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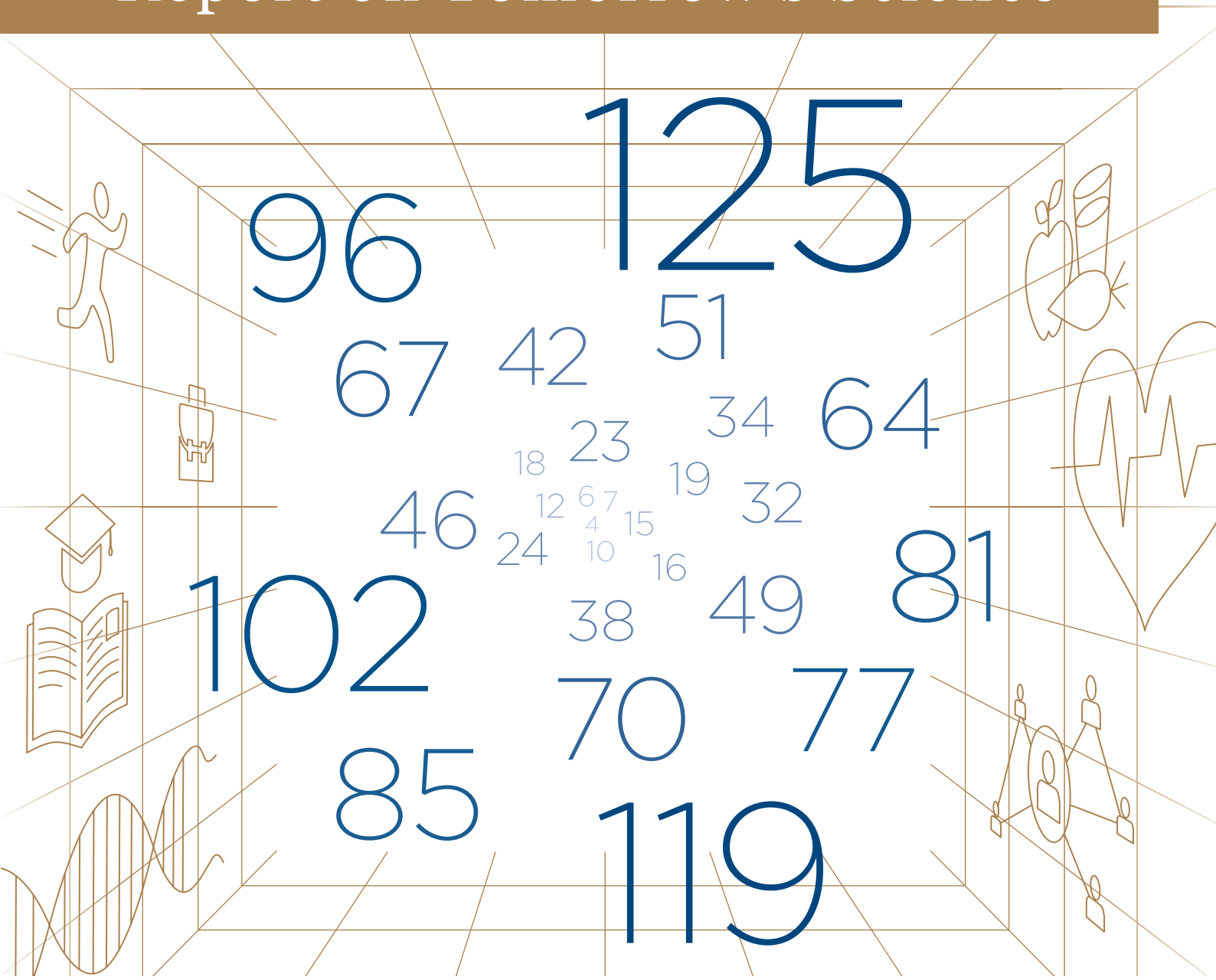

Ageing and the Life Course

Research for Longer Lives

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Report on Tomorrow's Science

Ageing and the Life Course

Research for Longer Lives

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Table of Contents

Executive Summary 5

I. Background, Motivation, Goals, and Approach 8

II. Ageing and the Life Course as a Challenge for Society and Research 10

II.1 Rising Life Expectancy Requires Societal Adaptation 10
II.2 The Significance of Research on Ageing and the Life Course 11
II.3 Age(ing) and the Life Course: Definition and Delimitation 13
II.4 Interdisciplinarity in Research on Ageing and the Life Course 15
II.5 Challenges from the Perspective of the Disciplines 18
II.5.1 Demography 18
II.5.2 Medicine 18
II.5.3 Basic Fields of Biology/Medicine and Neurosciences 20
II.5.4 Psychology 21
II.5.5 Social Sciences and Economics 22
II.5.6 Humanities 24
II.5.7 Engineering Sciences and Human Geography 24
II.6 Conclusions: Ageing and the Life Course as a Challenge for Society and Research 26

III. Research Landscape: Conditions of Research on Ageing and the Life Course 27

III.1 Research Funding in the EU 27
III.1.1 Background 27
III.1.2 The Lisbon Strategy and Healthy Ageing 28
III.1.3 EU Funding Initiatives 29
III.1.4 EU-Funded Research on Ageing and the Life Course in Germany 35
III.2 Examples of Research Funding Policies of Other Countries for Evaluation Guidance: Netherlands, Sweden, France, UK, US 37
III.3 Setting Research Foci and Funding in Germany 46
III.3.1 Research Funding by the Federal Government 46
III.3.2 Research Priorities in the Helmholtz Association 52
III.3.3 Research Priorities in the Leibniz Association 53
III.3.4 Max Planck Society 55
III.3.5 Fraunhofer-Gesellschaft 56
II.3.6 DFG Funding Programs 56
III.3.7 Funding of Junior Researchers: Graduate Schools and Research Groups 57
III.3.8 Non-Profit Organizations and Endowments 58
III.4 Conclusions: Research Landscape—Conditions 60

IV. Current Priorities in Research on Ageing and the Life Course 64

IV.1 An Overview of Research on Ageing and the Life Course in Germany 64
IV.1.1 Basic Research in Biology, Medicine, and Neurosciences 66
IV.1.2 Medicine 66
IV.1.3 Psychology, Social Sciences, and Economics 67
IV.1.4 Humanities 68
IV.1.5 Engineering Sciences and Geography 69
IV.2 Interdisciplinary Research on Ageing and the Life Course: Two sample cases 70
IV.2.1 Research on Ageing and the Life Course in the context of Poverty and Social Inequality 71
IV.2.2 Brain and Behavioral Plasticity—Cognition 72
IV.3 Conclusions: Topical Foci of Current Research on Ageing and the Life Course 74

V. Evaluation and Recommendations 76

V.1 Does Current Funding Meet the Challenges of Research on Ageing and the Life Course? 78
V.2 Research Infrastructure 82
V.3 Recommendations for the Further Development of Research on Ageing and the Life Course in Germany 83

Appendix 92

I. People Involved 92
II. References 94
III. Tables 115

Tables and Figures

Tables

Table 1. Overview of Relevant EU Funding Initiatives 30

Table 2. ERA-Nets Related to Ageing and the Life Course 32

Table 3. Joint Programming Initiatives Related to Research on Ageing and the Life Course 34

Table 4. Research Personnel in Full-Time Equivalents (FTE) in Comparison to Germany 38

Table 5. Departmental Research (Direct Project Funding and via Departmental Research Institutes) 51

Table 6. Leibniz Research Alliances Associated With Research on Ageing and the Life Course 54

Table 7. Large Foundations Supporting Research on Ageing and the Life Course 59

Figures

Figure 1. Federal Expenditure on Research and Development by Government Department (2017) 47

Figure 2. Opportunities for the Strengthening of Research on Ageing and the Life Course 83

Figure 3. Strengthening Discipline-specific Ageing Research 84

Figure 4. Orient Funding Programs Towards Interdisciplinarity 86

Figure 5. Education and Training in Interdisciplinary Research on Ageing and the Life Course 88

Figure 6. Biopsychosocial Model of Research on Human Ageing and the Life Course 89

Figure 7. Building up Data Collections and Analyses as well as Methods Centers 90

Figure 8. Evaluating Application-Oriented Research and Making Output Available 90

Executive Summary

This Report on Tomorrow's Science is a response to the fact that the field of research on ageing and the life course has gained enormously in importance due to the 40-year increase in average life expectancy and a pronounced diversification of the life course over the past 150 years. Indeed, the research findings from this field have contributed to this demographic development. It is now necessary to shape these longer lives so that quality of life, productivity, and innovation can be maintained and extended in a society with a higher proportion of older adults. The increase in (functionally healthy) average life expectancy is a major achievement of sociocultural development, made possible by the developmental plasticity of the human species. Human ageing in this sense is not predetermined, but rather it is the result of continued interactions between biology, individual decisions and lifestyles, and sociocultural context. If research is to do justice to this interactive nature of human ageing and provide explanations and predictions, an appropriately broad spectrum of disciplines needs to be involved, ranging from molecular biology, via medicine and behavioral sciences to economics, sociology, and epidemiology.

This report seeks to answer the following questions: Where does research in this field stand in Germany today? Can weaknesses be identified and how can they be remedied so that future research on ageing and the life course is better able to provide answers on how longer lives can be optimized for individuals and society alike?

Where Does Research in this Field Stand?

Diseases and their molecular basis, healthcare, and technological assistance systems for old age and across the life course are the research topics dominating most funding strategies to date, although this narrow thematic range needs to be expanded. Even within the previously-most-funded domains of biomedicine and engineering sciences, a differentiation is required. The neglect of other research areas and the fact that funded projects have often failed to include all relevant disciplines hinder a sustainable and effective growth of the field of research on ageing and the life course, as well as work on essential research questions.

For example, in order to maintain competencies and functioning across the life course and into late life, it is insufficient to simply treat diseases. Research on the organization of work within longer lives, the further development of the educational system to foster lifelong learning, and the strengthening of health resources (which is not the same as the treatment or prevention of illnesses) is also required. Equally, technology-oriented ageing research mainly targets the compensatory effect of technology in cases of a loss of functioning, whereas the use of technology for maintaining or increased functioning is hardly considered. In view of the large funds spent on the field of "technological assistance systems in old age," it is also concerning that hardly any systematic longitudinal studies have tested the efficacy of technology developed with larger samples. Furthermore, strategies to move from prototype development and piloting

to the market and into people's daily lives are unfortunately lacking.

Developing and maintaining human abilities, conditions for the success of disease prevention measures, as well as the impact of prenatal life conditions on later life or the development and consequences of social inequality are examples of complex phenomena that unfold over long periods of time and are concurrently influenced by multiple life domains such as education, employment, family, health, personal attitudes, and the physical environment. Today, it is possible to better understand the development and effects of such complex processes because it enables analyzing interactions of cells and organisms, individuals, social groups, and societal institutions. Approaches focusing on these interactions have proved fruitful, although in Germany the social, behavioral, engineering, and biomedical sciences, and the humanities are still very much acting in silos. The humanities, social, and behavioral sciences are also much less represented in German research on ageing and the life course than they are—for example—in the United Kingdom (UK), Sweden, or the Netherlands (as assessed by respective proportions of publications). Such benchmark countries have engaged in concerted strategic research support of centers, programs, infrastructure, and targeted academic training, which have helped them to successfully establish and integrate research capacity for research on ageing and the life course across a broad range of relevant disciplines. This concerted effort has also been linked to the development of specific research foci in each country. In view of its high complexity, programmatic support holds strong significance for ageing research. This also includes research-strategic discussions in and with the academic community to overcome discipline-related and geographical fragmentation on the one hand, and to establish ageing research sustainably in larger research structures such as universities, extramural research institutions, and funding agencies on the other. Examples from other countries—such as France, the Netherlands, the US, or the UK—indicate that a central impulse by the government or parliament in terms of a national program and broad legislative debate are very important to attain productivity and orientation in ageing research.

Central Recommendations

Expansion of the Range of Research Topics

The previous concentration of funds on examining the development and treatment of individual diseases as well as compensatory technological solutions should be supplemented by funding incentives that cover the existing gaps in these domains (geriatrics, research on the provision of healthcare), but also—and more importantly—those that aim to support investigating the conditions for development of the strengths of old age across the life course. Furthermore, it is essential to evaluate time-limited funding priorities regularly and in a transparent manner.

Broad and Equal Interdisciplinarity

Besides discipline-specific research funding, formats and infrastructure that bring the relevant disciplines together in sufficient breadth and on equal terms are necessary. In Germany, there is a lack of appropriate risk-taking support schemes that provide funding for longer periods and bring the riskier, broadly-based, and on-par interdisciplinary research approaches into the foreground. Examples from the UK, Sweden, the Netherlands, and the US show how this can be achieved.

Building joint models across disciplines on the researchers' side, formulating new evaluation criteria on the part of funding agencies and advisory boards, and setting institutional foci enable research that makes good use of the knowledge available in a broad range of academic disciplines.

While short-term, smaller-scale, mostly discipline-specific projects on ageing and the life course exist, a nationwide call to establish research centers (single site or network) with a renewable ten-year perspective is necessary. This funding scheme for research on ageing and the life course has been successful in other European countries such as Sweden, as well as the US.

Existing research structures should also be expanded:

- This applies to the further development of the relevant Leibniz Research Alliances as well as the founding of interdisciplinary groups in the field of research on ageing and the life course at the health/disease centers of the Helmholtz-Gemeinschaft.

- The Deutsche Forschungsgemeinschaft (DFG) [German Research Council] should consider funding relevant research fields and developing appropriate competencies (e.g. in the area of population-wide longitudinal studies or the application of various molecular-biological ageing paradigms).

- Federal departmental research institutions should initiate or intensify cooperation on questions of research on ageing and the life course. For instance, this would be apposite for labor market and occupational research relating to ageing and the life course, for questions of social participation, and regarding the provision of longitudinal data.

Based on international experience, research impulses could also emanate from:

- the institution of professorships on the life course and ageing;

- person-specific funding in analogy to funding practices at the Howard Hughes Medical Institute; and

- interdisciplinary training opportunities at the postdoctoral level (as well as later career stages).

Strengthening the Academic and Social Political Foundations of Funding Policies
The German Federal Government outlined its funding policies within the ageing research agenda "Das Alter hat Zukunft" [Ageing has a future], although this agenda neither had a strong basis in science nor did it lead to debate in academia (for example, with professional associations and research agencies). Furthermore, the agenda has not (yet) been publicly evaluated, but it seems to have been concluded. The role of the European Union (EU) and the coordination between European and German research initiatives are also characterized by strong potential for development.

Besides the lack of discussion of such an agenda and its effects within the research field, the parliamentary and societal discussion of funding priorities and research findings also hold strong importance. A debate of this kind could also follow up on important parliamentary initiatives such as the further advancement of welfare indicators (Enquete-Kommission "Wachstum, Wohlstand, Lebensqualität" [Study Commission "Growth, Welfare, Quality of Life"]).

Research findings on ageing and the life course in their full breadth should be continually and systematically evaluated and made available for policy-making, as well as for public participation and discourse.

I. Background, Motivation, Goals, and Approach

In the "Reports on Tomorrow's Science" format, the Academy comments on opportunities and risks of research for selected domains in Germany. The first "Report on Tomorrow's Science" on innovations in the life sciences was published in 2014 (2015 in English).[1] The Academy now presents a Report on Tomorrow's Science for the field of research on ageing and the life course. The Leopoldina has been committed to this topic for over ten years in numerous Academy Working Groups and it has developed statements on societal challenges and issues. For instance, the "Aging in Germany" series dealt with research on ageing and work, lifelong learning, technology, environment, and the family, companies, macroeconomics, politics and civil society as well as health research. It revealed the challenges as well as the opportunities of a society offering longer life. Many other statements of the Academy on topics such as fertility, multimorbidity, medicine at the end of life, socialization, as well as the opportunities and challenges of the omics technologies touch on these themes, directly or indirectly.

A standing committee of scientific experts has advised the Leopoldina in the field of research on ageing and the life course since 2011. Under the name "Demographic Change," this committee relies on the collaboration of many different disciplines such as biology, medicine, psychology, social sciences, economics, history, and engineering, as well as their different methods, including assessments at both the individual and population level, making use of different sources and data collection methods. The topics of research on ageing and the life course are wide-ranging, spanning from the cellular and molecular basics of the biology of ageing, to the ageing person's experience, actions, and functioning, and on to the shaping of contexts (the health system, education and work, culture and social relationships) in a long-lived society. The multidisciplinary committee's work is characterized by a so-called lifespan or life-course perspective, which focuses on the systemic nature of human ageing and its cumulative aspects across the lifespan/life course as well as cultural and historic differences and changes across the history of humanity. Modern ageing research has shown that human ageing is not solely determined by a person's genetic attributes; instead, the evolutionarily-shaped default setting of the course of ageing evolves in interaction with the respective societal living conditions and the developing experiences and behaviors of the individual. The biopsychosocial nature of human ageing results in an individually and societally highly-relevant potential for change that research on ageing and the life course can tap into.

Ageing and the life course are such fundamental phenomena of human existence that they literally touch on every topic of the life, behavioral, and social sciences as well as the humanities. This multiplicity and how to respond to it scientifically and politically represents one of today's core challenges.

In order to provide our society with the best possible knowledge to master demo-

1 German National Academy of Sciences Leopoldina (2015b).

graphic change, research on ageing and the life course in Germany needs to be represented at the research institutions of our country across a broad range of disciplines, as well as being well integrated and active in research networks. With this report, the National Academy of Sciences Leopoldina intends to describe the present state of research on ageing and the life course, highlight where it is competitive in international comparison or not, outline its potentials, how it could be strengthened, which advantages we have based on our specific research landscape and the situation in Germany, and which emphases should be placed in the future. To prepare this review, the authors made use of a range of instruments, including literature and database searches, discussions with experts, and workshops with members of the Leopoldina's Standing Committee "Demographic Change" and other invited experts on specific topics (see Appendix). We concentrate on the 2006-16 period, but data from 2017 were also used where available. The respective date of data is given.

First of all, we describe important current topics and challenges of research on ageing and the life course, then the funding priorities and initiatives as well as institutional and publication-related foci,[2] before we evaluate German research funding in the context of scientifically successful countries and EU research sponsorship.

2 The presentation of funding initiatives and focus programs (Chapter II) is based on the respective institutions' public sources. The transparency desirable for a full analysis is not always available; for example, the research projects and evaluations assigned by the German Federal Ministries are not fully accessible and cannot be searched systematically. Similarly, publication and project databases of the EU and the DFG, but also the *Web of Knowledge*, which are evaluated in Chapter III, only make very restricted information and search options available. It is therefore possible, and likely, that we have overlooked some programs or research.

II. Ageing and the Life Course as a Challenge for Society and Research

II.1 Rising Life Expectancy Requires Societal Adaptation

A triumph of humanity: that is the way in which the United Nations (UN) acknowledge human ageing today.[3] The average life expectancy around 1850 was barely above 30 years.[4] Since around that time (the first mortality tables were published in 1871), life expectancy at birth has more than doubled in Germany. Different age groups contributed to this development at different points in time and in different ways. First of all, infant mortality was greatly reduced, from about one quarter of all births in 1870/71 to below 1% today. Life expectancy after the first year of life has significantly increased since that time, by over 30 years for men and 34 years for women. Since 1970, the over-65-year-olds have benefited most from rising life expectancy.[5] Meanwhile, the over-80-/85-year-olds make up the most rapidly-expanding population group.[6]

The (numerically) more balanced relationship between older and younger groups of the population is part of the so-called "second demographic transition" (van de Kaa & Lesthaege) that has been developing since the 1970s.[7] It has changed the societal distribution of life opportunities and participation, health and individual productive forces between generations, between parents and the childless, immigrants and native Germans.[8] This can be exemplified by the radical change of mothers' life courses: their reproductive period has shortened by about three years and shifted back biographically. Mothers' upbringing and caregiving role has not only been increasingly complemented by paid work, but it also takes up a much smaller portion of life in view of the extended lifespan that remains for mothers (and fathers) after their children have grown up.[9] The significance of grandparents and the shaping of their role in family and society has also profoundly changed in a world with fewer children and more healthy seniors.[10]

The question of shaping the extended period of old age has also influenced sociopolitical debate. The improvement of older people's quality of life and the partially-sustained implementation of social structures that improve people's well-being across the lifespan can be regarded as successes. However, many areas still need improvement, such as the social inequality of the quality of life and longevity or ensuring productivity in a society with higher proportions of older people. It is

3 UN (2002).

4 General life expectancy is calculated from birth. In the first third of the 20th century the massive prolongation of life expectancy was the result of reduced infant mortality (zero- to under-one-year-olds). Only in the last third of the 20th century did the gains in years of life mainly occur in the over-60-year-olds. Lampert T, Kroll LE (2014); Floud R, Humphries J, Johnson P (2014); Kocka J, Staudinger UM (2009).

5 Klenk J et al. (2007).

6 Christensen K et al. (2009).

7 The second demographic transition is characterized by a further decline in birth rates under maintenance level, diversification of partnership and familial life forms outside marriage, decoupling of marriage and reproduction, postponement of age at marriage and first birth; and in an extended understanding of this concept also by migration, ageing, change in values etc. Lesthaeghe R, van de Kaa D (1986); Lesthaeghe R (2014).

