeles).

Predoctoral Research Fellows

Alves Conte de Morais, Ana Sofia (Licenciatura in Psychology, 2004, University of Lisbon): Memory-based decision making; cognitive aging and the use of decision strategies; the role of attention in learning. (LIFE)

Bahnemann, Markus (Cand. med., University of Witten/Herdecke): Decision making in social contexts.

Bartling, Karen (Drs. in Psychology, 2006, University of Maastricht): Social development in early childhood (especially mother-child interaction); neural correlates of early interaction; EEG methods. (LIFE)

Barton, Adrien: Philosophical theories of probability; connections with psychological issues; philosophy of quantum mechanics; structure of scientific images.

Becker, Michael (Diploma in Psychology, 2004, Free University Berlin): Cognitive development; changes in educational systems; quantitative methods in social sciences. (LIFE)

Brehmer, Yvonne (Diploma in Psychology, 2003, Saarland University; Dr. phil. in Psychology, 2006, Humboldt University Berlin): Dynamic and plasticity of cognitive development and aging; computational modeling of cognitive processes; neural correlates of age-related changes (as of 2006: Karolinska Institute Stockholm).

Brose, Annette (Diploma in Psychology, 2006, Free University Berlin): The interaction of emotion, situational influences (events) and cognition within and across individuals across the lifespan; emotion regulation and its developmental trajectories; the study of intraindividual variability and its relation to developmental change. (LIFE)

Burzynska, Agnieszka Zofia (B.Sc. in Biotechnology, 2005, Universities of Gdansk and Perugia, M.Sc. in Neuroscience, 2007, University of Göttingen): White matter integrity and connectivity in aging brain (diffusion MRI); correlations with cognitive performance and genetic background. (LIFE)

Diao, Linan (Diploma in Management, 2002, Jilin University, P.R. China): Agent-based computational economics; simulation in financial markets.

Dubberke, Thamar (Diploma in Psychology, 2006, Philipps University Marburg): Research in teaching and learning.

Gaissmaier, Wolfgang (Diploma in Psychology, 2002, Free University Berlin; Dr. phil., 2007, Free University Berlin): Memory-based decision making; modeling and predicting voting behavior; simple heuristics underlying intuitions; medical decision making.

Green, Nikos (B.Sc. in Cognitive Science, 2004, University of Osnabrück; M.Sc. in Cognitive Science, Track: Brain, Behavior and Cognition, 2006, University of Amsterdam): Cognitive science; cognitive neuroscience; computational and cognitive modeling; developmental neuroscience; decision-making.

Gresch (Hausen), Cornelia (Diploma in Social Sciences, 2004, University of Mannheim): Social origin and educational career decisions; quantitative methods of empirical social research; immigrants. (LIFE)

Grühn, Daniel (Diploma in Psychology, 2002, Free University Berlin): Emotion and emotion regulation across the lifespan; cognitive functioning in the old and the oldest-old; cognitive and emotional mechanisms of successful aging (as of 2006: University of Geneva).

Gundert, Stefanie (Diploma in Sociology, 2003, University Duisburg-Essen): Life-course and labor-market research; temporary employment and fixed-term contracts; women's employment (as of 2006: Yale University).

Hachfeld, Axinja (Diploma in Psychology, 2006, Free Univerity Berlin): Research in instruction and learning; reading competence.

Hämmerer, Dorothea (Diploma in Psychology, 2005, University of Freiburg): Cognitive Models of Neuromodulation.

von Helversen, Bettina (Diploma in Psychology, 2004, University of Erlangen-Nuremberg): Categorization and estimation strategies; ontogenetic development of heuristic strategies; adaptiveness of basic cognitive capacities to environmental structures; legal decision making. (LIFE)

Husemann, Nicole (Diploma in Psychology, 2004, University of Bielefeld): Research in teaching and education; personal goals; academic cheating.

Huxhold, Oliver (Diploma in Psychology, 2002, Free University Berlin; Dr. phil., 2007, Free University Berlin): Lifespan cognitive development and cognitive aging; intra-individual and inter-individual variability in cognitive performance; cognitive processes contributing to balance control.

Jonkmann, Kathrin (Diploma in Psychology, 2005, Humboldt University Berlin): Social dynamics in the classroom; school achievement research; developmental regulation across the life span. (LIFE)

Johnson, Tim (BA, 2004, R.D. Clark Honors College, University of Oregon): Experimental economics; cooperation; political science methodology; voting behavior; institutions.

Kleinspehn, Anna (Diploma in Psychology, 2004, Free University Berlin): Development of emotional and self-related processes across the lifespan; age differences in cooperative behavior; individual differences and context covariates underlying interpersonal interactions; subjective experience of own aging.

Klusmann, Uta (Diploma in Psychology, 2004, Free University Berlin): Research in teaching and learning; teacher stress; personal goals.

Kotter-Grühn, Dana (Diploma in Psychology, 2004, Technical University Dresden): Developmental psychology of life-longing (Sehnsucht); self-regulation and subjective well-being over the lifespan; self-perceptions of aging; personality and social relations in middle and old adulthood. (LIFE)

Krugel, Lea (Cand. med., Charité Universitätsmedizin Berlin): Neurobiology of reward-based decision making, neuroimaging.

Marewski, Julian (Diploma in Psychology, 2005, Free University Berlin): The use and ecological rationality of recognition and ease of retrieval in decision making; adaptive memory; process models of decision making under uncertainty; eye-movements and decision making under uncertainty; ecological rationality in political environments.

