

Research Scientists

Julia A. M. Delius
Sandra Düzel

Caroline Beese
(as of 05/2019)

Andrew R. Bender
(until 01/2018)

Andreas M.

Brandmaier

Maike M. Kleemeyer
(as of 09/2019)

Ylva Köhncke
(as of 07/2017)

Ulman Lindenberger

Sarah Polk
(as of 04/2019)

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

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

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

The Berlin Aging Study (BASE)

Longitudinal data in BASE are available for eight measurement occasions spanning more than 18 years, and mortality-related informa-

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



Figure 10. BASE participant Mrs. A., aged 106, at her home during a visit by BASE colleagues Denis Gerstorf and Sandra Düzel in 2018.

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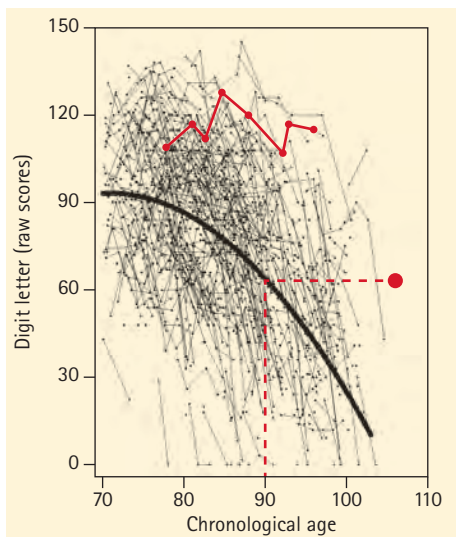


Figure 11. BASE participants' score trajectories in the Digit Letter test, with Mrs. A.'s scores highlighted in red. At the age of 106 (larger dot), her score was still at the level of the average 90-year-old BASE participant.

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

The Berlin Aging Study II (BASE-II)

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

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

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Lifebrain

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

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

Lifebrain Researchers at the MPI for Human Development

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

www.lifebrain.uio.no



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📍Kühn, S., Düzel, S., Eibich, P., Kreckel, C., Wüstemann, H., ... Wagner, G. G., & Lindenberg, U. (2017). In search of features that constitute an "enriched environment" in humans: Associations between geographical properties and brain structure. *Scientific Reports*, 7, Article 11920. <https://doi.org/10.1038/s41598-017-12046-7>

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

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

the design of effective strategies for preserving cognitive health in old age.

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

Future Research Directions

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

Overview of the Berlin Aging Study (BASE)

www.base-berlin.mpg.de

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

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

The Berlin Aging Study: International Research Group

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

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

www.base2.mpg.de

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

The Berlin Aging Study II: Steering Committee

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

Coordination

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