8 Ibid.

9 BMFSFJ (2006); Stock G et al. (2012).

10 Kocka J, Kohli M, Streeck W (2009).

vital to create conditions that allow for the better development and maintenance of each individual's mental and physical health across the life course, as well as enabling them to participate in society.[11] On average, today's old people are healthier (than the elderly of their parents' generation) and no longer want to be "cared for" by families and societal institutions. Beyond fulfilling material needs, striving for continued societal participation that transcends retirement and the phase of parenthood is gaining political force.[12] This mood is also reflected in the continuing debate on a specific convention for older people based on general human rights in the UN[13] and the European Union Agency for Fundamental Rights.[14] The UN already focused on demographic change in 1982 and 2002.[15] This term denotes the change of a population's age structure, becoming evident—among others—in a rising proportion of older people. The World Bank and the World Economic Forum regard population ageing as the "mega-trend" of the present and future. At the World Economic Forum 2017, the demand was raised that the EU receives a financial mandate for ageing policy, as is the case for agricultural policy, for example.[16] Indeed, along with the climate, health, and the provision of energy, food, and water, demographic change is considered one of the major societal challenges of the 21st century in the EU,[17] yet it still lacks a dedicated commissioner or budget. The World Health Organization (WHO) is planning a "Decade of Healthy Aging" for 2020-30.[18]

The differences in life expectancy both between countries as well as within countries are remarkable. If life expectancy is taken as a marker of living conditions, these are best in Japan, Spain, and Sweden today. It is thus one of the tasks of ageing research to investigate how living conditions and life expectancy are causally linked. These associations are by no means trivial because they are fed by a wealth of highly complex interactions at all sorts of levels, from genetics to culture. As the classical experiment is not available to test causality, ageing research applies creative quasi-experimental designs and invests in the further development of statistical analysis. What exemplary findings has research on ageing and the life course yielded so far that contribute to improvements in the quality of life and the sustainability of modern welfare states? How has it influenced—and possibly altered—the understanding of ageing and the life course in the 21st century? What opportunities and limits does it reveal? In the context of demographic change, somewhat like climate policy, decision-makers need to gain insights into highly complex relationships. What can research achieve in this context?

II.2 The Significance of Research on Ageing and the Life Course

Within the limits set by the respective societal and institutional context and by genetics, each person's lifespan and quality of life is malleable. Research on ageing and the life course has focused on which factors are crucial for the limits, how they can be shifted societally and individually and thus allow life courses and ageing to be shaped.[19] A wealth of verified scientific findings on the socio-economic, socio-cultural, and psychological determinants of healthy ageing are already available, from which conclusions for preventive and social-policy activities and programs

11 Kocka J, Staudinger UM (2009).

12 For example, the WHO concept of active ageing: Opportunities for full participation in all societal areas and for full exploitation of potential physical, mental, and social well-being depend on the risks and chances individuals have experienced during their lives. WHO (2002).

13 UN (2010); UN (2012).

14 European Union Agency for Fundamental Rights (2018).

15 In the International Plans of Action on Ageing (Vienna 1983 and Madrid 2002).

16 WEF (2017).

17 European Commission (2017).

18 (WHO) (2016); Bussolo M, Koettl J, Sinnott E (2015); WEF (2016).

19 Kocka J, Staudinger UM (2009).

can be drawn. Are increases in morbidity and the need for care leading to strains on the pension system or work productivity? Ageing research can provide answers to such important questions.[20]

Ageing research has already revealed that many of the widespread notions about old age and ageing are obsolete.[21] For instance, the idea that pensioners mainly want to rest and recuperate no longer applies to most elderly people (discussed in the framework of the so-called third age of life). An older population is not necessarily a more ill population. Today's generation of older adults maintain their individual performance levels for an average eight to ten years longer than the previous generation were able to. Many data sources indicate that healthy life expectancy can not only keep up with rising life expectancy, but under optimal conditions it can even increase disproportionally, leading to a so-called "compression of morbidity."[22] In particular, "functional health"[23] has been found to have improved from generation to generation,[24] despite a simultaneous increase in the number of diagnosed diseases. This historic gain in years in functionally good health is an indication of the considerable plasticity of human ageing. This development is not a foregone conclusion, although it requires continual investments in research, followed by the application of its findings, as recently shown in a study by the Global Burden of Disease Project.[25]

Besides general healthcare and physical activity, education and lifelong learning—specifically mental stimulation—are particularly important in this development. Such initiatives and interventions are necessary in early childhood, at school age, during working life, as well as the life phase after active employment. With its data sets, the related research work provides the basis for evidence and validation in these domains.

The findings of research on ageing and the life course have already led to central insights with strong relevance for actions of the welfare state and other social-political activities:

- Human ageing does not begin with the transition into retirement age, but rather at conception. (We meanwhile know that the physical and mental state of parents in the months before conception influence their child's health and development.) The influences of the ageing process accumulate across the lifespan. Those planning to be mentally fit and healthy in old age should continually reset their course. The issue with ageing is not the provision for older groups of the population, or advocating lifestyle changes in old age, but rather shaping the whole lifespan with a view to a longer life.

- Ageing is not an illness, it is a basic part of human life. Ageing can be accelerated or slowed down. The question of whether biological ageing can be eliminated remains open. Viewing ageing as a pathological process disregards the exceptionality and complexity of this process, which permeates the life of every single individual and society as a whole. It is therefore not meaningful to distinguish "primary" (i.e. mainly genetic) determinants of ageing from so-called "secondary" (environmentally and activity-determined) factors; rather, the individual interaction of these factors determines the concrete trajectory of ageing. Ageing is multifactorial.

20 Börsch-Supan A et al. (2009); Kochsiek K (2009).

21 Ehmer J, Höffe O (2009).

22 Fries JF, Bruce B, Chakravarty E (2011); Crimmins E (2015).

23 Functional health denotes the capacity to lead an autonomous life despite the presence of diagnosed disease.

24 Crimmins E (2015).

25 Foreman KJ et al. (2018).

- Older people do not form a uniform group. Sociocultural, economic, and personal differences need to be considered when organizing healthcare, caregiving, residential assistance, and measures for continued social participation. This diversity of ageing also manifests in rising (healthy) life expectancy. The discrepancy in life expectancy between the socially most disadvantaged and the most privileged social class is still ten years in Germany.[26]

- Age(ing) observed in the concrete context of today is only one variant of what human age(ing) can be, in both the positive and negative sense. For instance, the decrease in life expectancy in Russia after the end of the Soviet Union, or among white men in the US in recent years.[27] Human ageing is mutable. Research needs to elucidate which conditions can contribute to an improvement of ageing for growing numbers of people. In the third age of life, the opportunities for social participation including productive activities need to be extended, as this has proven to positively influence quality of life and health.

- Research on ageing and the life course is genuinely multi- and interdisciplinary. Ageing research does not exist as a narrowly-defined discipline; rather, among the numerous individual discipline-specific questions, central questions are located at the interfaces between disciplines, and others cannot be sufficiently answered within a single discipline.

The impulses that research on ageing and the life course can exert on health, engineering development, the employment market, the educational system, urban and regional development as well as cultural development are far-reaching.[28] European research has been called on to offer solutions to the challenges of altered lifestyles and ageing.[29] Doing this adequately requires research approaches that take the systemic quality of human ageing into account, namely the biopsychosocial reality of the phenomenon. Research funding hardly reflects this integrative perspective, or even not at all.[30]

II.3 Age(ing) and the Life Course: Definition and Delimitation

In this section, we turn to the definition and terminological delimitation. "Age" initially has a simple numeric meaning, namely a person's respective calendar (or chronological) age at a certain point in time. However, age can also refer to a phase of life like that of "teenagers," "twens," or "centenarians" (100-year-olds). With this extended concept of age, one shifts from capturing a momentary state to the description of a period of time and augments an inherently featureless number by implicit characteristics of the relevant life phase. According to the German etymological dictionary Wahrig, the German word "*Alter*" [age] comes from the Germanic **ala*, which means "growing" and "nurturing."[31] In English, the positive expression "growing old" is used in this sense. The term ageing focuses on the *process* of ageing and its temporal expansion.

Accordingly, ageing research initially concentrated on a certain life phase, such as "old or very old age" and "older or old people." Nonetheless, the final stage of life was not (only) regarded as the state of "old age," but increasingly as a part of the

26 Lampert T, Kroll LE (2014).

27 Case A, Deaton A (2015).

28 Kocka J, Staudinger UM (2009).

29 European Commission (2016); Kuhlmann S, Rip A (2014).

30 Andrews G (2005).

31

process of "ageing" from the beginning of life onwards, which then influenced the term "ageing research." Current ageing research consequently examines the entire life course from conception onwards, and it even increasingly involves parental and grandparental influences predating conception. Due to the systemic character of ageing[32] whereby human ageing develops in an interaction between biology, the individual, and life environments, the differences between people of the same age become larger in the course of life. The systemic nature of ageing also implies that the functional meaning of calendar age sometimes dramatically differs among birth cohorts and among countries due to the diversity of respective living conditions.[33] In many research disciplines, the perspective has meanwhile established itself that calendar age is not very helpful when assessing the characteristics and functioning of a person or a population of a certain average age.

The term "gerontology" for ageing research—with the Ancient Greek root *geron*, for "old man"—originally included the biological, sociological, and psychological investigation of older age. Today, gerontology does not display a scientifically unitary profile.[34] Only few gerontologically-oriented university institutes with such training tracks exist at German universities today (Dortmund, Erlangen-Nürnberg, Heidelberg, Kassel, Vechta). These institutes strongly vary in the scope represented there. In addition, there are some universities of applied sciences that offer relevant degree programs (see overview in the Appendix III.5).[35]

In the US, the new term "geroscience"[36] recently developed out of the biomedical disciplines; however, it exclusively refers to biological ageing to delineate itself from "gerontology," which is often imputed a lack of scientific precision (as a discipline). In Germany, the DFG has established a further terminological variant for the biology of ageing by using "biogerontology" as part of the name of one of its review boards [*Fachkolleg*]. In the engineering sciences, one sometimes encounters the term "gerontechnology" to describe the application of technologies—including non-technical changes of local environments—to support older people. Finally, the term "geriatrics" is established in medicine for the elderly.

In order to include a broad and fully differentiated range of disciplines focusing on the investigation of human ageing, we use the umbrella term "ageing research," which does not comprise connotations of a specific discipline (and has no intentions of forming one either), as well as the term "life-course research" (see below).

The individual scientific disciplines have different perspectives on the research of age(ing). For instance, ageing is defined as the development of an organism in the course of time, from its conception until death, but also as the loss of remaining life time[37] as the result of all changes occurring throughout life.[38] The distinction of the term ageing from that of senescence emphasizes that not all changes experienced by an organism are biological in nature. In biology, senescence includes all processes that begin after completion of the organism's maturation; for example, in cellular biology, the loss of cells' ability to divide with maintained metabolic activity.[39] However, in demography, senes-

32 E.g. Staudinger UM (2015).

33 Skirbekk V, Loichinger E, Weber D (2012).

34 Künemund H, Schroeter KZ (2015).

35 See also Deutsche Gesellschaft für Gerontologie und Geriatrie (DGGG) (2019). Gerontologische Lehrstühle in Deutschland. Available at: https://www.dggg-online.de/studium-karriere/lehrstuehle.html (retrieved 22 August 2019).

36 Kennedy BK et al. (2014).

37 Bryson MC, Siddiqui MM (1969).

38 NIA (2011).

39 Althubiti M et al. (2014).

cence is defined as a rise of age-specific mortality, which is often measured by the period of time within which the mortality rate doubles.[40] Consequently, the mortality rate accelerates in old age. For very old age, this is contentious as there are indications of a flattening of the curve.[41] Biologically, ageing is usually regarded as a cumulative degenerative process. Strictly genetically-determined limitations of the lifespan are found in some organisms, whereas various basic mechanisms of biological ageing—which operate in parallel and interact in complex ways—are observed in mammals.[42] Only in recent years have the neurosciences also moved non-degenerative, plastic, and compensatory mechanisms—as partially counteracting degenerative processes—to the center of research attention.[43]

Meanwhile, ageing is understood and investigated as a lifelong process not only from a biological perspective but also from a behavioral and social-science viewpoint. Along with institutional attributions and cultural appraisals that result from traditional structuring of the life course in phases and different domains such as work, education, and family, this view of the life course is also part of humanity's cultural repertoire.[44] In psychology, the term lifespan denotes human development across the entire period of life,[45] whereas in sociology the term life course encompasses "the sequence of activities, positions, and events from birth until death."[46] The life course thus mainly characterizes the sociostructural integration of individuals throughout their entire life history as participation in societal positions, i.e. as membership in institutional orders.[47] The social sciences emphasize that age(ing) also needs to be regarded as a period of existence in such an order; for example, in an occupation or a company. The focus on individual life phases and transitions—for instance, from school into working life—which also exists in social-science life-course research, will only play a role here if it is associated with ag(e)ing itself; for example, in terms of biologically-definable life phases such as childhood, adolescence, reproduction, etc.

In history, representative for approaches in the humanities, age(ing) is understood as an historically-based dimension of life that is therefore variable. Age(ing) is examined and understood as "part of the symbolic order" of humanity and thereby as a "cultural construction" that has also become regarded by many as a "social construction" in recent years due to the increasing rates of older people in populations.[48]

These multifaceted conceptualizations of the research area of "age, ageing, and the life course" form the basis of the following inventory and evaluation.

II.4 Interdisciplinarity in Research on Ageing and the Life Course

The characterization of ageing and the life course as "systemic" and the anchoring of this topic in many disciplines prompts the question of what kind of "interdisciplinary" collaboration is regarded as necessary or at least promising (but also demanding) for research on ageing and the life course. Two aspects are central here: first, the collaboration not only between two closely-adjacent disciplines (e.g. whose foundations are taught together) such as sub-fields of biology, important as they may be; and second, a degree of genuinely collaborative research that not only adds disciplines in

40 NRC (1997).
41 Kirkwood TBL (2015); recently: Barbi E et al. (2018).
42 López-Otín C et al. (2014).
43 Lustig C et al. (2009).
44 Ehmer J (2019).
45 Baltes PB (1987).
46 Own translation. Mayer KU (1998).
47 Mayer KU (1998).
48 Ehmer J (2019).

the sense of multidisciplinarity, but also creates a new knowledge space.[49]

Disciplines initially constitute themselves (historically) around specific questions, theories, and methods, but then also via an institutional framework for scientific knowledge gain. Disciplines are networks of researchers who share a definition of problems and their observations and interpretations. Interdisciplinarity thus means engaging with methods, theories, and findings of other disciplines (and also their language and concepts), and learning from them.[50] Even assuming that interdisciplinarity is always required when problems cannot be examined in discipline-specific frameworks, interdisciplinarity is associated with a process of learning, or at least it has the potential for such a process.[51] Participating researchers need patience, they have to be prepared to recognize that theories and methods of their own discipline are perhaps not the royal road, they should be open for other academic cultures and possess fundamental understanding of the other disciplines and be prepared to expand such a perspective while they continually contribute their own specific academic expertise. Everyone involved shares responsibility for the result.

A special variant of interdisciplinarity that is also highly relevant for ageing research is the linkage between basic research and application. Biomedicine can serve as an example: for about 10-15 years, particular attention has been paid to the question how basic research can be transferred to clinical research, on into clinical practice, and back again into research.[52] Biomedical research with this direct application connection linking clinical and basic research bidirectionally is usually called "translational."[53] The cooperation of several biomedical disciplines with this aim is explained by the complexity of disease etiology and treatment processes. Here, and also in the general discussion on interdisciplinarity, sufficient time for research but also adequate funding policy criteria and cultural and organizational incentives in the research institutions themselves are considered prerequisites for successful cooperation.[54]

From the perspective of knowledge gain, it does not seem necessary to make binding prescriptions as to the extent of integration practiced by researchers.[55] Nonetheless, for pragmatic reasons, it is advisable to develop a "shared knowledge space" regarding research questions and available resources, as well as the abilities and willingness of participating discipline representatives and their general discussions.[56] In research on ageing and the life course, the minimal consensus could comprise:

- selecting a biopsychosocial approach;
- taking historical changes of human ageing into account;
- examining analysis of both the individual and aggregates of individuals;
- taking the large differences among people and societies into account; and
- studying the life course (in addition to separate phases or transitions).

However, numerous organizational and institutional hurdles stand in the way of realizing interdisciplinary research of this kind. In recruitment, research funding, and

49 Mittelstraß converts the term of inter- into transdisciplinarity to capture the research transcending discipline boundaries, developing new forms of conjoint work and thus also changing the involved disciplines. Mittelstraß J (2008).

50 Joas H, Kippenberg HG (2005).

51 Krohn W (2017); Mittelstraß J (2008).

52 On the role of pharmaceutical industry and the cooperation between publicly funded and industrial research in this context: Maxmen A (2011).

53 Jost N et al. (2015); Fitzgerald L, Harvey G, (2015), Budge J et al. (2015); Yu D (2011).

54 Erler JT (2015); Bentires-Alj M et al. (2015); Ciesielski T et al. (2017).

55 Wechsler D, Hurst AC (2011).

56 Ibid.

publication opportunities, discipline-specific research is at an advantage. For instance, adequate evaluation of interdisciplinary research poses the challenge that it is insufficient to access only one canon of discipline-specific knowledge and an established academic community.[57] Quality criteria at these interfaces are different (by no means lower) than in the individual disciplines themselves. The National Academy of the Sciences (NAS) in the US as well as the British Academy have developed a series of solutions for the evaluation of interdisciplinary research. For example, reviewers who are themselves experienced in interdisciplinary research should be selected, interdisciplinary alliances should be formed within and among funding organizations, and training programs should become part of the awarded research support.[58] Without doubt, it is specifically necessary to develop criteria for the review and evaluation of interdisciplinary research that capture the scope of the research, the extent of integration of different approaches, as well as the development of new concepts.[59] Practical instructions on realizations and evaluations of successful and unsuccessful interdisciplinary research are available.[60]

Not only experience reports but also scientific research on innovation, team work, organizations, etc. allow derivation of preconditions and adequate criteria to measure the success of such projects; these need to be expressed clearly by academic leaders and funding agencies and brought to bear in their career and grant award decisions. [61]

In Germany, the DFG has had evaluation criteria developed specifically for interdisciplinary public health research by a research "round table." While the application of different methods was stipulated as a mark of quality, applicants were also asked to provide an especially detailed explanation of their project to take into consideration that reviewers would concentrate on weaknesses of content in their own field of expertise, and not on an integrative summary evaluation.[62] In the DFG, interdisciplinarity is understood as „the joint work on scientific questions by representatives of different disciplines," albeit the disciplines are not precisely defined and the researchers' assignment to the DFG discipline system remains the determining criterion.[63] In contrast, it seems necessary for the evaluation of interdisciplinary research funding and results, that the respective funding agency itself clearly defines what kind of interdisciplinarity (regarding the form and extent of cooperation and of cognitive integration, the spectrum of represented disciplines, etc.) it supports. This could then be the basis for the selection of reviewers and setting of criteria.[64] A doubling of the demands due to the consideration of all excellence criteria of two or more disciplines needs to be avoided in favor of the introduction of independent excellence criteria for interdisciplinary research.

To foster the investigation of interdisciplinary problems, it also seems essential to strongly support infrastructural measures. We therefore also present larger research structures for research on ageing and the life course in this report, and not only content.

57 NAS (2005); Bhaskar R, Danermark B, Price L (2018); Huutoniemi K, Rafols I (2017).

58 Institute of Medicine (2000); Institute of Medicine (2000); British Academy (2016).

59 Suggestion on this by Huutoniemi K, Rafols I (2017); Gleed A, Marchant D (2016).

60 E.g. Thompson Klein J (2010); Strang V, McLeish T (2015).

61 Strang V, McLeish T (2015); Tang P, Molas-Gallart J, Rafols I (2014); Prager K et al. (2015); NRC (2014). E.g. not only should discipline-specific publications be rated, but also successful publications in journals beyond the traditional scope, co-authorships, a person's contribution to the establishment of a new approach. Review committees need to be composed so as to assemble the expertise for such evaluations and require appropriate guidelines.

62 An evaluation of the implementation has not yet been published. Gerhardus A, Becher H, Groenewegen P et al. (2016).

63 DFG (2013).

64 Exemplified by funding by the British Economic and Social Research Council: Tang P, Molas-Gallart J, Rafols I (2014); or of the University of Brussels: Rons N (2011).

II.5 Challenges from the Perspective of the Disciplines

Each discipline is characterized by a specific approach to research on ageing and the life course that is briefly presented in a kind of tour de force through the landscape of discipline-specific research on ageing and the life course in the following.[65] For each of the disciplines introduced here, we will pose the following questions: (1) How is the research field defined; (2) what is its value within the respective discipline; (3) can central research topics be identified; and finally (4) what role does exchange with other disciplines play?

II.5.1 Demography

Demography as the science of the structure and dynamics of populations is part of the foundation of all social science research, and this is particularly the case for research on ageing and the life course. While research on different population parameters (births, ageing, gains and losses through migration) is labeled "demography," researchers are also discussing the term "population science," by which its range and interdisciplinarity is more strongly expressed.[66] For example, beyond the traditional investigation of mortality, a range of changes in older age have moved into focus with the rise in life expectancy. Education, health, and participation in labor markets are fundamental for the understanding of population structures and their effects.[67] Conditions even before birth and in early childhood have been identified as significant for the life course.[68] Genetic constitution at birth, continually changing epigenetic control of genetic expression as well as the pattern of gene expression itself play a decisive role in understanding life trajectories. Such parameters already require contributions of different disciplines. It has become clear that with increasing age, chronological age is increasingly less meaningful in terms of a person's functioning, attitudes, and goals, or more general economic effects.[69] An adequate new assessment of ageing metrics is the topic of this research.[70] To achieve these complex research goals, population science affiliates itself with biomedicine, epidemiology, economics, the social and behavioral sciences as well as the humanities.[71]

II.5.2 Medicine

In relation to stages of life, the specifics and characteristics of illnesses in old and very old age remain insufficiently investigated in medical research. This concerns the features and treatment of illnesses in very old patients on the one hand, and the potential long-term development of these illnesses on the other. Paradoxically the data situation is also weak at the other end of the age spectrum, in childhood and adolescence.