Mata, Jutta (Diploma in Psychology, 2004, Humboldt University Berlin): Food choice (decision rules, developmental aspects); preference prediction; development of prosocial behavior (behavioral game experiments). (LIFE)

Mohr, Peter (M.Sc. in Business Administration, 2006, University of Münster): Economic decision-making; risk perception. (LIFE)

Müller, Andrea G. (M.A. in Sociology, 2000, University of Iowa; M.A. in Educational Science/Sociology, 2002, Martin Luther University of Halle-Wittenberg): Conditions of immigrant students' school success; bilingual education and second language acquisition; everyday school-related communication skills (LIFE).

Nagel, Irene (Diploma in Psychology, 2005, Maastricht University): Age-related changes in human cognition and behavior; age-related changes in the human brain (structure, functional activation, dopamine system); using fMRI (functional magnetic resonance imaging) to examine the interplay of increasing age, genetic predisposition, brain structure, and task-specific brain activation patterns, and their relation to cognitive decline in elderly. (LIFE)

Neumann, Marko (M.A. in Educational Sciences, 2006, Humboldt University Berlin): National and international school achievement research; impact of institutional opportunity structures on the development of scholastic abilities; school effectiveness research; quality assurance and quality improvement in the educational system.

Pieper, Swantje (Diploma in Psychology, 2006, University of Münster): National and international school achievement research; quality assurence and quality improvement in the educational system; effects of homework assignment on acedemic achievement).

Rauers, Antje (Diploma in Psychology, 2004, Free University Berlin): SOC in social and cognitive lifespan development; age trajectories of collaborative cognition; intrapersonal and interpersonal knowledge organization.

Richter, Dirk (M.A. in Quantitave Research, Evaluation and Measurement in Education, 2005, The Ohio State University; M.A. in Education, 2006, Technical University Dresden): Teacher education; teacher testing; development of novice teachers; statistical modeling.

Röcke, Christina (Diploma in Psychology, 2002, Free University Berlin; Dr. phil. in Psychology, 2006, Free University Berlin): Within-person coupling of well-being and cognitive performance across the lifespan; intraindividual variability as a tool to understand lifespan development; emotion and emotion regulation across the lifespan; social relationships and closeness across the lifespan (as of 2006: Brandeis University Boston).

Scheibehenne, Benjamin (Diploma in Psychology, 2004, Humboldt University Berlin): Cognitive modeling of preferentical choice; effects of having too much choice; food choice.

Schellenbach, Michael (Diploma in Computer Science, 2004, Saarland University): Spatial navigation; pedestrian navigation systems; virtual reality.

Schneider, Michael (Diploma in Psychology, 2002, Technical University Berlin; Dr. phil., 2006, Technical University Berlin): Cognitive learning theories; conceptual and procedural knowledge; diagrams as cognitive tools (as of 2006: Swiss Federal Institute [ETH] Zurich).

Shing, Yee Lee (M.A. in Educational Psychology, 2003, University of Georgia, Athens): Lifespan and developmental psychology theories; the development and plasticity of basic cognitive mechanics and intellectual functioning over the lifespan; multivariate analyses of dynamical developmental and change

processes; neural correlates of cognitive developmental and aging processes. (LIFE)

Straubinger, Nils (Diploma in Psychology, 2006, University of Münster): Thinking, problem solving, judgment and decision making; lifespan cognitive development (focus on probabilistic thinking); the role of external representations (e.g. diagrams) in probabilistic thinking. (LIFE)

Tsai, Yi-Miau (M.Sc. in Psychology, 2003, National Taiwan University, Taiwan): Research in learning and instruction; achievement motivation and goals; context and cultural effects on motivation. (LIFE)

Verrel, Julius (D.E.A. in Mathematics, 2001, Jussieu, Paris; M.Sc. in Cognitive Neuroscience, 2006, Radboud University, Nijmegen): Motor development and aging; interaction of sensorimotor and cognitive skills. (LIFE)

Wenzlaff, Hermine (Diploma in Biology, 2005, University of Tübingen): Neurobiology of perceptual decision making; electrophysiological recordings (EEG, MEG); cognitive modelling; correlation of neurophysiological components with modelled parameters.

Werkle-Bergner, Markus (Diploma in Psychology, 2004, Saarland University): 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. (LIFE)

The Institute was founded in 1963 by Hellmut Becker, who was joined subsequently by Friedrich Edding (1964), Dietrich Goldschmidt (1964), and Saul B. Robinsohn (1964) as the first generation of scientific directors. In the first decade of its existence, the development of educational research and educational policy was emphasized.

The appointment of a second generation of directors (Wolfgang Edelstein, 1973, and Peter M. Roeder, 1973) added to this framework a commitment to basic research in human development and educational processes.

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 concentrated more and more on questions of basic research associated with the nature of human development, education, and work in a changing society. At the same time, life-span 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 of the Center for Lifespan Development (2004), adding an emphasis on neural correlates of human behavior and cognitive plasticity, and by the appointment of Ute Frevert as director of the newly established Center for the History of Emotions (2007), adding perspectives from cultural history to the Institute's research agenda on human development. Continuity and change is also involved in the establishment of a Max Planck International Research Network on Aging (MaxnetAging) directed by Paul B. Baltes († 2006).

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Center for Adaptive Behavior and Cognition
(Director: Gerd Gigerenzer)

Center for Educational Research
(Director: Jürgen Baumert)

Center for the History of Emotions
(Director: Ute Frevert) (as of 2007)

Center for Lifespan Psychology
(Director: Ulman Lindenberger)

Independent Junior Research Group Neurocognition of Decision Making
(Head: Hauke Heekeren)

International Max Planck Research School LIFE
(Co-chairs: Jacquelynne S. Eccles – University of Michigan, Ulman Lindenberger – Berlin, John R. Nesselroade – University of Virginia)

Max Planck International Research Network on Aging
(Director: Paul B. Baltes †)