The great heterogeneity of the group of older people challenges medical research in terms of content, organization, and funding.[72] In their totality, the extraordinary complexity of the interactions among extrinsic and intrinsic factors, often effective for decades, the high likelihood of multimorbidity in old age, behavioral trajectories and personality patterns that have stabilized over years, and the additive and self-reinforcing effect of minor and major life events can still be captured conceptually within the general schema of a gene-environment interaction, but hardly in detail and in their concrete consequences.[73]

65 Discipline labels and structure following the DFG system, except for demography.

66 Mohneke S, Doblhammer-Reiter G, Willekens F (2015).

67 E.g. WU Demography Group (2018).

68 E.g. Doblhammer G (2004); van den Berg GJ, Doblhammer G, Christensen K (2009).

69 E.g. Baumgart M, Priebe S, Groth M, Hartmann N, Menzel U, Pandolfini L, Cellerino A (2016); Staudinger (2020); Loichinger E, Hammer B, Prskawetz A, Freiberger M, Sambt J (2017).

70 Sanderson WC, Scherbov S (2010); Scherbov S, Sanderson WC (2016); Skirbekk V, Staudinger UM, Cohen J (2018).

71 E.g. Myrskylä M, Gagnon, Bengtson T (2014); Jagust WJ (2016); Gassen NC et al. (2016); Bleker LS et al. (2016).

72 Cf. German National Academy of Sciences Leopoldina (2015a).

73 For instance, they interact with telomeric length. Blackburn E, Epel E (2012); Puterman E, Epel E (2012).

In the traditional medical approach, an organ-related deficit is cured or treated preventively according to the rules of evidence-based medicine. Nonetheless, the existing concepts reach their limits if the existing set of instruments is badly adapted to the specifics of the situation of old age (or childhood).[74] New approaches and methods for the analysis of variability of biological, socio-economic, psychological, and cultural factors as well as their interactions need to be developed to further improve the quality of evidence-based medicine in old age, but also for longitudinal and cohort comparison studies.[75] Health-related social inequality is also targeted in this perspective.[76]

Precision medicine or personalized medicine, increased consideration of prevention, rehabilitation, and healthcare research as well as palliative medicine, but also the International Classification of Functioning, Disability and Health's biopsychosocial model of health and disease (mainly in geriatrics) can be interpreted as a response to the previous neglect of the interactive nature of human development and ageing. Likewise, with its process-like understanding of health and illness, "regenerative medicine" attempts to counteract disease processes preventively or curatively and reconstitute normal functioning rather than simply treating symptoms, and it shows great potential particularly in the domain of chronic illnesses, which increase in old age.[77]

Viewing the course of illness and health on the population level is the core topic of epidemiological research. In the last two decades, life-course oriented epidemiology experienced a shift of its major research themes. Originally, the discipline focused on the manifestation of illnesses, but the search for causal relationships now involves the integrative study of social and biological trajectories of functioning. Rather than being regarded a risk factor, ageing has become the examined process itself. Epidemiological research shares important approaches with psychology, sociology, demography, and public health and is ideally in close exchange with basic biological research.[78] In the last two decades, physical influences on well-being in old age, including cognition, have been more closely investigated. The notion of "active ageing" (often also termed "successful ageing") thereby grew beyond the original focus on prevention of chronic illness.[79] This emphasis also links many disciplines, particularly medicine, neurobiology, epidemiology, sports science, and psychology.

Public health and health services research, including nursing science—which remains under-represented in Germany—is also a very important multidisciplinary field for ageing and the life course, but it plays a relatively marginal role in German medical departments.[80] Concretely, ageing-related public health and health services research is concerned with how the healthcare of a population with a growing proportion of old and very old people can best be ensured. This research distinguishes itself from the curative medicine of the hospitals and doctors' practices because first, it focuses on society and the population rather than the individual, second, it considers the efficient utilization of existing resources and their just and adequate

74 Mangoni AA, Jackson SHD (2004); German National Academy of Sciences Leopoldina (2015a).

75 Precision Medicine Initiative of the National Institutes on Health in 2015. E.g. for cardiology: Antman EM, Loscalzo J (2016). System biology is another research strand that examines the interaction of elements: Bielekova B, Vodovotz Y, An G, Hallenbeck J (2014); Fontana L et al. (2014); Loscalzo J, Barabasi AL (2011).

76 E.g. Hurst L et al. (2013).

77 Cossu G et al. (2014).

78 Ben-Shlomo Y, Cooper R, Kuh D (2016).

79 Bauman A et al. (2016).

80 Precipitated by the shortage of caregivers and family practitioners, mainly in rural areas, this restraint has changed here and there in the past years. Policy-makers have reacted with greater awareness and commitment regarding health services research (and the health services themselves).

distribution, and third, it emphasizes the avoidance of illnesses, and often explicitly, the prolongation of life. Health services research acts at the interface between clinical research, classical public health research, and health economics. Among others, topics requiring interdisciplinary cooperation are the role of the world of work and working life in health research.[81]

II.5.3 Basic Fields of Biology/Medicine and Neurosciences

Cell and molecular biology play an important role in research on biological ageing, interpreted primarily in terms of the mechanisms on which ageing processes are based. These mechanisms are regarded as causal for biological ageing and for the practical, or even only theoretical, restriction of the lifespan. To date, nine central biological ageing theories can be identified: genomic instability, telomeric shortening, epigenetic changes, loss of proteostasis (i.e. the homeostatic network that controls the entirety of a cell's proteins in space and time), deregulated nutrient sensors, mitochondrial dysfunction, cellular senescence, depletion of stem cells, and altered intercellular communication. It is a widespread assumption that, to the extent that the underlying biological mechanisms are known, it would be possible to intervene preventively and slow down or even eliminate ageing.[82] Bringing together models of ageing generated based on animal and human research is essential in this venture.[83] Other researchers press for the use of new molecular-biological indicators in population-representative longitudinal studies;[84] however, the appropriate, mainly biomathematical methodology and modeling approaches still pose enormous challenges. This research on general ageing topics in biology appears more fragmented and less interdisciplinary than the mostly quite clear issues and questions of biomedical ageing research. So far, exchange between the two domains only rarely occurs.

Not least due to its significance as a cause of death, research on the cardiovascular system is strongly represented. Further core topics are metabolism research (mainly due to type II diabetes) and immunology, but questions of the biology of ageing also play a very important role in cancer research. A current topic associated with nutrition research concerns the relationship between the microbiome and ageing.[85]

Work on neurodegenerative diseases such as the different types of dementia, Parkinson's disease, and amyotrophic lateral sclerosis, but also age-associated macular degeneration, the most frequent neurodegenerative illness of all and a common cause of blindness in old age, is of course particularly important in this context. Neurodegenerative diseases are characterized by great complexity. The factor "age" plays a major role for their occurrence and their trajectory, but the underlying processes are not yet understood. Biopsychosocial approaches are also required here.

The neuroscience view on normal and pathological brain development across the lifespan is regarded as underdeveloped, meaning that a joint understanding of these processes has not yet been achieved because most studies have only been carried out on restricted age ranges or with limited sample sizes. The lack of harmonization of neuroscientific instruments also encumbers an integrative perspective.[86]

81 Müller R, Senghaas-Knobloch E, Larisch J (2016).

82 López-Otín C et al. (2013).

83 Ibid.

84 Gage FH, Guarente LP, Wagers AJ (2016).

85 Overview by Kennedy B et al. (2014); O'Toole PW, Jeffery IB (2015).

86 Coupé P, Catheline G, Lanuza E, Manjón J (2017).

II.5.4 Psychology

The psychology of ageing examines individual developmental trajectories across the lifespan, particularly focusing on how biological influences interact with sociocultural and idiosyncratic factors.[87] Two central findings result from the relevance of such interactions for the life course: (i) There are large differences *between* people of the same chronological age. (ii) Even *within* a person can differences depending on the three influences be seen: These are investigated under the heading "plasticity of ageing." The psychology of ageing and the lifespan has developed strongly since the middle of the last century, presumably also due to demographic ageing and the fact that many longitudinal studies with an initial focus on earlier developmental stages evolved into the phase of older age. In addition, the growing interest of large-scale, originally socio-economically oriented studies (e.g. the German Socio-Economic Panel, GSOEP) in psychological constructs such as control beliefs, personality, subjective well-being, but also cognition and social support, opened up opportunities to examine interdisciplinary issues in large representative samples. The psychology of ageing will also benefit from worldwide efforts to make large population panel studies comparable across countries.

The psychological domains of functioning of cognition, personality, motivational and emotion regulation as well as the development of social relationships and support are at the center of research interest. Cognition represents a focus of psychological ageing research so far due to the advanced reliable and valid measurement instruments available, but also due to the great interest in reducing age-associated cognitive losses or shifting them to the end of the life course.[88] The attention paid to the ageing brain is furthermore also due to the adjacency of neurobiological brain research. The predominant strategy of studying healthy or normal cognitive ageing on the one hand and pathological development, particularly dementia, on the other, as separate processes, is assessed as only partially successful so far.[89] More than fifteen years ago, experts already judged that interdisciplinary collaboration is essential to investigate variations in environmental factors, age-associated changes in sensory functioning and health as well as neurological trajectories.[90] Cognitive ageing research that involves both biological and sociocultural components and is interested in the modifiability of cognitive ageing benefits from the molecular-biological, neurostructural, and neurofunctional analysis of brain plasticity in adulthood.[91]

However, there is a lack of systematic comparisons of countries and birth cohorts in the field of cognitive ageing research.[92] In order to examine the influences of sociocultural factors on psychological and biological ageing, it is necessary to carry out multi-level comparisons of countries and their inhabitants and capture historical changes within the countries compared. The unfavorable effect of one-sided negative images or stereotypes of ageing, or the beneficial effect of equal gender roles can serve as examples of effects of cultural influences on cognitive ageing.[93]

In the last 15 years, neurophysiological research of emotion regulation and of interactions between the two domains of functioning has developed at the interface between psychology and neuroscience. Findings show ageing-related changes in emotional experience and its regulation in

87 Baltes PB, Lindenberger U, Staudinger UM (2006).

88 Salthouse T (2009); Kray J (2019).

89 Hofer SM, Alwin DF (2008).

90 NRC (2000).

91 Kühn S, Lindenberger U (2016).

92 Work based on SHARE and the numerous international comparisons of welfare systems are exceptions.

93 Wurm S, Huxhold O (2012); Bonsang E, Skirbekk V, Staudinger UM (2017); Vogel C, Wettstein M, Tesch-Römer C (2019).

that fewer negative emotions are reported in old age.[94] One exception may be the experience of loneliness in very old age. This area has become a productive intersection between psychological and biomedical research.[95]

The psychology of personality ageing has also achieved great advances in the last two or three decades, both regarding measurement reliability and validity and the availability of cohort-comparative longitudinal studies. As is the case for cognition, it became clear that the collaboration with the neurosciences, but also the social sciences, can bring significant knowledge gains. Many research projects extending into adjacent research fields are also available on social interactions, social support, and social networks, and their functions for the ageing individual. For instance, close collaboration with stress physiologists was able to reveal which mechanisms allow social support to serve as a buffer.[96]

II.5.5 Social Sciences and Economics

In social-science ageing research, the challenges of demographic change are reflected in the rise of life-course research since the 1950s. Ideally this research reconstructs longitudinal processes with the assistance of experts on the various age phases, respectively life domains, from childhood to old age, ranging from school and education to work and health.[97] Institutionalized transitions, for example, from one educational institution to another, and their consequences are important factors to be examined,[98] but numerous other factors such as socio-economic structures, cultural values, or critical life events and decisions also play a role.[99] Whereas the cooperation of different disciplines is necessary and frequent, only few interdisciplinary publications exist to date. Particularly, differentiated considerations of the association between macrosocial context and human development are well founded, but rare.[100] The unexplored potential of cooperation between sociological ageing research and other disciplines is the topic of hopeful contemplation. For instance, the examination of biological effects of social factors during different life stages is regarded as promising, but also the utilization of new technologies for data collection.[101] From the perspective of interdisciplinarity on equal terms and the systemic notion of ageing research, it is interesting to see that the behavioral level has often been neglected in more recent approaches of this kind.

Integrating context is theoretically well conceptualized and implemented for social structure, but hardly at all for the physical environment. Here the perspective should be enriched by including the viewpoints of urban and regional development research, architecture, labor science, etc.[102] Regional and socio-economic differences in ageing processes and opportunities to compensate for disadvantages, to promote social participation in particular, seem to form an important field for applied research that is still in need of expansion. A major component was identified as the institutional strengthening of lifelong learning and of life models that allow for parallel foci rather than the temporally sequential foci in the domains of education, work, family, leisure, and private life.[103]

94 Kessler EM, Staudinger UM (2009).

95 Cacioppo JT, Cacioppo S (2018).

96 McEwen BS (2007).

97 Mayer KU (2000a/b); Kohli M, Künemund H (2004); Bertram H, Bujard M (2012); Bertram H, Holthus B (2018).

98 For education across the life course, e.g. Schenck-Fontaine A, Schönmoser C, Frembs L (2018); Walther A, Stauber B (2016).

99 Mayer KU (1990); Kohli M (2007).

100 Diewald M, Mayer KU (2009); Mayer KU (2009); Blossfeld HP et al. (2014).

101 NRC (2012); NRC (2013).

102 E.g. Evans GW (2004); Friedman SL, Wachs TD (1999); Macintyre S, Ellaway A (2000).

103 Brandl S, Hildebrandt E, Wotschack, P (2008); Bertram H (2016); Klammer U et al. (2017).

Besides life-course research, comparative research on the welfare state contributes a great deal to ageing research, whereby some exemplary studies analyze the influence of social security systems on the ageing of cognitive abilities, economic security, etc.[104] Not only does social and economic participation across the life course play a role in research, but also political participation. Electoral behavior and political attitudes have been analyzed from the viewpoint of political science and psychology.[105] The growing proportion of older people in the electorate, particularly their overrepresentation due to generation-specific voting behavior and party membership, has been examined regarding changes in interest-driven politics.[106] In the instance of healthcare provision, civil society, an important contextual factor for individual ageing, is also examined under the catchword "functionality."[107]

Not least thanks to the availability of school achievement data, the focus of educational science is on educational trajectories up into young adulthood, respectively the transition onto the labor market, as well as the study of occupational education. With the data collection on competencies of adults within the comparative studies of the Organisation for Economic Co-operation and Development (OECD), PIAAC (Programme for the International Assessment of Adult Competencies) and CiLL (Competencies in Later Life, a study added to PIAAC for the 66-80 age group), as well as the National Education Panel Study (NEPS), steps have been taken to extend this research by including the whole life course.[108] However, in the years prior to 2012, qualitative studies were still predominant among those with the highest citation rates (globally).[109] The interlacing of occupational and educational biographies or the relationship between education and further aspects such as health and social engagement are at the heart of the study of "lifelong learning" and "adult education." Learning in the context of work and the acquisition of competencies and learning technologies are more recent topical trends.[110]

In economics, one can distinguish between population and the individual as the research reference. On the population level, age structure as well as the distribution of resources influenced by social security systems, i.e. pensions, healthcare, and education play a role.[111] The dynamics of lifelong learning and productivity effects are taken into account rudimentarily.[112] With respect to the analysis of provision for old age it has been stated that the complexity of the situation requires the collaboration of many academic fields with economics, among them demography, social policy research, political science, law, psychology, rehabilitation sciences etc.[113] The distribution of income and assets in old age and among the generations is also a central topic in economics.[114] In connection with potentially conflictual financial generational justice, monetary or time budget transfers are also examined.[115] Finally, macroeconomics focuses on the effects of demographic age-

104 Rohwedder S, Willis RJ (2010); Ehlert M (2016); Heisig JP (2015); Ebbinghaus, B (2015); DiPrete TA (2002).

105 Alwin DF, Cohen RL, Newcomb TM (1991); Alwin DF (2016); Grasso M et al. (2016); Shin M, Agnew J (2016); Jou W, Endo M (2016).

106 Andersen TM et al. (2016); Streeck W (2009); Munimus B (2012); Schmidt M (2012); Konzelmann L, Bergmann M, Rattinger H (2014); Goerres A (2010); Niedermayer O (2016).

107 Moye J, Marson DC, Edelstein B (2013).

108 Friebe J, Schmidt-Hertha B, Tippelt R (2014).

109 Fejes A, Nylander E (2015).

110 Rubenson K, Elfert M (2015); Schäffer B, Dörner O, Krämer F (2015).

111 Among others, at the Munich Center on Economics of Aging. E.g. Börsch-Supan A (2014). For Japan: Coulmas F (2007).

112 E.g. Skirbekk V (2008); Mahlberg B et al. (2013a and b); Börsch-Supan A, Weiss M (2016); Strulik H, Werner K (2016); Backes-Gellner U, Veen S (2013); Pfeifer C et al. (2012).

113 Ruland F (2007).

114 E.g. DIW, SAVE Study at the Munich Center on Economics of Aging.

115 Loichinger E, Prskawetz A (2017); Hammer B, Prskawetz A, Freund I (2015); Lee R (2015).

ing on economic growth and international economic relationships depending on the respective social systems. This is usually done within the framework of models of overlapping generations.[116]

On the individual level, decisions related to employment, investment, saving, education, starting a family, or taking retirement belong to topics of interest. The incentive effects of pension insurance schemes have long been well examined.[117] Interdisciplinary studies bringing together economics and psychology or genetics are assessed as promising.[118] Much attention has been paid to the strong correlation observed between socio-economic status (as measured via occupational training, income, and assets) and health (as measured by morbidity and mortality).[119] Further development of indicators capturing well-being and the opportunity for international comparisons are being followed with great interest.[120]

II.5.6 Humanities

Demographic ageing has less acute than cumulative chronic effects on sociocultural characteristics and thus attracts increasing interest in the humanities and cultural studies.[121] The humanities' perspectives on topics of ageing and the life course focus on images of ageing, representations, mindsets, and societal interpretations, subjectivity and identity, space and time, as well as physicality (corporeality).[122] Concepts and theories, especially of the "cultural turn," are shared by numerous disciplines so that overarching studies on the topic of ageing can be summarized under "humanistic gerontology" or "cultural gerontology." Age(ing) may thus develop into a category like "gender," which has spread across disciplines.[123] In interdisciplinary collaboration, concepts of the other disciplines need to be questioned and enriched by knowledge from the humanities. Examples include the integration of research on postcolonialism and ageing,[124] biological ageing and art[125], or the importance of chronological understandings of the life course.[126] The use (respectively indispensability) of historical data, as in the investigation of climate change, has also been debated in the behavioral and social sciences, economics, and humanities.[127] The informative value of longitudinal studies would grow if they could be extended back in time beyond the second half of the 20th century. The history of institutions and resources, networks, family and kinship systems, political, social, and ecological changes could provide additional information via the many associations between populations and such factors.[128]

II.5.7 Engineering Sciences and Human Geography

Not only does time play a role for human life courses and ageing, but also the environment, not least the physical environment. The influence of home and work environments as well as local residential environments, including technological and other infrastructural facilities, is examined in the engineering and environmental sciences of ageing and the life course.[129,130]

116 E.g. Börsch-Supan A, Härtl K, Ludwig A (2014).

117 E.g. Börsch-Supan A, Schnabel R (1998); Engels B, Geyer J, Haan P (2017); Lüthen H (2016); Corneo G, Bönke T, Lüthen H (2015); Riphahn R, Schrader R (2017).

118 German National Academy of Sciences Leopoldina et al. (2016); NRC (2013).

119 Stowasser T, Heiss F, McFadden D, Winter J (2014).

120 Bloom D (2014); German National Academy of Sciences Leopoldina et al. (2016/2015c).

121 Overall, this still remains a marginal topic, so these research fields are combined here.

122 Ehmer J (2019); Ehmer J, Höffe O (2009); Göckenjan G (2000); Conrad C, v. Kondratowitz H-J (1993).

123 Twigg J, Martin W (2015); for history: Kramer N (2013).

124 van Dyk S, Küpper T (2016); Gilleard C, Higgs P (2000).

125 Banerjee M, Wohlmann A, Dahm R (2017).

126 Grenier A, Griffin M, McGrath C (2016); Ruppert S (2012).

127 Raphael L, Wagner GG (2015); Mayer KU (2015); Kreager P et al. (2015).

128 Ibid. Ehmer J (2019).

129 The engineering and environmental sciences are also considered together because human ageing and the life course still do not play a role in large parts of these disciplines.

130 Claßen K et al. (2014).

The connections to the social, behavioral, and medical sciences are obvious. Changes such as the increasing mechanization and automation of daily and working life, but also the interactions between regional demographic structure and availability or reductions of basic infrastructure as well as the influence of environmental characteristics such as air and water quality or noise on the course of ageing are examined.

In the engineering sciences, a new class of older adults' needs play an important role, often in relation to age-associated impairments that can be dealt with by technological means, but also for health support and disease prevention, maintenance of autonomy, social networking, participation, and leisure enrichment.[131] The field of "gerontechnology" is an expression of the variety and scope of research that has focused on adaptations of residences and the environment, mobility, communication, medical technologies, and others for about three decades. Thanks to intensive funding, a large number of potentially helpful technological prototypes, such as smart walkers, smart homes, fall detection systems, have been developed, but in contrast to the US or Britain, the step from studies with small case numbers to the collection of robust evidence has not yet taken place in Germany. Accordingly, the engineering sciences are indeed very important for questions of ageing and the life course, but as a field, it is still not programmatically consistent.[132]

Increasingly, the role of environments for well-being and health aspects is also analyzed with advanced methodology based on large datasets. Human geography/urban and regional planning studies (also in collaboration with sports science, for example) examine effects of physical environments on ageing processes, such as the offer of incentives for physical activity in residential surroundings. Numerous empirical studies on this have been published in recent years,[133] but longitudinal studies are lacking.[134] The best representative data on residential situations in the second half of life are available in the Deutscher Alterssurvey (DEAS). However, these could be much more extensively utilized, or combined with other data (e.g. well-being, health, cognition). Applying "geomapping" and using environmental information in large datasets appears to be gradually developing in Germany as well (see established research on "ageing," "health," and "neighborhood" for comparison).[135]

The catchphrase "age-friendly communities" mainly characterizes research on physical environments and involves an insufficient number of sociocultural factors.[136] In recent times, the topic of mobility biographies has been taken up in connection with the sociology of space.[137] However, only few good studies comprehensively examining different types of mobility in old age exist at present. Research on older car drivers, and generally longitudinal studies in the field of engineering sciences and environmental science, are also lacking in Germany. The findings of earlier studies with far-reaching implications are meanwhile no longer up-to-date.[138]

131 Lindenberger U, Nehmer J, Steinhagen-Thiessen E (2011); Schulz R et al. (2015).

132 Schmidt L, Wahl HW (2016).

133 Saelens B, Handy S (2008); Gerstorf D et al. (2010); Vogel N et al. (2017).

134 Hirsch JA et al. (2014).

135 Mendes de Leon CF et al. (2009); Kawachi I, Berkman LF (2003).

136 Phillipson C (2011); Wahl HW, Oswald F (2010); Plouffe L, Kalache A (2010); Menec C, Sharratt M (2017).

137 Scheiner, J, Holz-Rau, C (2015).

138 E.g. the European MOBILATE project. Mollenkopf H et al. (2006).

II.6 Conclusions: Ageing and the Life Course as a Challenge for Society and Research

Ageing and the life course are basic biopsychosocial phenomena of human existence that have changed a great deal over the past 150 years due to sociocultural developments. It is not an exaggeration to state that they touch every topic in the life, behavioral, and social sciences as well as the humanities. In all disciplines, the life course, ageing processes as well as population processes are increasingly investigated in the sense of multi-level complexity, namely taking the associations among biological, psychological, and sociocultural influences on ageing processes into account. Furthermore, the associations being considered within each level of analysis are also increasingly rich, for example, the interactions among various molecular-biological ageing processes, the association of social, emotional, and cognitive ageing processes, as well as the study of cohorts in comparison and of intergenerational relationships.[139] At the same time, theoretical understanding has grown, as to be seen in the dyadic analysis of decisions on having children or not, multi-actor models, multi-dimensional life contexts, cross-domain effects, etc.[140]

An important motor of this increasing consideration of the complexity of ageing is the extension of data collection to prospective cohort comparison studies, the price reduction of biomarker measurement and genetic sequencing as well as progress in statistical analysis methods for large longitudinal data sets.[141] New national cohort studies have recently been started in the US, Europe, and many newly industrialized countries, and great efforts are being made to harmonize ongoing studies across nations to investigate the interplay of biological, socio-economic, cultural, behavioral, environmental, and other factors.[142] However, the minority of these studies are characterized by an equal involvement of the various relevant disciplines: usually one of them is the "supreme discipline," and the others subordinate themselves as supportive disciplines. These developments have also recently prompted the Leopoldina to emphasize the importance of population-wide longitudinal studies and highlight how central it is to establish permanent research infrastructures for these purposes.[143]

A certain degree of hope is warranted due to the observation that disciplines that originally considered restricted sets of analysis levels, topics, and influencing factors, are increasingly prepared to open themselves to other disciplines' perspectives to do justice to the complexity of the ageing process. Approaches and models are being sought that could represent a common basis for collaboration.[144] The nature and extent of such an opening are quite varied, although the most obvious cooperation is always to be found where disciplines' content already overlaps; for instance, between pre-clinical and clinical medicine, or between cognitive psychology and the neurosciences.[145]

The scientific problems and possibilities that appear to require interdisciplinarity, however, do not render discipline-specific research redundant. Not every discipline or subdiscipline and not every project has the same level of interdisciplinary cooperation requirements regarding methodology or knowledge gains.

139 Cf. Mayer KU (2015). For the German Socio-Economic Panel SOEP: Schupp J, Spieß CK, Wagner GG (2008).

140 For pairfam, the panel on partnership and family dynamics: Huinink J et al. (2011). For the National Educational Panel Study (NEPS): Blossfeld HP, Roßbach HG, von Maurice J (2014).

141 Gage FH, Guarente LP, Wagers AJ (2016).

142 Collins FS, Varmus H (2015).

143 German National Academy of Sciences Leopoldina et al. (2016).

144 Kreager P et al. (2015).

145 Yeung AWK, G TK, Leung WK (2017). For Austria: Mutz R, Bornmann L, Daniel HD (2015); Yegros-Yegros A, Rafols I, D'Este P (2015).

The collaboration among disciplines requires all involved researchers' openness and competence to engage in interdisciplinary dialogue as well as research-infrastructural preconditions. The equal funding of individual disciplines and interdisciplinary research regarding research infrastructure and training opportunities via recruitment, funding instruments, peer review, and even publication systems is not an easy task and sometimes associated with contradictory systems of incentives. It therefore requires special attention.[146] Specific criteria for the review and evaluation of interdisciplinary research should be developed that capture the breadth of research, the extent of integration of different approaches, and the emergence of new aspects.[147] Besides scarce reflections of the multi-level complexity of human ageing in most research, a lack of interest in the topic of ageing and the life course within the humanities, for example, presents a difficulty. It is thus important to create incentives promoting the pursuit of this topic.

Although insurmountable obstacles seem to stand in the way of realizing such a model of ageing research, the overview provided above emphasizes that movements in this direction can currently be observed in various science fields and—as we will see in the following—funding agencies. However, this should not detract from the fact that the combination of the micro and macro level in the research of human ageing strongly requires further development.

146 Barry A, Born G, Weszkalnys G (2008); Turner S (2000).

147 For suggestions on this, see Huutoniemi K, Rafols I (2017); Gleed A, Marchant D (2016); Thompson Klein J (2010); Strang V, McLeish T (2015).

III. Research Landscape: Conditions of Research on Ageing and the Life Course

Setting funding priorities has medium- and long-term effects that extend beyond the concrete project support; for instance, via the development and dissemination of methods, theories, data, networks, and training of junior scientists. Therefore, it is a central aim of this report to track and classify these priorities. For this purpose, the following section provides an overview of the funding policies relevant to ageing researchers in Germany and the extent to which they target research of the life course and ageing that crosses discipline boundaries. Beyond the EU and Germany, the research funding policies of France, Sweden, the UK, the Netherlands, and the US are included as benchmarks. These countries were selected based on their international reputation in ageing research.

III.1 Research Funding in the EU

III.1.1 Background

EU funding now makes up a considerable portion of third-party funds at German research institutions, and success in the competition for European funds has become an important individual career factor. Furthermore, the strategic orientation of EU research funding has a feedback effect on national research. This concerns EU tasks such as the regulation of clinical research, but also the establishment of a communal European research space, involving the programmatic collaboration of national funding organizations, within the so-called Joint Programming Initiatives (JPIs), for example. In the period of time documented here, the 7th Research Framework Programme (RFP) regulated most of the funding since 2007. Within this framework, researchers from Germany received 6.4 billion EUR in funds for 8,000 projects in all fields of research.[148] In 2014, the various funding schemes were merged in the "Horizon 2020" program.

The 7th RFP played a role for research on ageing and the life course by adding two components to industry-oriented research funding: On the one hand, support granted under the heading "Health, Demographic Change and Well-Being," and on the other, establishing the European Research Council (ERC), which promotes basic research.

Below we show how the linkage between ageing and health entered into programmatic research funding schemes and which thematic perspectives were developed by the EU Commission for the field of ageing and the life course in recent years. We then highlight those of the various parallel EU funding research initiatives that involved or benefited researchers in Germany.

III.1.2 The Lisbon Strategy and Healthy Ageing

In 2000 the EU member states agreed various steps to improve economic growth, productivity, and employment opportunities in its "Lisbon Strategy." This largely happened due to concerns that the "population ageing" (according to the EU Commission) would have negative effects on growth and cause an increase in social expenditure.[149] The improvement of pop-

148 Europäische Kommission (2018).

149 Kok W, European Commission (2004).

ulation health in view of longer lives was regarded as an important condition for a successful interaction between an ageing population, economic growth, and employment and thus declared to be a central condition for welfare in Europe.[150] In 2010, the member states again agreed guidelines for their economic and employment policies, in the so-called Europe 2020 Strategy. "Healthy ageing" was supposed to be promoted mainly by technology support.[151] In particular, this meant developing "technologies to allow older people to live independently and be active in society."[152] In 2011, a model partnership between industry and science, the "Active and Healthy Ageing" alliance, was formed to realize this goal.[153] Beyond rising costs of health and social systems due to demographic aging, this choice of topic was explained by the interests of active industrial sponsors. Large companies in the food, pharmaceutical, and IT industry collaborate with scientists and policy-makers in this alliance.[154] In 2015, future key domains in research, education, and innovation were evaluated by the EU Directorate General "Research." The appointed expert group "Health" highlighted demographic change as well as technology and globalization as the long-term mega-trends influencing research and development, and also tertiary education in Europe.[155] In view of demographic aging, the group emphasized that (1) global population movements change the spread of infectious diseases and (2) altered life styles and environmental conditions change the manifestations of non-communicable disorders. In particular, age-specific approaches were necessary to combat obesity, degenerative, and mental disorders. Genes, environment, and life style needed to be regarded as causal factors and should replace organ-centered therapeutic approaches. According to the group, health research was primarily still carried out in national contexts, but institutionalized cross-border collaboration such as that carried out in physics (CERN), molecular biology (EMBL), and space research (ESA) could serve as a model.[156] It must be noted that in both of these emphasized points, demographic change was discussed (1) as being due to migration and (2) as being associated with the life course rather than ageing.

In a new vision paper targeting the 2020-30 period[157], the tension between the threat of a ticking "demographic time bomb" on the one hand, and the gain of life years[158] on the other, has been opened up. As a vision for the future, the positive "change scenario" of demographic development is of great significance: Populations could lead 100 years of a productive and healthy life, social inequality could be reduced, and ecological living conditions could be improved. Education would be a lifelong effort and health would be interpreted as well-being in healthy working environments and with an adequate work-life balance, reflecting a very expedient but also very ambitious scenario. However, this backdrop helps to understand a number of the currently active EU initiatives that are summarized in the following (Table 1).

III.1.3 EU Funding Initiatives

In the *7th RFP*—the predecessor of the current "Horizon 2020" (H2020) program—the agenda for ageing research was already

150 Suhrcke M et al. (2005).

151 Achieving the goal of "healthy ageing" was defined as addition of two additional healthy years of life according to the Healthy-Life-Years indicator.

152 "Health and demographic change" was highlighted in the summary of the Innovation Union of 2010; cf. European Commission (2010).

153 International Longevity Alliance (2017).

154 The CEOs/VPs of GlaxoSmithKline, Danone, Johnson & Johnson, Nokia, Tunstall, Vodafone are listed in the operational plan; cf. Steering Group of the European Innovation Partnership on Active and Healthy Ageing (2011).

155 In the context of Horizon 2020, a group of 27 experts, most of them scientists, were asked to give their opinion on health- and biomedical research of the future. Borch K et al. (2015).

156 European Commission's Scientific Panel for Health (2016).

157 European Commission (2017).

158 Kocka J, Staudinger UM (2009).

thematically concentrated on biomedicine, but certainly more extensive within this spectrum than in the current version. Research on healthy ageing, age-associated illnesses, prevention, and disease management was to be supported, and biomedical advances were to be considered. In particular, biomarkers of ageing, developmental processes in long-lived organisms, immune systems in old age, determinants of ageing and longevity, and the influence of the environment as well as frailty were to be investigated. The participation of older people in clinical studies was to be increased and a road map for ageing research in Europe was to be developed (see next below).

The road map for ageing research "Futurage" (2011), developed with funds of the 7th RFP, was elaborated in a comprehensive scientific and societal consultation process in 13 EU countries.[159] The following priorities for the coming years were selected in this research agenda:

- Healthy ageing (defined here as the ability to participate socially, be productive, and lead a physically- as well as cognitively-independent life);
- Maintaining and regaining mental capacity;
- Inclusion and participation in the community and in the labor market;
- Quality and sustainability of social security systems;
- Ageing well in the domestic and local environment;
- Inequalities in relation to old age and ageing (migration and old age, socio-economic inequalities, gender);
- Biogerontology: From mechanisms to interventions.

Table 1. Overview of Relevant EU Funding Initiatives

Acronym	Title	Definition
7th RFP	Seventh Research Framework Programme 2007-2013	The EU's framework program for research and innovation
H2020	Horizon 2020 (2014-2020)	The EU's framework program for research and innovation, successor of the 7th RFP
ERA-Nets	European Research Area- Nets	Networks of national research organizations
JPI	Joint Programming Initiatives	Networks of member state supporters without prior agreement of funding
Article 185 initiatives		Joint research programs of several member states according to Art. 185 of the EU Treaty
AAL/IMI	Active and Assisted Living Programme/ Innovative Medicines Initiative	Programs according to Art. 185
EIT Health (KIC)	European Institute of Technology—Knowledge and Innovation Community Health	Consortium of enterprises and academia, six centers in EU
ERC	European Research Council	Individual research funding

159 From Germany, the ageing researcher and psychologist Hans-Werner Wahl, Universität Heidelberg, was involved. Walker A (2011).

Although the EU Commission itself had called for the development of such a research funding agenda, its results were presented and discussed in the European Parliament, and the European Economic and Social Committee (EESC) had provided comments,[160] no reference was made to it in the further development of the later funding programs nor was a strategic discussion initiated among policy-makers and the authors of the road map.[161]

The EU Commission also analyzed the findings of economic ageing research of the 7th RFP, although these also did not enter into the shaping of the following program.[162] According to these findings, the multi-dimensional character of ageing and sociopolitical interventions (including family, social, labor market, and economic policies) on the one hand, and the development of human capital throughout the life course on the other should be investigated in greater depth.

Strategic suggestions were also presented in the context of family policies in the life course and in generational succession, as developed by the "FamiliesAndSocieties" project of the 7th RFP. The linkage between data on familial life events and data on educational and labor market data was called for.[163] Supported by broadly-based sociopolitical consultation, the "Family Platform," a coalition of twelve research institutions, developed a research agenda.[164] Care of children, elders, and frail individuals as well as the integration of caregiving in individual and familial life courses, family policy that does the increasing diversity of family forms and minorities justice, the transitions of young adults into working life and parenthood, vulnerability, and risks of poverty were identified as important areas for social policy, as well as research.[165]

In 2010, after the first half of the term of the 7th RFP, an EU-funded road map of future research was also developed for molecular biogerontology. It lists twelve research priorities ranging from the development of biomarkers for ageing and longevity to telomere research, and on to metabolism research.[166] Furthermore, a road map on the use of information and communication technology in the context of ageing was developed with funding from the EU, with involvement of the project manager VDI/VDE-IT on the German side. In the fields of independent living, health, work, and leisure, research funding should target the establishment of an assistive environment including information and communication technology.[167]

However, no reference was made to any of these strategic reports in the following Horizon 2020 program.[168] In the funding announcements, only the strategic research agenda on personalized medicine, the road maps on eHealth and on assisted living, and the European Framework for Action on Mental Health and Wellbeing were taken into account.

In the current research funding program Horizon 2020 (2014-20 term) one section is devoted to several so-called "societal challenges," one of which is "Health, Demographic Change and Well-Being." In

160 EESC (2012).

161 Expert interviews.

162 European Commission, Directorate-General for Research and Innovation (2014).

163 Di Giulio P et al. (2013); Carlson L, Oláh LS, Hobson B (2017).

164 Rupp M et al. (2011).

165 Ibid.; Kapella O, de Liedekerke AC, de Bergeyck J (2011).

166 CORDIS (2011).

167 Hadjri K (2012

168 E.g. the scientific advisory board on "Health, Demographic Change, Wellbeing" with its strategy paper on health research, the consultations for the work program 2018–20 (cf. Horizon 2020 Advisory Group for Societal Challenge 1, "Health, Demographic Change and Well-being" [2016]) , and the cross-initiative "European Summits on Innovation for Active & Healthy Ageing" in 2015 and 2016 (cf. European Commission [2015c]; European Commission [2016e]; European Commission's Scientific Panel for Health (SPH) [2016]).

Table 2. ERA-Nets Related to Ageing and the Life Course

Acronym	Topic	Relationship to Research on Ageing and the Life Course	Term	Total Budget (Million EUR)
Ongoing				
NEURON	Neurosciences, neuro-degenerative diseases	Neurodegenerative diseases gaining importance in the context of demographic ageing (e.g. Call 2008)[1]	2007-2020	115.5[2]
NORFACE	Social sciences	Welfare State Futures; DIAL (Dynamics of Inequality Across the Life Course) on labor market integration in late adulthood and the transition into retirement, for example	2004-2021	70[3] (total, 18 of which for DIAL and Welfare State Futures respectively)
Completed				
CoCanCPG EUROCOURSE	Cancer	Cancer regarded as an age-correlated illness[4]	2006-2010	3.15[5]
ERA-AGE	Ageing	Postdoc support program FLARE (Future Leaders of Ageing Research in Europe), First Europe-wide Call for Active and Healthy Ageing Across the Life Course	2004-2012	4.6[6]
WORK-IN-NET	Innovation of work	"Building the Workplace of Tomorrow": Shaping work settings for older people and intergenerational transfer of knowledge and experience	2004-2010	1.93[7]

1 ERA-NET NEURON (2008).
2 For 2008-2017.
3 NORFACE (2017).
4 CORDIS (2010).
4 Ibid.
6 CORDIS (2009a). CORDIS) (2016b).
7 European Commission (2004).

this context, "translational, collaborative health research" is supported, which should contribute to better health and increased well-being as well as more active and healthy ageing.[169] The budget for this is 7.47 billion EUR (less than 10% of the total 80 billion EUR for the entire H2020 program).[170]

Nevertheless, the thematic specifications of the RFP do not fully reflect the strategic orientation of the funding of research on ageing and the life course.

Formally under the roof of Horizon 2020 but independent in terms of content, a number of longer-term and cross-national associations (with and without their own EU budget) developed their own strategies to support research. The common budgetary obligations of the associated member states (usually involving only some of the EU member states) reflect the EU's thematic funding priorities. These associations include ERA (European Research Area)-Nets, JPIs, Article 185 initiatives, European Innovation Partnerships, and European Joint Programme Cofund Actions. In the following, we summarize those activities of such associations that are related to research on ageing and the life course.

169 European Commission (2015b).
170 European Commission (2013).

ERA-Nets allow joint announcements of national funding agencies (Table 2). Among the current 64 (55 with German involvement) ERA-Nets (since 2014), less than 10% can be thematically assigned to the domain "Health, Demographic Change and Well-Being"[171] and only few have clear references to ageing and the life course. The only ERA-Net specifically focusing on ageing (ERA-AGE) hardly involved any German participants (funded from 2004 to 2015). Among others, several research funding agencies announced funding of more than 4.2 million EUR for research on healthy ageing, which led to support of six multinational research projects.[172] Furthermore, several postdoc stipends were awarded (FLARE—Future Leaders of Ageing Research in Europe). Linkages to research on ageing and the life course can also be found in the ERA-Net on neurodegenerative diseases; in cancer research and systems biology, ageing only plays a role as one of many risk factors. Among the non-biomedical ERA-Nets, one is on social inequalities in the life course, and a completed one is on innovations in the working world regarding older employees.

Whereas the setting of topics of ERA-Nets is described as strategic and top-down in most other fields such as bio-economics or energy, the field of health is characterized by a mixture of topics that are defined and advanced by member states.[173] Across the EU, the ERA-Net instrument is regarded as hardly being integrated into national strategies and as having little strategic power itself due to a lack of initiative on the part of some member states.[174] The 15-year history of the ERA-Net on neurodegenerative diseases (with German involvement) shows that it took 5 years after its foundation in 2003 until the first calls for research proposals were made in 2008, and until 2015 for a joint strategic agenda to be formulated.[175]

Taken together, the ERA-Nets are nevertheless a significant support instrument that raised more than 650 million EUR in total for announcements together with JPIs in 2016. Particularly the recently introduced co-funding by the EU increased the budget considerably. In Horizon 2020 it is now necessary to make at least one call for research proposals in an ERA-Net, which is then topped up by EU funds.[176] The instrument has thus gained significance, and this will benefit the two ongoing ERA-Nets relevant to research on ageing and the life course.

Existing since 2008, the European funding program **Joint Programming Initiatives** (JPIs; Table 3) is another research support instrument of strategy development across nations. JPIs connect government departments and funding organizations of member states and associated countries, which then agree on joint goals with the help of researchers.

One of the ten currently active initiatives is working on ageing in the narrow sense of the word under the title *More Years, Better Lives* (MYBL). It builds on the findings of the Joint Academy Initiative on Ageing, published under the title "More Years, More Life." More than 8.4 million EUR were raised by the participating countries for the first two calls for research proposals (in 2015 and 2016). They focused on the extension of working life and the social state (the latter without German involvement). The current call for proposals is on ageing in the digital world. The German Federal Ministry of Education and Research [Bun-

171 European Commission, Directorate-General for Research and Innovation (2016). Number of active ERA-Nets, ERA-Cofund, and ERA-Plus measure according to https://www.era-learn.eu (retrieved September 12, 2017).

172 The topics were: "Continence," "Assisted active living," "Mobility in daily life," "Health in nursing homes," "Healthy ageing at work and after retirement," and "Hearing."

173 Ibid.

174 European Commission (2016a).

175 The Lancet Neurology (2016).

176 Niehoff J (2014).

Table 3. Joint Programming Initiatives Related to Research on Ageing and the Life Course

JPI Title	Term	Budget (Calls) in EUR[177]
Neurodegenerative Diseases (JPND)	2009-2020	96 million (2011-2015)
A Healthy Diet for a Healthy Life (HDHL)	2010-2019	50 million
More Years, Better Lives—The Potential and Challenges of Demographic Change (MYBL)	Since 2010	8.4 million (2015-2016)
Urban Europe—Global Urban Challenges, Joint European Solutions	Since 2011	41.7 million

desminsterium für Bildung und Forschung, BMBF] initiated this funding scheme, but its management then moved into the hands of Italian, and later Dutch researchers and research support organizations.[178]

A further JPI concentrates on *neurodegenerative diseases*. It is the oldest JPI and was initiated by France, originally focusing on research on Alzheimer's disease. With the involvement of 23 EU member states and another seven countries including Israel and Canada, it is the largest JPI (MYBL is the smallest), including regarding the budget of its calls for research proposals.[179] Between 2011 and 2015, projects and centers (in Germany, the Deutsches Zentrum für Neurogenerative Erkrankungen (DZNE) [German Center for Neurodegenerative Diseases], one of the JPI founding organizations) were funded by the EUR with 96 million EUR in total.[180] The JPI on nutrition also includes the contribution of nutrition to healthy ageing as well as elders' specific dietary needs[181] and was able to provide 50 million EUR of research funds.[182] Another JPI focuses on urbanization and life styles but does not explicitly refer to ageing and the life course. However, population diversity, settlement patterns, active lives, and urban environments are investigated aspects and factors that are relevant for research on ageing and the life course.

The JPI on neurodegenerative diseases is the only one in this field that has estimated the funding budgets invested across the EU and thus created a basis for efforts to merge or complement research. Many JPI chairs have indicated a lack of coordination with Horizon 2020 and other programs and structures on the national level. An evaluation of JPIs published in 2016 could not find any reference to JPIs in national research funding policies.[183]

Besides ERA-Nets and the JPI, there is more large-scale funding of collaborative projects on the field of ageing and the life course. Article 185 initiatives (based on the article of the EU Treaty), established in 2014, need to be mentioned in this context. In contrast to the loose JPI associations where consortium member states can participate in research calls on a case-by-case basis or not, these initiatives are a support program scheme with financial commitments on the part of the involved EU member states. Among these long-term initiatives, particularly technological and medical research are relevant to the topics of ageing and the life course. From 2008 to 2020 1.4 billion EUR were spent on, or budgeted for, support of technolo-

177 Terms are included if this information is publicly available.

178 JPI MYBL (2016b).

179 Hunter A et al. (2016).

180 JPND (2014).

181 JPI HDHL (2015).

182 JPI (2016a).

183 Hunter A et al. (2016).

gy in the *Active and Assisted Living Programme*, a sum that is equally distributed between public and private funds. This initiative lists more than 150 projects, with German firms or researchers involved in more than 60 of them and most led by partners in industry.[184] Between 2009 and 2013, the BMBF made 45 million EUR available for assistance systems relevant in old age based on microsystems engineering and information and communications technology.[185] The BMBF ended its involvement in this program in 2014.[186]

The *Innovative Medicines Initiative* (IMI) was decreed by the European Council in 2008.[187] It is the EU's financially largest research funding initiative and was also established as a cooperation between industry and publicly funded research. From 2008 to 2013, 2 billion EUR were spent on research, half from the EU budget, the other half from private industry. Between 2014 and 2020 about 3.3 billion EUR are to be raised, 1.6 billion of which coming from the EU. The development of new medication is the foremost aim of the IMI.[188] The greatest part of the IMI budget (39%) goes to research on infection. In the second funding period since 2014, geriatric medicine is in special focus and will receive about 48 million EUR. The second strategic IMI research agenda (since 2014) follows the setting of priorities by the WHO, which puts age-related illnesses on the ninth place of a priority list.[189]

For the *European Institute of Technology* (EIT), founded in 2014 within the Horizon 2020 framework, the EU Commission also selected health and active ageing as one of the research foci. EIT Health has about 80 million EUR per year available for seven years. Healthy ageing is to be achieved via interventions at the workplace and to provide support in case of cognitive, motor, and metabolic dysfunction at work and in daily life.[190] The headquarters are located in Munich; Mannheim and Heidelberg are further centers in Germany. It is EIT Health's aim to support educational programs and public campaigns, commercial applications in the health domain, as well as applied research under the leadership of non-academic partners.

In addition, the EU began a 10-year brain research program (Human Brain Project) in 2013, involving neuroscience, medicine, and information sciences. The establishment of infrastructure is at the core of the program, comprising six technology platforms to share data and also computer capacity among the scientists involved, but also to develop computer models and applications. Studies on ageing or life-course processes play almost no role at all.[191]

III.1.4 EU-Funded Research on Ageing and the Life Course in Germany

Following the analysis of the prioritization (or the lack thereof) of topics concerning research on ageing and the life course on the program level of EU support, the distribution of funds to research projects is relevant for this report. Exemplarily, we consider the largest of the 640 projects with German involvement to be found under the keywords "ageing/aging." In the period of interest, nearly 300 of such projects were funded with more than 1 million EUR each and about 180 with more than 2 million EUR.[192]

184 AAL (2014); European Parliament, Council of the European Union (2008).

185 AAL (2016).

186 KoWi (2016).

187 Council of the European Union (2014).

188 Vaudano E (2013).

189 IMI (2010b).

190 EIT (2015).

191 Exceptions: Krubitzer LA, Prescott TJ (2018); Calabrese V et al. (2018) on Parkinson's disease.

192 From 5th Research Framework Programme (1998) onwards. The figure is only an approximation as the keyword search also leads to, e.g. "ageing power stations" or nanotechnology. Due to multiple allocations in the EU project database, it is not possible to delineate clearly how the projects are distributed across disciplines. This was done by own evaluations based on the title and abstract. This leads to 112 projects under life sciences, 91 under medicine and health, 97 under natural sciences (including biology), and 55 under biotechnology.

In **medicine**, the largest project is SPRINTT (54 million EUR total budget for 5 years), a 3-year intervention study on the topic of sarcopenia and frailty, with leading participation of Sanofi and the Universität Erlangen-Nürnberg as German research partners.[193] Frailty is also examined in another project (5 million EUR, Universität Siegen) in terms of non-medical environmental factors. In 2017 yet another frailty research project began, involving the Medizinische Hochschule Hannover on the German side (ADVANTAGE; 3.5 million EUR for 3 years). This project is based on the activities of the European Innovation Partnership on Active and Healthy Ageing (EIP-AHA). However, taken together, research on cardiovascular diseases—including projects on medical technology—receives the greatest share of EU research funds. About 112 million EUR (public and private) are invested here, with substantial participation of Philips, the Charité, institutes of the Fraunhofer-Gesellschaft, the universities of Frankfurt, Aachen, Heidelberg, and various Max Planck Institutes. Cancer follows cardiovascular diseases in second place with about 62 million EUR (Charité, Deutsches Krebsforschungszentrum, universities of Erlangen-Nürnberg, Medizinische Hochschule Hannover, Tübingen, Jena, Aachen, and others). At least two projects with funding of more than 2 million EUR are on diabetes, musculoskeletal, and liver diseases (universities of Erlangen-Nürnberg, Dresden, Hannover, Mainz). In the research on lifestyle factors modifying health and ageing, nutrition is in the focus of attention (universities of Saarland, Bonn, Heidelberg, Tübingen, Mannheim, Regensburg, Erlangen-Nürnberg, Robert Koch-Institut). One of the largest projects in this context is on the association between the urban environment and the quality of life, in which longitudinal cohorts are merged (Mindmap; 5.5 million EUR; German partner: Albertinen Krankenhaus Hamburg).

193 IMI (2010a).

Regarding the **biomedical factors of ageing,** organ-related investigations of pathological ageing are at the forefront, and they include prevention and care beyond the main topic of treatment. In the domain of brain research, neurodegenerative diseases, particularly Alzheimer's disease, are primarily examined. The largest individual project is on imaging of neuroinflammation in neurodegenerative diseases (about 25 million EUR) headed by Universität Münster. On the whole, cellular/genetic approaches to the examination of neurodegenerative diseases have priority. One of these research projects not only focuses on brain pathology, it considers the continuum of health to illness (for Parkinson's disease, PROPAG-AGEING, about 6 million EUR, with participation of the University of Göttingen).

In basic **molecular biological research**, which does not focus on specific organs, the largest individual project is devoted to epigenetic plasticity of the genome. The epigenetics of ageing is the topic of another large project (IDEAL, over 10 million EUR in total, with the University of Tübingen). Nuclear receptors and proteome analyses in the context of ageing and the biology of the life course are topics of further large research projects. Deutsches Krebsforschungszentrum, the University of Tübingen, and the European Molecular Biology Organisation (EMBO) play a role in most of the large-scale molecular biological research projects, together with many other institutes and universities.

Several projects in Rostock and Berlin (Humboldt-Universität) focus on healthy ageing. Furthermore, the merging of medical cohort studies/biobanks is funded in two projects. The University of Bonn is involved in a smaller completed project, and Helmholtz-Zentrum München (German Research Center for Environmental Health) is participating in an ongoing large project that is funded with 10 million EUR.

Most projects in the domain of ageing research within the **engineering sciences** serve to develop healthcare-related applications, including individual robots, microsensors, and with private industry participation, pharmaceutical development. A further area is the use of IT in certain environments such as health or administrative facilities, or the urban environment, as well as by certain groups like older people. The institutes of the Fraunhofer-Gesellschaft are most strongly represented on the German side. The universities of Stuttgart, Dresden, Düsseldorf, Freiburg, Bonn, Hamburg, the Charité in Berlin, Münster, and Erlangen-Nürnberg also play an important part.

In the **social and behavioral sciences**, the Survey of Health, Ageing and Retirement in Europe (SHARE) received about 17 million EUR per year (from the 7th RFP onwards). Furthermore, there are smaller social-science projects concentrating on economics, work, and employment, but also on well-being and social cohesion, involving universities in Berlin, Bremen, Hamburg, Vechta, Hannover, and Rostock.

In contrast to the programmatic support within the focus area "Health, Demographic Change and Well-Being" (H2020), funding via the **European Research Council** (ERC) is granted only based on the respective project's quality and the researcher's profile, and the topic is up to the applicant. Studies funded in this context can be regarded as individual support without involvement of private industry and thus as classical basic research. Accordingly, they can provide information about which facets of ageing and the life course are being investigated without direct programmatic stipulations.[194] ERC funding particularly targets research projects promising significant scientific breakthroughs. Such breakthroughs are mainly expected in high-risk research with high levels of interdisciplinarity.[195]

Of the around 370 recipients of an Advanced Grant and the around 570 recipients of a Starting Grant that were awarded to researchers at German institutions since 2007 as well as the around 260 recipients of Consolidator Grants since 2013, about 50 work on questions of ageing and the life course in the wider sense. Of these ERC grants, 41 are associated with the life sciences, all of which are in the context of genetics and cell biology. Cologne, Munich, Göttingen, Frankfurt, and Berlin (Freie Universität/Humboldt-Universität) are the sites that were able to obtain several grants. Eight ERC grant allocations can be classified as being in the social and behavioral sciences, or in the humanities, but sometimes in a border area. Two allocations are to be found in the natural and engineering sciences (informatics and synthetic chemistry/materials research).[196]

In comparison among the European applicants, the granted projects from Germany are generally more than averagely often in the life sciences, and this is no different for ageing research.[197] According to an analysis by the ERC, the most references to ageing (excluding neurodegenerative diseases) among all ERC projects are to be located in the fields of physiology and endocrinology as well as the neurosciences and public health. In the social sciences and humanities, they concentrate on the field of population research/demography.[198]

In summary, only few of the ERC Advanced, Consolidator, and Starting Grants allocated to researchers in Germany are

194 However, it is necessary to consider that, in the long run, the perception of future career chances, scientific socialization at programmatically influenced centers, and appraisals of the prospects of success at high-ranking journals can impact researchers' thematic and methodological choices over and above a concrete call for proposals.

195 ERC (2017).

196 For a list of German grantees, cf. Appendix.

197 ERC (2015).

198 Ibid.

for projects referring to old age, ageing, or the life course. Among those few that do exist, the proportion of non-biomedical projects is vanishingly low.

III.2 Examples of Research Funding Policies of Other Countries for Evaluation Guidance: Netherlands, Sweden, France, UK, US

Besides the EU research support policies and the actual funding, it seems helpful to turn to several European neighbors to consider their policies regarding research on ageing and the life course. Brief sketches of national foci and research funding successes, along with cited sources based on assessments provided by experienced researchers on ageing and the life course from the respective country (expert interviews carried out in April-June 2017) help to identify possibilities and potentials of funding schemes, evaluate the German support and research, and draw conclusions for the German situation from international experiences.

The numbers of publications or citations need to be seen in relation to public research investment, which can be reflected in the number of researchers (Table 4).[199] Specifics in publication practices, in terms of language, formats, and their capture by international databases also need to be taken into account when carrying out such comparisons, so that a contrasting of personnel and publication statistics can only provide an approximate assessment of a country's research performance. While it is clear that the listed countries' research outputs cannot be directly compared due to their divergent sizes and research budgets, researchers can neither be classified by topics nor in terms of their time investment, productivity, or the quality of their findings.[200] Nevertheless, particularly noticeable differences in topic-specific publication rates allow conclusions about the research foci set in the research funding policies of a certain country.

Netherlands

From the end of the 1980s onwards, the Dutch Ministries of Research and of Health gave important impulses for research on ageing and the life course with the ageing research program NESTOR (Nederlands Stimuleringsprogramma Ouderenonderzo-

Table 4. Research Personnel[1] in Full-Time Equivalents (FTE) in Comparison to Germany (Rounded, in Relation to Population Numbers, FTE per 10,000 inhabitants)

	2006	2010	2015
Germany	13.2	17.2	18.8
United Kingdom	24.4	26.3	27.3
France	14.5	14.9	15.8[2]
Netherlands	14.8	15.9	18.5
Sweden	18.3	19.1	21.9

1 Personnel in the public and non-profit sector, OECD definition according to Frascati handbook.

2 Count for 2014.

Source: Main Science and Technology Indicators 2016

199 In particular, the Netherlands and Sweden belong to the top research countries within the EUR and associated countries (alongside Switzerland, Denmark, and Israel) according to the JRC index that relates the most cited publications, university rankings, patents, and ERC grants to population size and research and development investments. The UK, as a country of comparable size to Germany, is also a front runner. Hardeman S et al. (2013); OECD (2015).

200 Discussion of input and output in the performance measurement of research, e.g. Waltman L et al. (2016).

ek). On the one hand, it stimulated intense discussion of strategy in its steering committee, and on the other hand, it supported the establishment of substantial research capacities in medicine, psychology, and the social sciences at various universities, especially by collecting longitudinal data. The initiation of the Longitudinal Aging Study Amsterdam (LASA) fell into this funding period. Its interdisciplinary approach (social sciences and biomedicine) was a response to the observed problem of fragmentation by discipline. Further population-based studies were initiated in Maastricht, Rotterdam, and Den Haag, and later also in Leiden.

After the initial phase until the mid-1990s, several funding programs of limited effect followed until more funds went into research in the framework of the BeterOud program of the Ministry of Health and Social Matters in 2008-16, albeit only into biomedical research (about 80 million EUR in the first four years). In addition, 65 million EUR are going into research on dementia across eight years until 2020. The European participation—for instance—in the JPI on neurodegenerative diseases (JPND) is part of this research support. As a priority, funds were provided for new health interventions, particularly clinical studies.[201]

At a low level, the Netherlands Organisation for Scientific Research (NWO) has funded ageing-related research via programmatic calls for research proposals. From 2012 to 2014, the NWO mainly issued calls on the topics of old-age provision and care in the field of "social security", and from 2008 until 2015 longitudinal studies were funded within a separate program (and then merged under the umbrella of a national infrastructure), among them LASA, SHARE, and TRAILS as studies on developmental trajectories and ageing. In the framework of the national initiative "Brain & Cognition" 35 million EUR were made available for 2010-15. Although ageing and development was not a separate program area, it is represented in the three foci of learning, health, and security.[202]

In comparison to the longer established field of ageing research, that of life-course research is not only smaller, but also more disparate. The two research communities and their data infrastructures are not integrated, although ageing research could benefit from the well-developed research infrastructure of longitudinal studies whose participants have meanwhile reached or even passed middle adulthood.[203]

In the Netherlands, public and industrial research funds are merged, especially in the domain of pharmaceutical research. The Healthy Ageing Campus of the University of Groningen that was started in addition to established research groups in the field of ageing is an example of the desired integration of public research and industry in the field of medicine. Groningen is also the location of the population-based LifeLines study that will accompany and examine three generations. The study begins before birth and continues into very old age. Like the National Cohort health study in Germany (that only begins at age 20 and continues to age 69; see sub-section on BMBF funding of health research in Section II.3.1), its focus is on classical sociodemographic variables as well as biomedical information. Variables that describe participants' experience and behavior are, if available at all, under-represented. LifeLines is supposed to capture the interaction of environmental factors with genetic and phenotypic characteristics with the aim of investigating healthy ageing and chronic diseases.[204] Beyond the University of Groningen, a research conglomerate of eight medical

201 Expert interviews.

202 NWO (2015).

203 Smits CHM et al. (2014).

204 Scholtens S et al. (2015).

research institutions at Dutch universities (NFU) also put active and healthy ageing on the agenda in 2011.[205]

Furthermore, a national public participation process on setting the agenda for research until 2025 was completed in 2015. This agenda lists five societal challenges to be worked on in research, among them "Quality of life from childhood until old age." Quality of life is understood as physical, mental, and social well-being.[206] "Medicine" and "Cognition, brain, and behavior" are further foci.[207] Other strategic processes take up ageing as an economic challenge/chance in innovation support and within the context of regional prioritization such as healthy ageing in the northern areas of the country. These foci represent guidelines for the government's as well as funding agencies' research support policies.[208]

Sweden

Sweden has a special ageing research infrastructure. This is promoted by the fact that, subject to clear data protection regulations, official registry data are available for research (just like they are in the other Scandinavian countries). They are linkable by a personal identification number that every Swedish inhabitant has received since 1947 after more than a year of residence. The registry data comprise demographic information such as birth, marital status, moves, education, work, medical information, income, and residential situation. This singular data situation provides Sweden, and the other Nordic countries, with a considerable advantage in the (anonymized) longitudinal observation and research of the life course and ageing. The Swedish data can also be used by researchers in other European countries. The application for data and their use is also less difficult and the likelihood of permission to link official data sets with research-initiated studies higher than in other European countries.

The beginnings of Swedish ageing research are closely associated to individual local pioneer studies, mainly the Gothenburg H70 study, an examination of 70-year-olds begun in 1970, regarded as significant for the longitudinal studies being taken up at that time.[209] The Stockholm and the Betula study belong to these pioneering studies at a time when ageing research was still in its infancy internationally. The public healthcare system with its interest in the needs of older people, in provision of care and prevention, gave the initial impulse for this research, which science then followed up on.

From 2000 onwards, Swedish ageing research was granted three further sources of support. First, national population studies such as the Swedish National Study of Aging and Care (SNAC) were initiated. Second, calls by the Swedish Social Research Council led to the founding of several multi- and interdisciplinary ageing research centers that receive(d) 0.5-1 million EUR per year.[210] Third, the universities have provided funds for the medium-term support of ageing research. Thanks to their size and duration, these programs also support multidisciplinary collaboration rather than the individual projects alone.

The founding of competence centers has led to a concentration of ageing research in Sweden at the Karolinska Institute's Ageing Research Centre (ARC), at the University of Lund in neurosciences and

205 NFU (2012).

206 DuSRA (2016b).

207 De Haas (2017).

208 NWO (2013); OECD (2014).

209 Davey A, Malmberg B, Sundstrom G (2014).

210 Partial funding by the Swedish Science Council, up to about 1 million EUR/year for each center for a period of ten years. Forte (2017). Among others, the Centre for Ageing and Health (AgeCap), the Ageing Research Centre (ARC), the Centre for Ageing and Supportive Environments (CASE), the Centre for Health Equity Studies (CHESS), and the Swedish Institute on Social Research (SOFI) are part of this initiative.

stem cell research, and at the University of Stockholm in genomics as well as the fields of applied social and behavioral sciences such as social policy research and public health.[211] This focus-shaping research support policy has meanwhile been replaced by strengthened individual funding, and since 2018, parts of the budget of renowned centers like ARC have to be funded by the respective university or via third-party funds.

In the last five years, research interest in ageing in Sweden has been further intensified by impulses from Horizon 2020 and the EIT Health. Researchers of aging and the life course expect positive effects of the Nordic countries' plan to unify the data processing of health and social registers and of biomaterial databases. The main aim is to ease and improve the linkage among molecular-biological, medical, social, and behavioral research.[212] The Swedish National Data Service SND, established in 2008, now makes available approximately 2000 data sets in the health and social sciences and humanities, and supports the entire data management process as well as training to improve usage.

Ageing and demographic change are prominent topics in Swedish politics, which uphold a strong connection to research in this domain. The Commission on the Future of Sweden that was initiated by the Prime Minister regarded demographic changes, particularly the rise in life expectancy, the decreasing proportion of the labor force within the population, migration, and societal cohesion as central developments determining Sweden's future in the coming decades in the context of globalization and the need to achieve a sustainable economic system.[213]

The topic of ageing is well represented in research and innovation policies, not least to improve public services and achieve longer working lives and broader labor market participation with the help of research and development.[214]

The government has labeled demographic change as a societal challenge in its research strategy. The main research support field comprises the life sciences with a focus on molecular biology. Sweden's strategic research aims also feature research on cancer, diabetes, stem cells, and regenerative therapies, the neurosciences, and health services research, albeit a little less prominently. Regarding research budgets, epidemiology and psychiatry are ranked third; specifically, the life course and health belong to the field of epidemiology. The thematic foci in this area are reproductive epidemiology (perinatal influences), psychiatric impairments in the life course, and multimorbidity in old age.[215] Cooperation with industry is a stated political intention.[216]

France

Ageing research has also been targeted by research funding in France over the past decade. This occurred in the context of national plans for the strengthening of prevention and healthy ageing[217] that led to the law passed in 2014 on the "adaptation of society to ageing," which acknowledges the "Revolution of ageing" as a "sign of progress of French society." In light of consequences for health, residential, and social policy, medical, particularly geriatric, and epidemiological research are funded via the Ministries for Health and Seniors, but also via the Ministry for Research. Since the 1990s, so-called Scientific Interest Groups [groupement d'intérêt sci-

211 Aksnes DW et al. (2012).

212 Standardization of legal and ethical procedures of access and use, technical instruments, especially a common data platform for researchers. Nordic eScience Strategy 2007, cf. Norden (2012); NordForsk 2017.

213 Government Offices of Sweden (2013).

214 Government Offices of Sweden (2015).

215 Karolinska Institutet (2015).

216 Swedish Ministry of Education and Research (2008).

217 Broussy L (2014), Pinville M (2013), and Aquino J (2013) were commissioned by the Prime Minister to report on the adaptation of society to population ageing and thus made a significant impact.

entifique—GIS] bringing several existing institutions together on a topic (but not physically under one roof) can be founded via the Centre national de la recherche scientifique (CNRS). Among them, there are several biomedical research groups on ageing and the life course as well as one that also focuses on ageing in a regional perspective.[218] The Institute for Longevity and Ageing [L'Institut de la longévité, des vieillesses et du vieillissement], founded in 2002, resulted from such a GIS.[219] It concentrates on pathophysiology, research on medical interventions, and technological support of old age. [220]

The National Health Research Institute INSERM [Institut national de la santé et de la recherche médicale], which is involved in the Institute for Longevity and Ageing together with CNRS and the Institut national d'études démographiques (INED), also hosts the population-wide cohort study GAZEL on the influence of working conditions on health and disease in old age, which was established by occupational physicians in 1989,[221] as well as the population-wide epidemiological cohort study CONSTANCES, which builds on GAZEL. CONSTANCES was started in 2012 to assess the influence of factors such as environmental pollution, dietary habits, pharmacotherapy, etc. on the health of the French population.[222] Both studies collect extensive psychological, sociological, and biomedical data and bear great potential for international cooperation.

Since 2007, six health service networks so far have been founded regionally under the name "Gérontopôle," where clinical research and healthcare services collaborate with regional administrative units, companies, senior citizen's institutions, and associations. Funding is directed towards the treatment of certain illnesses such as Alzheimer's disease as well as research on the optimal support of independent living in old age. In 2015, the network involved about 35 research projects, eleven of which were carried out nationally as clinical studies. In the past decade or so, the Ministry of Health has provided special funding for geriatric-clinical research, beginning with the "Program for geriatrics" of 2006, with which clinics were to be prepared for the coming rise in geriatric patients.[223]

Non-medical ageing research is influenced by EU associations such as the JPIs or the involvement in SHARE. There are only a few larger centers such as those at INED and INSERM, and they mainly target health issues.[224]

United Kingdom

Since the end of the Second World War the UK has systematically funded longitudinal birth cohort studies. In 1946 the Medical Research Council (MRC) started the National Survey of Health and Development (NSHD), the oldest study of its kind.[225] For life-course research, support of "The Cohort and Longitudinal Studies Enhancement Resources" (CLOSER) network seems particularly important, as it merges NSHD and seven further longitudinal studies—four of them birth cohort studies—to improve their data quality, allow their linkage and cooperation, and train researchers in the use of the collected data.[226]

218 Expert interviews.

219 With the support of Etienne-Emile Baulieu, then Vice-President of the Académie des sciences, in partnership with INED, INSERM, and the Alzheimer Society, initially funded by the Ministry of Research with 1 million EUR/year, and via INSERM since 2005. Available at http://discours.vie-publique.fr/notices/023001747.html (retrieved December 6, 2017).

220 Mariani J, Hansler MF, Baulieu ÉÉ (2006).

221 Goldberg M et al. (2007)

222 Zins M et al. (2010). Participants aged 18–69 years, carried out by the Research Center for Population Epidemiology and Health (CESP—Inserm/Université Paris-Sud/Université de Versailles Saint-Quentin-en-Yvelines—UVSQ) in partnership with the CNAMTS (national health insurance for employees) and the CNAV (national pension insurance).

223 Jeandel C, Pfitzenmeyer P, Vigouroux P (2006); Jeandel C et al. (2011).

224 Tuchman M et al. (2015).

225 Wadsworth M (2005).

226 CLOSER (2016).

In the UK, research is funded by discipline-related Research Councils that are meanwhile united under one roof. Ageing research was one of the fields on which five of seven Councils and thus almost all disciplines collaborated. Initially this was the case from 2000 in a coordinating board for scientific consensus in interdisciplinary ageing research. In 2004/5 the House of Commons focused on ageing and on ageing research and noted that a lack of coordination among the Councils represented the major obstacle for progress in ageing research. Performance assessment by the Research Assessment Exercises (RAE) was also identified as an impediment as it hindered multi- and interdisciplinary research and thus a fundamental approach to research on ageing.[227] At the behest of parliament, five of the Research Councils jointly launched the largest funding program of the UK to date under the title "New Dynamics of Ageing" (2005-13).[228] Besides deciding on these issues, behavioral, biological, clinical, cultural, historic, social, and technological factors modifying ageing trajectories were to be examined and improvements for older people were to be deduced from the findings.[229]

A little shifted in time, the five Research Councils jointly supported three centers focusing on the ageing brain, frailty, and health-related quality of life in their program "Lifelong Health and Wellbeing" (2008-15). In the context of this program, the Medical Research Council developed its own research strategy. Mental health and well-being, lifestyle influences on health, and influences of ageing on health and independence were designated its three priorities.[230] In a further step, the Research Councils agreed to fund "biosocial" research in 2014, i.e. the cooperation of social-science, biological, and medical fields to investigate the "dynamic interactions between biology, experience and behaviour across the course of life." Beyond the funding of databases necessary for such cross-disciplinary work, the research support of the National Centre for Research Methods (NCRM) also invests in the further training of researchers in social- and life-science methods.[231] A new overarching initiative with new centers in the fields of healthy ageing, particularly involving brain, frailty, and life-quality research are in planning.[232]

At present, a strategic plan in the biological sciences (Biotechnology and Biological Sciences Research Council) intends to support the topic of "staying healthier for longer as lifespans increase and society ages", while feeding the world population also has a demographical focus among its priorities.[233] The biosciences are to concentrate on normal (healthy) ageing as well as nutrition and exercise. In the natural sciences (Engineering and Physical Sciences Research Council, EPSRC), ageing is not a separate strategic point, but is covered by the cooperation programs in the fields of health technologies, robotics, mobility, and physical environments. The MRC places its current research agenda (until 2019) under two headings, and both bear a strong relation to ageing research: the area "resilience, repair and replacement" covers infection research, degenerative illnesses, regenerative medicine, cellular research; "living a long and healthy life" includes molecular biology, interdisciplinary life-course research, as well as lifestyle and environmental influences on health.[234] In a call for research proposals, the MRC selected the UK Dementia Re-

227 Science and Technology Committee (2005).

228 Engineering and Physical Sciences Research Council, the Biotechnology and Biological Sciences Research Council, the Medical Research Council, the Arts and Humanities Research Council, and the Economic and Social Research Council (2015).

229 Hennessy CH, Walker A (2009). Expert interviews.

230 MRC (2010).

231 ESRC (2014).

232 Research Councils UK (2014).

233 BBSRC) (2014).

234 MRC (2014).

search Institute (UK DRI), newly founded in 2015; so far about 280 million EUR (250 million UK Pounds) were provided for research. Initially, it will concentrate on basic biomedical research.[235]

Government policy concentrates on supporting the employment of older people, pensions, and public health. In order to examine the association between employment and health in old age, the government funded research via the MRC Research with 6.5 million EUR (2013-16).[236] At present (2017-19), a reform of care and social welfare for elders and people of working age is being discussed.[237] In the area of healthcare, the reduction of socio-economic health inequality across the life course and better care for older people are at the center of debate.

A unique characteristic of the British system is the establishment of centers for applied research under the umbrella of the What Works network, which was founded in 2013. Following the example of evidence-based medicine, ten such centers are tasked with collecting scientific evidence on interventions in education, health, social and labor market policies, etc, evaluating them in terms of their efficacy, the importance of target figures, and the quality of scientific findings (e.g. in systematic reviews) and subsequently providing the information to policy-makers in multifaceted formats. The Centre for Ageing Better as well as the What Works Center for Wellbeing are two centers that explicitly focus on ageing and the life course (topical range: work, physical exercise, coping with life changes, health and well-being, culture, education and learning, neighborhoods, and local communities). The Centre for Ageing Better was founded following the work of the Select Committee of the House of Lords, which recorded in 2013 that the UK was insufficiently prepared for the growing number of older people.[238] The National Institute for Health and Care Excellence and the Early Intervention Foundation also consider ageing and the life course in their work.

The effects of Brexit on this research are difficult to prognosticate, even if the majority of the described research is not directly dependent on EU funding. Nevertheless, the adjustments of funding allocations that will be necessary as a consequence of Brexit will probably lead to far-reaching restructuring of the British research landscape, and that will also affect ageing research.

US

The most important, but by no means only funding institution for ageing research in the US is the National Institute on Aging (NIA), which was founded in 1974. It includes biological, clinical, social-, and behavioral-science as well as neuroscience ageing research. Some of its funds are intramural and go into its own research, but the majority are extramural. With 55%, the neuroscience domain receives the highest portion and has experienced the largest increase of the past years.[239] Currently, the NIA has an annual budget of 1.6 billion US$ (about 1.49 billion EUR).

The NIA is one of 27 institutes carrying out health research that belong to the National Institutes of Health (NIH) under the U.S. Department of Health & Human Services. With its focus on ageing, this institution is not quite aligned with the disease-oriented funding of the other NIH institutes. Nevertheless, the contrast is not sharp: on the one hand, dementia research is also supported via the NIA, and on the other hand, issues of ageing also via other NIH research. Across the whole

235 UK DRI (2018).

236 Department for Work and Pensions, UK (2014).

237 House of Commons, Briefing Paper (2018).

238 Select Committee on Public Service and Demographic Change (2013).

239 NIA (2016).

NIH, about 2.8 billion US$ are spent on ageing research annually. The largest sum of more than 6 billion US$ is awarded to cancer research and about 5.2 billion US$ go into research on infectious diseases.[240] Alzheimer research obtained about 1.1 billion US$ in 2015, and about 40% of that sum came from the NIA.

The foundation of the NIA and its early history had some special characteristics that are also instructive for today's situation. In contrast to the other health research institutes that are devoted to concrete illnesses such as diabetes or cancer, the NIA was set up to investigate healthy (normal) as well as pathological ageing. As the research field was still young and not very developed, funds were not only issued for research projects, but also for coordination and institutional support, namely for the establishment of centers, cooperative programs, and infrastructural support at the universities. In comparison to other NIH institutes, innovative funding formats involving large sums for such programs and constituting a broad scientific competence network, were essential to strengthen the visibility and attractivity of this research. In addition, the support of foundations, associations, media, and members of the House of Representatives and the Senate played an important role, particularly in securing funds.[241]

However, the NIH paradigm of establishing institutes to study specific diseases also proved formative for ageing research. Especially in the beginning years, the budgetary security of the NIA only seemed achievable by showing competence for an illness. This resulted in the repeatedly criticized "Alzheimerization of aging" over the following years. Nevertheless, research on this disease still makes up about half of the NIA budget.[242]

Meanwhile the NIA supports 29 Alzheimer centers and about the same number of centers on demographic, economic, social- and behavioral-science, biological, and minority-related research at universities across the US. Furthermore, it funds numerous longitudinal studies, graduate and postdoctoral training programs as well as data infrastructure such as cell repositories, the Health and Retirement Study (HRS), or the development of platforms for the harmonization of ageing studies, etc.

A large share of the NIA budget goes to the HRS, a representative, longitudinal national survey of the population of over-50-year-olds carried out since 1990. It has served as a model for many national surveys in other countries, for example, the European SHARE study.[243] During HRS preparation, it became clear that in terms of content and disciplines, existing studies concentrated on an overly-narrow range of questions, and they neither considered the full spectrum of interacting factors that influence ageing nor assessed population groups such as women and ethnic minorities adequately. In 2006 the data collection was extended to include biomarkers and genetic factors as well as additional psychosocial and economic aspects.[244] In an evaluation of 51 longitudinal ageing studies that are stored in an NIA-funded database,[245] it was shown that cognitive functioning, physical heath, socio-economic factors as well as predictors of mortality and morbidity are mainly examined.[246] Increasingly, biomarkers are now also measured and data are harmonized.[247]

240 Duplications possible, estimate for 2017. NIH (2016).

241 Khachaturian ZS (2006a/b).

242 Hudson RB (2013).

243 ELSA in UK, SHARE in Europe, JSTAR in Japan, KLOSA in Korea, CHARLS in China, LASI in India, MHAS in Mexico, HAALSI in South Africa, most of which are also partially funded by the NIA.

244 Sonnega A, Weir D (2014); Hodes RJ, Suzman R (2015); Hauser RM, Weir D (2010).

245 NIA (2013b).

246 Stanziano DC et al. (2010).

247 Hauser RM, Weir D (2010).

In 2013, the so-called GeroScience Interest Group (GSIG) established itself as one of more than 90 scientific interest groups in the NIH. It aims to link research across the disease-specific institutes and connect biological ageing research and biomedicine.[248] In high-ranking workshops (summits), the GSIG announced the endeavor to fund studies that apply basic biological knowledge from ageing research to medical questions, and to include more environmental factors, whereas personal characteristics like those examined in the behavioral sciences play a lesser role.[249]

Since 2007, the NIA has organized several ageing summits on cognitive ageing and research on Alzheimer's disease to promote research on interventions and on topics such as resilience. However, the behavioral and social sciences see their importance for research on health and healthy ageing questioned by the NIH and NIA, as stated in a report in 2014.[250]

In 2016 the US Congress passed the "21st Century Cures Act," which grants the NIH funds for focus initiatives in 2017-22. This includes 1.8 billion US$ for cancer research (until 2023), 1.5 billion US$ for the BRAIN Initiative, and 1.4 billion US$ for precision medicine.[251] Since 2013, beyond about ten NIH institutes, the BRAIN Initiative involves further federal offices, the National Science Foundation, foundations, universities, industrial partners, etc. Science experts have calculated that the funds required by the BRAIN Initiative add up to 4.5 billion US$ for a decade from the NIH alone.[252]

Policies on ageing and seniors are institutionalized in US politics by, among others, the Senate Special Committee that has already existed since 1961. The White House Conference on Aging, a dialogue event that prepares many legislative acts and has brought many topics to the political agenda, also started in 1961. In 2015, the Obama administration held the sixth and last such conference so far, which focused on sociopolitical issues. Many vocal interest groups ensure the topic's continuing relevance.[253]

III.3 Setting Research Foci and Funding in Germany

III.3.1 Research Funding by the Federal Government

An Overview of Research Expenditure

In Germany, the expenditure for research and development (R&D) has risen in absolute terms, but only to a limited extent relative to the GDP. Only since 2015 does it seem to grow again.[254] Regarding per-capita spending, Germany only reaches the eighth rank behind Switzerland, the US, Sweden, and others (2015).[255] The proportions of R&D funding have also not significantly changed. Funds for universities and uncommitted funds for support and research organizations constitute slightly less than half of the state's R&D support. About 12% are allocated to the support of industry-related R&D.[256]

The Federal Government has become one of the most important donors of third-party funding for research and financed more than 60 000 research projects with over 9 million EUR between 2005 and 2015, 60%

248 The term "geroscience" was originally coined by scientists at the Buck Institute. Since 2007, it is used in the NIH context. Lithgow GJ (2013); Cire B (2016); NIA (2016c); Sierra F (2015).

249 Alliance for Aging Research (2017).

250 NIA, NACA (2014).

251 Bonamici S (2016).

252 The BRAIN Initiative |The Alliance. Available at: http://www.braininitiative.org/alliance (retrieved January 25, 2018); Underwood E (2014). Bargmann C et al. (2014).

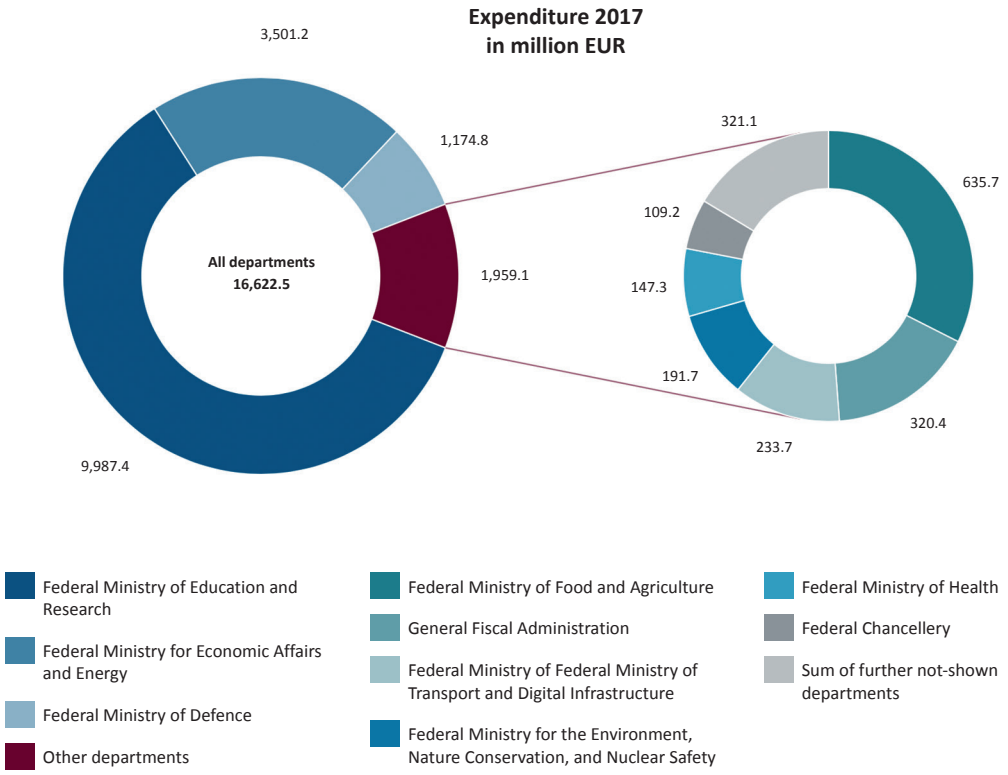
253 Day CL (2014).

254 Based on planning figures of the Federal Government; see Dehio J, Rothgang M (2017).

255 OECD (2017).

256 R&D in technology development and growth of productivity in private industry. This includes relevant activities by the Fraunhofer Gesellschaft and the Helmholtz Association. Rammer C, Schmitz F (2017).

Figure 1. Federal Expenditure on Research and Development by Government Department (2017)



Source: Federal Ministry of Education and Research, calculations by German Centre for Higher Education Research and Science Studies, updated 03/2017. Further data available at http://www.datenportal.bmbf.de/1.1.4

of which were granted to universities and non-university research institutions, and about 36% to private industry. The Federal Ministry of Education and Research (BMBF) spends the most federal funds on research by far (Figure 1).[257]

The Federal Government's Research Agenda

"Ageing" was first mentioned as a separate topic in the (2011-16) Federal Government's "Forschungsagenda zum demografischen Wandel" ("Das Alter hat Zukunft") [Research agenda on demographic change (Old age has a future)]. The agenda described selected societal and individual aspects of ageing and demographic change as well as social-policy aims of the former government and translates these into expectations for application-oriented research. The Federal Government's funding programs were listed as well.[258] The "Forschungsagenda" was not recognizably based on the state of research or the landscape of relevant research institutions. An evaluation was announced, but has not (yet) been presented.[259] The program comprised funding of about 415 million EUR for five years, the greatest part of which (360 million EUR) was to be spent on technology support.[260] Many references to ageing were made in the context of the health domain, on whose R&D activities the Federal Government spent about 1.4 billion EUR in total (2016).[261]

The agenda coincided with a "Demografiestrategie" [Demography strategy] that was passed in 2011 and 2015. Its focus was

257 Rammer C, Schmitz F (2017).

258 BMBF (2011c).

259 As of 09/2018. Cf. BMBF (2011b).

260 Deutscher Bundestag (2012).

261 BMBF (2018).

on the domains of employment with the aim of securing growth and the sustainability of public finances and social security systems as well as the cohesion of a diversifying society, and urban and rural living conditions.[262]

BMBF Funding of Health Research

An important infrastructural decision on the support of health research regarding demographic change was already taken by the Federal Government in 2010. With the explanation that population ageing would be accompanied by "dramatically increasing numbers of patients," and inspired by the NIH and strategies set in the US,[263] the BMBF set up six Health Research Centers devoted to common population diseases, like the NIH research on infectious diseases, cardiovascular diseases, lung diseases, cancer, neurodegenerative diseases as well as diabetes (the latter two already since 2009). The establishment of two further centers, one on psychiatric disorders and the other on child and adolescent health, was decided in 2018. They are conceived as nationwide networks under the umbrella of the Helmholtz-Gemeinschaft, linked to universities, and they also include federal institutes.[264] From 2011 to 2015, 700 million EUR were invested in the centers and along with 1.5 billion EUR for project funding at these institutions.[265] The Deutsches Zentrum für Neurodegenerative Erkrankungen (DZNE) [German Center for Neurodegenerative Diseases] is about twice the size of the other institutions (in terms of budget and personnel).[266]

The centers link basic life-science, clinical, population-related, and healthcare research on the most common diseases. They have proved their positive effect within the science system. In its evaluation of 2017, the German Council of Science and Humanities [Wissenschaftsrat] stated that translational research on the specific disease domains profits from the network structure of the centers.[267] Even if funds were granted to projects so far (as of 2017), these medium- and long-term investments into structures (rather than projects), are of particular significance for science.

Longitudinal studies, particularly those surveying the entire population, are central for research on ageing and the life course and form crystallization points for knowledge fields of the health, social, and behavioral sciences. Longitudinal studies can also provide policy-makers with essential information on causal relationships, albeit this potential remains under-utilized.[268] In particular, it is necessary to move from "the collection of quantitative observations" to their "qualitative evaluation."[269] A new longitudinal study of 20- to 69-year-olds, the German National Cohort study (NAKO Gesundheitsstudie), is being carried out by universities, the Leibniz-Gemeinschaft, and the Helmholtz-Gemeinschaft since 2014 and is funded by the BMBF together with the participating federal states (Länder). In the first ten years about 256 million EUR are intended for NAKO. The study is conceptualized to go on for 20-30 years and is intended to reveal causes of widespread diseases such as cancer and diabetes as well preventive measures. Biomedical and social variables play a role in this epidemiological study.[270] The Survey of Health in Pomerania (SHIP)—which has been funded since 1996, and has meanwhile been complemented by analogue studies

262 BMI (2017b).

263 Interview with Annette Schavan, cf. Lossau N (2011); Bundesregierung (2012).

264 In the establishment phase, the university clinics/institutes had to undergo a competitive process whereas the Helmholtz participation was already determined. More information on the governance: WR (2017).

265 Bundesregierung (2012).

266 WR (2017).

267 WR (2017).

268 Overview of population-wide longitudinal studies: German National Academy of Sciences Leopoldina et al. (2016).

269 WR (2016).

270 Cf. https://www.nako.de

in Brazil and Poland—is mainly funded by the BMBF and the federal state Mecklenburg-Western Pomerania. This study is carried out at the University of Greifswald and collects data on diseases, but also on the family, work, nutrition, social relationships, and healthcare provision.[271]

Since 2015, the BMBF funds research on the neuronal basis of active ageing, that is, healthy brain ageing and antecedents of diseases, as a five-year project with about 15 million EUR.[272] Within its life-science support focus on system biology, the BMBF funded a line of research that is specifically aimed at applying system biology to ageing topics with 47 million EUR from 2009 to 2017.[273] This targeted the development of therapies for age-related illnesses using molecular-biological approaches.

In the 2015-18 period, the BMBF spent 50 million EUR on the "Action Plan Healthcare Research," which was developed under the impression of demographic ageing and the increasing proportion of the old and very old among patients. Besides individual research projects, structural measures such as networks, research groups, centers, and professorships in gerontology and geriatrics are also funded.[274]

BMBF Funding of Engineering Sciences

Alongside health, the BMBF placed a support focus on ageing and technologies (human-technology interaction, information and communication technologies (ICT), and mobility and assistance systems). The commitment of the BMBF to this field was based on the support of microsystem and information technology whose application, e.g. for sensor technology in domestic settings, was meant to open a new market mainly for elders.[275] The BMBF was the foremost German funding agency in this field. A large proportion (ca. 40%) of the projects again concentrated on health and the provision of care. The focus is on ICT. Robotics, which seems especially interesting from the perspective of technology development, is only the topic of a small (but meanwhile growing) proportion of the projects.[276] With its technology research agenda that was passed in 2015, the BMBF has practically untied its support of technology from the former target group of old people.[277] An evaluation of the results of the previous focus has not yet been carried out, at least not in a publicly accessible manner. Aside from funding of the developing assistance systems in care, the new research support program is no longer specifically geared towards research on demographic topics or managing societal challenges that are concretely related to demographic change. Until 2020, 70 million EUR is to go into this field annually.

BMBF Funding of Research on Work and Related Topics

As well as technology and health, the BMBF also supported ageing research in the fields of the working world and vocational training, particularly in 2011-14, with about 37 million EUR via its program on applied research on work, with a demographic facet, in which researchers collaborated with companies or trade associations.[278] In the following program "Zukunft der Arbeit" [The future of work] (until 2020), the focus is on the consequences of technological change. Demographic change is not a separate field of activity, but rather it emerges in the context of maintaining health and employability.[279]

271 Völzke H (2012).

272 BMBF (2017a).

273 BMBF (2017b).

274 BMBF (2016e).

275 Hampicke M et al.(2011).

276 Jokisch M, Wahl HW (2015). Following a positively-rated Forsa survey on the acceptance of robots in domestic settings commissioned by the BMBF, the ministry launched a call for tenders on the development of autonomous robots with assistance functions in the summer of 2016. Forsa (2016); BMBF (2016b).

277 Funded by the BMBF in 2016–2020 with more than 350 million EUR. BMBF (2015).

278 BMBF (2011a); BMBF (2014).

279 BMBF (2016a).

Research at technical colleges on "Social innovation for quality of life in old age" (SILQUA-FH) involving topics such as social work, health, and care was supported from 2009 to 2015. Nationwide the BMBF funded more than 80 projects with about 29 million EUR.[280] In the following round, the specific focus on old age was dropped. Since 2017, the funded research on social innovation focuses on digitization and health.[281]

In 2011, the first of two BMBF-funded waves of the cohort study "lidA – leben in der Arbeit" began. This study at Bergische Universität Wuppertal collects data on the effects of employment on the health of the baby boomer generation until retirement. It is being continued since 2018 with joint funding from the DGUV (German Social Accident Insurance), the Deutsche Rentenversicherung (the German pension insurance organization), the Barmer health insurance, and the federal state North Rhine-Westphalia.

BMG and BMFSFJ Funding of Research on Dementia

The "Allianz für Menschen mit Demenz" [alliance for people with dementia] is a positive German example of coordination among research institutions and professional associations, scientific benchmarking of national dementia strategies, and evaluation of at least its own agenda (all this is sadly lacking elsewhere),[282] even if its scientific results have not yet been evaluated. Furthermore, the agenda for research on dementia set by the Federal Ministry for Family Affairs, Senior Citizens, Women and Youth (BMFSFJ) and the Federal Ministry of Health (BMG) emphasized the need for interdisciplinary collaboration between clinical research, social and behavioral sciences as well as epidemiology. An evaluation of the concrete form of collaboration and which conditions are conducive or obstructive for interdisciplinarity is required.

Federal Departmental Research Institutes

In the other federal departments, the long-term substantive foci set for departmental research institutes are of particular importance (Table 5). Healthy ageing as well as participation in the labor force and effects of work (usually until retirement age) are the listed institutes' research topics.

The German Centre of Gerontology [Deutsches Zentrum für Altersfragen, DZA] was established in 1974 and is in the remit of the Federal Ministry for Family Affairs, Senior Citizens, Women and Youth [Bundesministerium für Familie, Senioren, Frauen und Jugend, BMFSFJ]. Initially it was mainly responsible for collecting relevant information. Beyond its documentation tasks and providing political advice, it has strongly expanded its research activities since the 2000s and predominantly studies the living situations of older people from the perspective of the social and behavioral sciences and with a view to social policies (incl. healthcare research). Participation in the labor force, volunteering, poverty, and health as well as participation of people depending on care and of migrants in old age are at the center of attention.[283] The administrative offices of the Federal Government's Report on the Elderly [Altenbericht], the German Ageing Survey [Deutscher Alterssurvey], and the German Survey on Volunteering [Freiwilligensurvey] are located there. The DZA received about 2.7 million EUR annually as basic funding from the BMFSFJ (2015) as well as varying amounts of project support, around 0.7 million EUR in 2015.[284]

280 PTJ (2016); Braun A, Rosenbaum O (2016); Bührer S et al. (2016).

281 BMBF (2017c).

282 Kirchen-Peters S, Hierscher V (2013).

283 Tesch-Römer C, Simonson J (2015).

284 BMF (2017); WR (2008).

Table 5. Departmental Research (Direct Project Funding by Ministries and via Departmental Research Institutes)*

Ministry	Foci of Direct Project Funding by Departments	Research Institute(s) in Respective Remit and Their Research/Funding Emphases
Family Affairs, Senior Citizens, Women and Youth		Deutsches Jugendinstitut Growing up in Germany, Childhood, Youth, Transitions Deutsches Zentrum für Altersfragen (DZA) Statistical data on the life course, Old age
Education and Research	Research at technical colleges—Social innovations for the quality of life in old age (SILQUA-FH)	
Labour and Social Affairs	Pension schemes and provision for old age Fördernetzwerk Interdisziplinäre Sozialpolitikforschung [Support network for interdisciplinary social policy research]	Institut für Arbeitsmarkt- und Berufsforschung (IAB) Life chances and social inequality, Educational and occupational trajectories, Unemployment and participation, Labor market and social security
Interior, Building and Community		Bundesinstitut für Bevölkerungsforschung (BiB) Research groups 1) Demographic change and world population, 2) Ageing and mortality, 3) Mortality follow-up of NAKO Gesundheitsstudie
Health	Research on provision of care and disease avoidance/control New since 2016: Innovation fund on qualitative further development of care in public health insurance, incl. research on provision of care	Robert Koch-Institut (RKI) Healthy ageing
Environment, Nature Conservation and Nuclear Safety		Bundesinstitut für Bau-, Stadt- und Raumforschung (BBSR) im Bundesamt für Bauwesen und Raumordnung (Bonn) Urban/regional development and demography
Food and Agriculture		Thünen-Institut Demography and rural areas
Transport and Digital Infrastructure	Structure prognoses, cf. BBSR	

* The English translation of the German institutions is provided in the text.

The Federal Institute for Population Research [Bundesinstitut für Bevölkerungsforschung, BiB] was founded in 1973 by decree of the Federal Ministry of the Interior [Bundesministerium des Innern]. Besides the statistical registration of population developments and international collaboration, the BiB concentrates on familial constellations and ways of life, mobility, and migration, as well as population ageing, especially the potentials that the gained years of life offer for employment, voluntary work, and generational cohesion. An important reason for set-

ting this focus is the expected beginning of the baby-boomers' retirement in 2020. The BiB carries out many surveys, such as the Generations and Gender Survey or the longitudinal Transitions and Old Age Potential (TOP) study on the transition into retirement. The BiB's basic funding amounts to about 3.5 million EUR (2017, target).[285]

The Institute for Employment Research [Institut für Arbeitsmarkt- und Berufsforschung, IAB] is integrated in the Federal Employment Agency [Bundesagentur für Arbeit] and is also an important institution for research on aspects of the life course and ageing, primarily in terms of working life and pensions. Trends and topics such as digitization and its influence on changes of the labor markets and working life are investigated by the IAB as well as special groups on the labor market such as elders, refugees, or long-term dependents on social security payments.

At the Robert Koch-Institut (RKI), a departmental research institute in the remit of the Federal Ministry of Health [Bundesgesundheitsministerium], the topic of health in old age was initially raised in the context of health reporting and as a thematic focus.[286] "Healthy ageing" across the life course is anchored in the RKI's research planning since 2018. Non-communicable diseases play a special role for healthy ageing as well as the complexity of contributing lifestyle factors. Special groups such as children and youth, the socially disadvantaged, or very old people receive particular research attention.

Research Funded by Public Insurance Providers

Besides government departmental support, the research funded and carried out by the Deutsche Rentenversicherung (German pension insurance organization) in the area of provision for old age and rehabilitation needs to be mentioned regarding the "work-related effects of chronic diseases, disability, and coping with disability"[287] (providing about 750,000 EUR annually). The organization collaborates closely with universities and makes its data available for research. The "Forschungsnetzwerk Alterssicherung" (FNA) [research network on provision for old age] was established by the Deutsche Rentenversicherung and not only offers project funding since 2001 (mainly for economic and sociological research), but also supports junior scientists and awards prizes. With the support of a central office, this network has become a forum of exchange that also continually integrates researchers via colloquia and is active in policy advice.

The statutory health and care insurances support model projects in the field of caregiving with their own research departments. Scientific evaluations are funded in the medical domain. Research data are provided via the research data center of the Federal Statistics Office [Statistisches Bundesamt] or in direct cooperation with the statutory health insurances. Since 2014, data on healthcare provision from across the insurances are available for the first time.[288] Via the health insurances' innovation fund, 75 million EUR were granted to research on healthcare provision in the 2016-19 period.

III.3.2 Research Priorities in the Helmholtz Association

In the Helmholtz Assocation (HGF), ageing research falls into its "Health" area; it is the HGF's stated long-term goal to improve healthcare and quality of life „into old age."[289] About 20% of its budget, that is, about 590 million EUR in 2017, were

285 BMI (2017).

286 RKI (2010).

287 DRV (2015).

288 Detailed overview of all data of the social security providers: Schubert I, Swart E (2014).

289 HGF (2016).

earmarked for this aim.[290] Nonetheless, there is no Helmholtz-Institut for broadly based interdisciplinary ageing research. In the eight German Centers for Health Research (DZG) and other overarching initiatives, there is no explicit focus on ageing or the life course.

In 2017, the funds for health research were allocated to cancer (43%), gene-environment influences on common diseases (23%), diseases of the nervous system (15%), infectious diseases (11%), and cardiovascular and metabolic diseases (7%). Although research on ageing processes plays a role across all of these foci, the DZNE (almost 80 million EUR in 2017) is the Helmholtz health center that can best be identified with life-course and ageing research in terms of topics and structure. As neurodegenerative diseases (and not only those) occur more often in later phases of life and can develop across longer periods of time, it seems necessary to study them from a life-course perspective. This is taken into account by the DZNE's newly established Rheinland Studie, which examines health trajectories of people from age 30 until old age, as well as by DZNE research groups, for example, on ageing and cognition or on adult neurogenesis. The DZNE's agenda also anchors the linkage between at least some relevant disciplines, namely biology, clinical medicine, epidemiology, and healthcare research. Within the Helmholtz-Zentrum München [German Research Center for Environmental Health], the Institute for Epidemiology studies health behavior in old age based on the KORA-Age study, which is located there. The HGF addresses the topic also in the AmPro consortium on Ageing and Metabolic Programming.

The Munich center also plays a role in research on the genome, environmental factors, and ageing to "understand causes of disease molecularly." [291] The so-called "Querschnittsverbund" (an HGF-internal association on a cross-cutting topic) on regenerative medicine ("Technology and Medicine") regards the elderly in particular as a target group for the development of biomaterials, another focus set by the HGF.

The HGF regards the modeling of brain processes as a "key technology" and is involved in the European Human Brain Project via the Forschungszentrum Jülich. The development of the brain across the life course is also studied at the Institute of Neuroscience and Medicine in Jülich ("Decoding the Human Brain" program), mainly to treat illnesses more commonly occurring in old age, like the DZNE.

III.3.3 Research Priorities in the Leibniz Association

A Leibniz Institute for broadly based interdisciplinary ageing research does not exist; the Leibniz Institute on Aging – Fritz Lipmann Institute (FLI) is focused on biomedicine with an emphasis on cell biology. Within the Leibniz Association [Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz e.V., WLG], 12 institutional thematic research alliances were formed in the last ten years, in which the collaborators were to be integrated in joint multi- or interdisciplinary research projects. Each of these alliances receives 600,000-680,000 EUR for 6-8 years, supplemented by own and third-party funds. They are primarily concentrated on exchange, the promotion of junior scientists, and the initiation of collaborative projects for which third-party funds are to be acquired. The structure of collaboration is loose and therefore external evaluation has considered it "questionable" that research competencies can be pooled sustainably. Furthermore, these alliances are not conceptualized with a view to

290 Core funding budget in 2017: 591 million EUR plus 158 million EUR third-party funding, share of which for Health Research Centers and Berlin Institute of Health (BIH) ca. 90 million EUR, cf. HGF (2018).

291 HGF (2018).

Table 6. Leibniz Research Alliances on Ageing and the Life Course

Research Alliances	Leadership	Relation to Ageing Research
Healthy Ageing	Leibniz Institute on Aging – Fritz Lipmann Institute (FLI)	Biomedicine, research on cognition, urban development, and the labor market
Leibniz Education Research Network (LERN)	Leibniz Institute for Educational Trajectories; German Institute for Adult Education – Leibniz Centre for Lifelong Learning	GSOEP, NEPS, lifelong learning and educational trajectories
Health Technologies	Leibniz Institute of Photonic Technology (IPHT)	Age-associated diseases
Bioactive Compounds and Biotechnology	Leibniz Institute of Plant Biochemistry (IPB), Leibniz Institute on Aging – Fritz Lipmann Institute (FLI)	Active-substance research, infrastructure integration
Sustainable Food Production and Healthy Nutrition	Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB)	NutriAct: Study on dietary patterns of 50- to 70-year-olds

rapidly opening up new research areas or taking innovative approaches.[292]

One research alliance is on ageing research, while a few others have links to the topic. In these structures, ageing research is mainly biomedical in nature. The Leibniz Research Alliance "Healthy Ageing" was established in 2014 and is led by the FLI. It encompasses 20 institutes that carry out joint projects in focus groups. Besides biomedicine, research on cognition, urban development, and the labor market are most strongly represented.[293] The alliances on health technologies, sustainable food production and healthy nutrition, bioactive compounds and biotechnology, and on education research also take up ageing-related issues (Table 6).

In the new Leibniz Institute for Educational Trajectories (Bamberg), the large-scale NEPS with over 100,000 participants investigates the educational and competence development of six cohorts ranging from newborns to adults (1956-86 birth cohorts). It is currently being discussed whether the trajectories of the latter cohort are to be continued into old age and supplemented by age-specific data collection. This would open up internationally unique research opportunities.[294] The GSOEP (see section on longitudinal studies) at DIW Berlin [German Institute for Economic Research] also belongs to the Leibniz Association. It has established itself as an important instrument for research on life courses. As well as questions about the socio-economic status of various age groups (from birth, but not continuously for all cohorts), income, familial, and educational trajectories, childhood influences, well-being and health, as well as personality and cognitive functioning (since the early 2000s), are studied with GSOEP data by researchers from a variety of disciplines.

The Leibniz institutes focusing on economics investigate issues of ageing to varying degrees. Demographic change has been established as a cross-cutting theme at the RWI – Leibniz Institute for Economic Research for more than 15 years, analyzing the influence of population ageing on public finances, labor markets, and health costs, for instance.[295] Besides GSOEP, the DIW Berlin also focuses on demography

292 Hering J et al (2017).
293 WGL (2016).
294 Blossfeld HP, Roßbach HG, von Maurice J (2011).
295 E.g. Neumann U (2016).

and the population, on pension, family and social policies, among others. The ifo Institute – Leibniz Institute for Economic Research at the University of Munich has a focus on population economics and studies the association between macroeconomics and familial decision-making. The life course is also relevant at the ifo Center for Economics of Education. The Halle Institute for Economic Research (IWH) does not study demography but it does list a few publications on poverty in old age, for example.[296] The Institute for the World Economy (IfW) in Kiel does not have a relevant focus area. At the WZB Berlin Social Science Center, a research group is working on the relationship between demography and inequality, for example, with internationally and historically comparative studies on the transition into retirement.[297] The GESIS – Leibniz Institute for the Social Sciences in Mannheim is also part of the WGL as an infrastructural institution. Studies on socio-economic and educational inequality, on the quality of life, on family structures as well as changes in values, and on political attitudes belong to its portfolio. Apart from the German component of the OECD study PIAAC, assessing key adult competencies, GESIS does not have a specific research focus on ageing and the life course, but does carry out many surveys such as ALLBUS or the European and International Social Survey that each collect interesting social and also behavioral information.

With the ScienceCampus format, the WGL promotes cooperation with universities on topics relevant to research on ageing and the life course such as healthcare challenges in regions with shrinking and ageing populations (Essen), regenerative ageing (Jena), behavioral brain sciences (Magdeburg), as well as education in informational environments (Tübingen).

296 E.g. Kumpmann I, Gühne M & Buscher HS (2010).
297 E.g. Aisenbrey S, Fasang A (2016).

III.3.4 Max Planck Society

A Max Planck Institute (MPI) for broadly based interdisciplinary ageing research does not exist. However, the Max Planck Society (MPS) has designated ageing and demographic change as one of its topics for the future. In the document entitled "Research Perspectives 2010+," a Presidential Committee stated that "Aging healthily, living longer," brain research, comparative genomics, neuronal plasticity, developmental potentials, heterogeneity, and social interaction as well as (from 2014 onwards) ageing societies belonged to the Society's strategic topics. Research on aspects of ageing and the life course is carried out at the following MPIs: MPI for Biology of Ageing (Cologne), parts of the MPI for Human Development (Berlin), MPI for Demographic Research (Rostock) as well as parts of the MPI for Social Law and Social Policy (Munich), which also hosts the coordination of the SHARE study. The MPS funds a third of the SHARE expenditure for data collections in Germany. The interdisciplinary Berlin Aging Study (BASE), which began as an extensive interdisciplinary cross-sectional study of 70- to over-100-year-olds in 1990[298], was continued longitudinally, and then carried on with a new sample in BASE-II (2009-17), was coordinated at the MPI for Human Development (MPIB) in Berlin.[299] BASE was a project carried out jointly by the MPIB and five further Berlin research institutions or universities with the support of the BMBF. Molecular and clinical medicine as well as social and behavioral sciences cooperated in the context of BASE. Both BASE and BASE-II are involved in the EU-funded Lifebrain project on cognitive development across the life course.

The MPS is currently supporting two institute-wide research initiatives on neurodegenerative diseases and on the psy-

298 Mayer KU, Baltes PB (1996).
299 Lindenberger U et al. (2015).

chopathology of cognitive ageing and has funded a virtual International Max Planck Research Network on Aging (MaxNetAging) since 2004. Furthermore, there are International Max Planck Research Schools that are devoted to graduate training in the field of research on ageing and the life course. The newly established Max Planck Schools in the realms of cognition and life sciences are not specifically oriented towards ageing and the life course, but they do offer links. The MPIs for Biology of Ageing and for Demographic Research are particularly active in the promotion of junior scientists with several research groups on ageing or the life course.

III.3.5 Fraunhofer-Gesellschaft

None of the Fraunhofer Institutes is devoted to broadly based research on ageing and the life course. A link to ageing in the Fraunhofer-Gesellschaft is created by the alliance for the development of so-called "age-appropriate assistance systems" (Fraunhofer Ambient Assisted Living Alliance AAL) that now encompasses 11 institutes. "Older, disabled, and care-dependent persons" are identified as the main user group. The projects are located in the fields of medicine and care, habitation, and communication. The Fraunhofer Alliance benefits from the relevant EU funding and engaged in the preparation of research political recommendations and an AAL research strategy in 2008-10 as much as in networking between research and companies.[300]

In individual projects, the Fraunhofer Institute for Industrial Engineering also focused on topics such as ageing and age-heterogeneous work forces or care in old age.

In the following, universities are considered in the context of DFG funding rather than separately.

300 AAL (2016).

II.3.6 DFG Funding Programs

Whereas general research framework conditions as they are discussed and shaped in the DFG committees for clinical research, genetic research, animal-experimental research, and IT infrastructure are also relevant for research on ageing and the life course, two more recent initiatives are particularly relevant. "Biogerontology and Geriatrics" is institutionalized as a sub-section of the medical review board since 2012. An initiative of three gerontological-geriatric societies preceded the foundation of this section, but it was not aiming for a limited biomedical section. So far, only few funded projects can be identified that are ascribed to this field. Furthermore, at the end of 2017, the DFG issued a programmatic announcement inviting applications for six-year research groups to strengthen public health research in interdisciplinary cooperation of disciplines such as demography, epidemiology, psychology, health economics, legal studies, statistics, and medical disciplines. However, the announcement did not contain any reference to ageing or a lifespan perspective.

Besides these two positive strategic decisions, long-term support in the thematically open large-scale funding schemes such as Collaborative Research Centers [*Sonderforschungsbereiche* (SFB)] and Clusters of Excellence have a particular effect regarding structure formation due to their duration, size, and networking. In principle, they enable interdisciplinary cooperation and further development, but are also built on strong discipline-specific projects and smaller cooperation groups. In the following, we therefore examine how research on ageing and the life course is represented in such joint projects and other programs. An overview of the relevant DFG projects (including individual projects) can be found in Chapter III.

A life-science SFB on "Environment-Induced Aging Processes" was funded from

2007 to 2012 in Düsseldorf. In the SFB scientists investigated molecular ageing processes in skin and developed models of transfer to medicine. Currently, several subprojects within SFBs on the homeostasis of skin (Cologne), chronic infections (Hannover) as well as chemical and biological principles of cellular proteostasis (Konstanz) are working on questions of ageing and the life course from a medical or biological perspective.

In the field of molecular and cellular biological life sciences, the Cluster of Excellence "Cellular Stress Responses in Aging-Associated Diseases" (Cologne) is being funded. Among the Clusters of Excellence, ageing also plays a role within the realm of hearing (Hannover), in the neurosciences, particularly for neurodegenerative diseases (two clusters: Munich, Berlin, generally: Tübingen), and in the investigation of cellular networks (Heidelberg).

The DFG funds Clinical Research Units [*klinische Forschungsgruppen*] on "Molecular and Cellular Aging" (Ulm), on "Regeneration in Old Age" (Charité) as well as (longitudinal) trajectories of psychosis (Munich). Age-associated epigenetic changes are studied in the context of treatment of leukemia (Freiburg). In non-cellular biology, two Research Units [*Forschungsgruppen*] investigate the interactions of fecundity and longevity (Freiburg) as well as early influences on adult behavior (Bielefeld). In nutritional research, trace elements are examined in the elderly (Potsdam).

Two of the four funded *DFG Research Centres* also relate to the biology of ageing, namely the Centre for Regenerative Therapies Dresden (CRTD, also supported as a Cluster of Excellence) and the Centre for Nanoscale Microscopy and Molecular Physiology of the Brain in Göttingen. Of 108 Priority Programmes [*Schwerpunktprogramme*], "Education as a Lifelong Process" (Bamberg) for use of the NEPS data and "German Labor Market in a Globalized World: Challenges through Trade, Technology, and Demographics" (HU Berlin und Mannheim) are the two social-science and economics programs focusing on aspects of ageing and the life course. The program "Emerging Roles of Non-coding RNAs in Nervous System Development, Plasticity and Disease" in Göttingen is based on molecular and cellular neuroscience and also investigates the nervous system at different stages of its development.

Two Scientific Networks [*wissenschaftliche Netzwerke*] sponsoring junior researchers' work on ageing and the life course are being funded since 2016 ("Images of Aging: Via a Dynamic Life-Span Model to new Perspectives for Research and Practise"—psychology; "Being Young – Growing Older: Temporalities in Transition"—educational science).

Internationally the DFG is setting priorities by participating in joint European funding, the so-called *ERA-Nets*. The DFG does not coordinate a thematically pertinent alliance, but is part of an ERA-Net in the social sciences that supports the examination of inequality in the life course from 2016 to 2021 ("Dynamics of Inequality Across the Life-Course: Structures and Processes (DIAL)" (projects at HU/Alice Salomon Hochschule (ASH) Berlin, Bamberg, ZEW – Leibniz Centre for European Economic Research in Mannheim). In cooperation with China, the DFG also supports research on population change in the facets of family, migration, and caregiving.[301] Furthermore, the DFG funds several longitudinal studies.

III.3.7 Funding of Junior Researchers: Graduate Schools and Research Groups

From 2006/07 onwards, seventeen graduate schools on ageing and life-course topics have been started, sixteen of which

301 DFG (2014).

remain active. Three of them focus on genetic aspects of ageing, two on psychiatric issues, one on geriatrics. The others are distributed across the social and behavioral sciences and economics (e.g. educational science, psychology, sociology, demography); the humanities are represented in three (one of which has been concluded). The engineering sciences are lacking; one graduate school is also open for students of architecture. Rather than ageing in the narrower sense, the life course is emphasized in the social sciences and economics; it is also mostly part of an overarching field: the graduate school on "Microeconomic Determinants of Labor Productivity" explicitly refers to demographic change, the Bamberg Graduate School focuses on educational trajectories and also social inequalities across the life course, and the Berlin PhD program "Public Economics and Inequality" deals with social and tax policies and social inequality across the life course. The school on social change in the working world considers individual biographically or historically differentiable groups as well as changes of social order broadly; the school on migration and its consequences takes a cross-generational perspective.

Graduate schools are mainly funded by the DFG (7), the Max Planck Society (3), and the Hans Böckler Foundation (3). Heidelberg stands out as a site with three research schools alone.

In the area of junior research groups, the DFG is well represented with its five thematically relevant Emmy Noether Groups. The MPS also supports postdocs; junior research groups are mainly located at the MPI for the Biology of Ageing (Cologne) and the MPI for Demographic Research with reference to work and health (Rostock). Further junior research groups at the Helmholtz Centers and Health Research Centers (e.g. Deutsches Zentrum für Diabetesforschung, DZD, or DZNE) indirectly contribute to ageing research.

At the postdoctoral level, there is a lack of opportunities in Germany for interdisciplinary training on the challenges of research on ageing and the life course like that offered elsewhere, for example, by the Carolina Population Center, University College London (Soc-B) for graduates, or the interdisciplinary ESRC-MRC-Scheme (bridging social sciences and biomedicine) for postdocs.[302]

III.3.8 Non-Profit Organizations and Endowments

Non-profit organizations and endowments supporting research on ageing and the life course are mainly active on topics in the humanities, social, and behavioral sciences as well as medicine and nursing science. Besides the allocation of funds to independent research and the establishment of infrastructure, there are also some foundations that collect data themselves and thereby become relevant actors in the field: particularly, the Bertelsmann Stiftung and foundations close to political parties. Academization and the use of scientific methods have also entered into the practice of other organizations such as associations or corporate consultants and have led to the production of research-relevant knowledge, but often without peer review and without reference to previous research work or scientific context. We do not consider this form of information production on ageing and the life course further. We only include foundations here with an annual funding volume of more than one million EUR that are awarded externally (Table 7).

The largest funding agency in ageing research is the Robert Bosch Stiftung, which intensively supports geriatric research and teaching since 2002; for example, by endowing professorships (almost 4 million EUR for chairs for geriatrics in Aachen, Heidelberg, and Göttingen) and a graduate school (about 10 million EUR

302 CPC (2018); ESRC, BBSRC (2018).

for the graduate program "People with Dementia in Hospitals", involving more than 50 people). Ageing research projects on topics such as living environment, technology, sports, etc. are also funded. Spending on such projects (without geriatrics) reached 1.5 million EUR in 2016.

In 2003-13, the Jacobs Foundation funded the Jacobs Center on Lifelong Learning at Jacobs University Bremen as an interdisciplinary ageing research center with about 8.7 million EUR (CHF 10 Mio).

With 5 million EUR, the Volkswagen-Stiftung mainly funded projects in the social sciences and humanities on "Individual and Societal Perspectives of Aging," with foci on changes of the working world, risk prevention, and images of ageing from 2008 to 2011. Other programs such as the "Key Issues" [*Schlüsselthemen*] were also applied to questions of ageing research, mainly by researchers of the social and behavioral sciences, and humanities.

The Dietmar Hopp Stiftung supported research in geriatrics in Heidelberg for over ten years with about 2.8 million EUR and funds further studies in ageing research.

Other Non-profit organizations and endowments such as the Schader-Stiftung, Becker-Stiftung, BHF Bank Stiftung, Hertie-Stiftung, and the Daimler und Benz Stiftung fund projects or professorships with programmatic reference to research on ageing and the life course.

Table 7. Large Foundations Funding Research on Ageing and the Life Course*

Foundation	Annual funding budget (total)	Funding areas (only in relation to ageing and the life course)
Robert Bosch Stiftung	100 million EUR	Old age; dementia
VolkswagenStiftung	150 million EUR	Aging and the life course (various thematic calls for proposals)
Dietmar Hopp Stiftung	Approx. 37.4 million EUR (annual average 1995-2017)	Healthy ageing
Hertie-Stiftung	20-25 million EUR	Aging and the brain
Jacobs Foundation	20 million CHF	Aging and lifespan development
Körber Stiftung	4.8 million EUR	Demographic change
Daimler und Benz Stiftung	2.9 million EUR	Human-environment-technology interactions, e.g. robotics in care, growth and population, stress and burnout
Thyssen Stiftung	15.6 million EUR (2017)	Aging (no agenda, funding of research fields of the life and social sciences and humanities according to proposals)
Schader-Stiftung	Not specified	Aging and residence, dementia, regional demography, mainly as scientific events

*Details provided according to the foundations' annual reports and websites. Unless otherwise stated, an assignment of the annual funding budgets to specific funding areas is not possible.

III.4 Conclusions: Research Landscape—Conditions

EU Funding of Research on Ageing and the Life Course

In summary, the EU-funded projects largely match the program set by the EU research support system, which is clearly focused on funding research on biomedical and technical aspects of ageing. Accordingly, the EU supports the life and engineering sciences, whereas questions of ageing play a secondary role. In comparison, projects on individual and societal shaping of longer lives or broader interdisciplinary initiatives are funded to a much lower degree. It is striking that the numerous strategic agendas for ageing research from earlier years have not gained entrance into current EU funding. Strategy papers on personalized medicine (albeit put together without reference to ageing research) and by the alliance on "Active and Assistive Living" for the field of technology are the only exceptions.

EU funding is concentrated on research on age-correlated illnesses and their biological mechanisms, particularly at the cellular level. Interventions oriented towards successful or healthy ageing are mainly medical and therapeutic, and in terms of funding volume and the number of supported projects, directed towards technical applications in medical care and towards support of private industry.

The addition of geriatrics to the medical initiative IMI, which is the EU's largest funding instrument besides technology support, was long overdue and very welcome. Neurodegenerative diseases are a particularly strongly represented topic, both in the ERA-Nets and in the JPIs. Nutrition research, geriatrics, urban development, and—slightly lagging behind in financial terms—social inequality across the life course are further topics of European collaborative research.

Existing institutional structures such as the DZNE or the Fraunhofer Assisted Active Living alliance appear to make it easier for players in science to participate in decision-making within the EU funding system regarding content and react accordingly. With the BMBF's focus on support of research collaborations on neurodegenerative diseases and technological assistance systems, Germany has also influenced the development of research foci in the EU.

In the case of open funding (i.e. ERC projects initiated by researchers), it becomes clear that the topics of ageing and the life course in the narrower sense are under-represented, and among the few ageing-related projects, those with molecular-biological approaches are in the majority.

With very few exceptions, no systematic content evaluations of the focus on "Health, Demographic Change and Well-Being" were carried out by the Commission. Likewise, possibilities for researchers to carry out joint analyses across the boundaries of their projects are lacking. Finally, the transfer of findings of applied research into society that is institutionalized is only performed by companies, and does not occur at all for commercially less interesting findings or economically less attractive target groups.

Benchmarking Research Policies of Other Countries

Sweden, France, the Netherlands, the UK, and the US have all made ageing, demographic change, and quality of life core topics of social and research policies. The prolongation of working life and health across the life course are two important topics on the political agenda, and it is hoped that research will yield promising findings.

In all of these countries, concentrated strategic funding—of centers, programs, infrastructure, and targeted further education—has successfully led to research

capacities being established and developed, and specific topics have evolved in each country. In view of its high complexity, such programmatic support and science-strategic discussions among experts are of great importance for ageing research to overcome discipline-specific and local fragmentation and sustainably establish the topic and research field in larger research structures such as universities or funding agencies.

Especially thought-provoking is the UK's extraordinary measure of establishing a common interdisciplinary ageing research program across the Research Councils that originally funded projects separately by research areas. The very early initiation and funding of the UK's longitudinal studies as well as their use is also exemplary. In particular the systematic scientific processing of evidence on interventions by the What Works centers with their clear focus on ageing and well-being across the life course represents a successful connection between research and application.

In the US, the existence of the NIA that is divided into social, behavioral, neuroscience, biological, and medical areas, provides opportunities for its own research as well as the support of basic, overarching research on non-pathological ageing, among others. Notably both individual research applications and announcements for research centers are frequently interdisciplinary in nature. The balance among research areas in funding as well as the balance between basic and applied research or between disease-related and health-oriented research is an ongoing topic within the framework of the NIH. In evaluation, one needs to consider that although the NIA has its own budget, it is smaller than the budgets of the other NIH institutes that are focused on specific diseases. Coordination attempts such as those by the GeroScience Interest Group to concentrate on the joint cellular ageing processes that arch across diseases are indicative of the continuing content-wise and strategic convergence of the biology of ageing and medicine, at least. Via giant billion-dollar programs on brain research, the US also place particular emphases on Alzheimer's disease, cancer, and personalized medicine. These emphases affect all research activities, not least by concentrating funds and program coordination.

Research on ageing and the life course is also given special prominence in Sweden. The ten-year funding of several ageing research centers as well as the continual efforts to achieve an excellent longitudinal data infrastructure need to be highlighted. The regional networking of geriatric healthcare and research in France should be stressed. In the Netherlands, ageing research benefited from the early attention paid to interdisciplinary cooperation between the social and biomedical sciences and the establishment of longitudinal studies. An emphasis was later placed on "healthy ageing" in the funding of medical research. Not least, the unique nationwide public participation in the setting of funding priorities in research policies (Dutch National Research Agenda) is noteworthy, in which the quality of life in very old age, broadly interpreted, as well as physical, mental, and social well-being are considered highly important. In medicine and neuroscience, preventive approaches—for instance—regarding healthy lifestyles and behavior, as well as topics such as lifelong learning and the reduction of social inequality are also funded.

However, in all of these countries, the funding of biomedical ageing research notably exceeds that of all other areas by far. This financial concentration leads to the social and behavioral sciences orienting themselves towards health issues and the research areas of human capital/work, while ageing-related topics of the cultural sciences and humanities hardly attract any attention in research on ageing and the life course.

Funding Policies of the German Federal Government

Topics of research on ageing and the life course are mainly funded by the Federal Government if they are linked to diseases and care or technological applications: in this respect, the research support provided strongly resembles that of the EU. At the BMBF, the largest research funding agency within the Federal Government, the thematic area of demographic change was tapered down to a technological focus in terms of organization and content. The various governmental departments (e.g. ministries for economics, health, family) restrict their research funding to their respective responsibility. However, this administratively understandable approach does not do justice to the complexity of ageing and the life course.

In the extramural research funding provided by these departments, but also in their own research institutes such as the IAB, BiB, RKI, and DZA—notwithstanding their important contributions to questions of research on ageing and the life course—the potential for synergy and cooperation remains underutilized even though it would be particularly important for these questions.

In its funding of medical research, the Federal Government places an emphasis on the centers for research on disease complexes and on healthcare without making ageing an explicit research topic. In this context, it needs to be noted that in the US (NIH), research separated by diseases and without consideration of ageing is meanwhile regarded as too ineffective (see GeroScience Initiative).[303] In contrast, in clinical cell and molecular biology, biological ageing itself could be established as one of the BMBF funding foci besides diseases such as cancer.

An important, albeit financially less well-endowed addition was the support of projects of the technical colleges, mainly related to regional planning and healthcare provision, as well as the studies of the government departmental research institutes such as DZA, BiB, IAB, Bundesanstalt für Arbeitsschutz und Arbeitsmedizin [Federal Institute for Occupational Safety and Health], and Bundesinstitut für Berufliche Bildung [Federal Institute for Vocational Education and Training], via which topics of the working world are studied. Accordingly, ageing research in the social and behavioral sciences—which is usually under-represented in governmental research funding policy—was at least granted some attention, as was the RKI with its epidemiological data collection on life courses.

Many important domains of the life course such as the quality of life, culture, law, and politics, or the effects of being embedded in a physical environment (cities and communities) are completely left out of research funding. Even extended social-policy debates like those held by the Federal Parliament [Bundestag] about welfare indicators, which have direct impact on the shaping of individual lives and thus also ageing, were not included in the research agenda. In the field of health, the funding of geriatrics, public health/epidemiology, and palliative medicine is underdeveloped, a deficiency that is particularly glaring in view of the focus on the health aspect of ageing. In relation to other disciplines, the support of technology is very pronounced, although the funding agencies have not yet evaluated its benefits for (interdisciplinary) ageing research and for the population, and the gains are deemed to be rather modest.[304]

The BMBF agenda “Das Alter hat Zukunft” is not primarily driven by ongoing research. The evaluation of the funded

303 Kennedy BK et al. (2014).

304 Kucharski A, Merkel S (2018).

projects in terms of their effects (on individual ageing/life courses and societal consequences)—as was urged for technology funding by the academic community—does not seem to be making any progress.[305]

Extramural Research Institutions

First of all, it must be stated that there is no institute for broadly based research on ageing and the life course in Germany. The main focus of extramural research on ageing and the life course, represented by part of the work carried out at individual institutes, is on the investigation of diseases and on molecular-biological basic science. However, research on age-appropriate assistive systems and—to a lesser extent—educational research, demography, sociopolitical science, and economics is also represented. Social and behavioral longitudinal studies on developmental trajectories in Germany—which can be regarded as major drivers of research activities—have primarily been established at extra-university institutions. Research funding by extramural research organizations seems to be more varied and strongly based on science compared with federal support. The formation of alliances in the Leibniz Association are an important and suitable way to overcome the restrictions by institutes and their programs. However, it must be ensured that funding is also provided for infrastructure personnel and for support programs, at least for pilot studies, to maintain and foster the alliances' dynamics. The present budgets of these alliances seem to be too low. Furthermore, they are structured for networking and exchange rather than for collaborative development of new research projects.

The same is the case for the networks in the Helmholtz-Gemeinschaft. The setting of research foci by the German Centers for Health Research does not appear to allow steps beyond the disease paradigm, but it is precisely here that interdisciplinary research groups on ageing (not only in biomedicine, also in association with the social and behavioral sciences) could substantially stimulate and extend the investigation of both disease and health processes.

DFG Funding of Research Alliances

At present, the DFG funding programs are not integrating disciplines lying far apart to do justice to the complex research questions of research on ageing and the life course. Within this field, the life sciences are mainly benefiting from the coordinated DFG programs. Only two priority programmes involving life-course and ageing research fall into the realm of the social sciences, a further emphasis in this area was set by participation in a European alliance. Research on ageing and the life course in the humanities is not to be found in any program. Since 2012, open applications are possible in the newly established medical sub-section on biogerontology and geriatrics, but it has only been able to approve a very small number of applications. It remains to be seen whether the discipline-wide announcement of public health topics will also benefit research on ageing and the life course.

Foundations supporting research have set important impulses in some areas of research on ageing and the life course. By funding research and teaching, the Robert Bosch Stiftung has made a particular contribution to research in geriatrics, but also to ageing research more broadly, and has ensured the establishment of research capacities. Its commitment certainly contributed to the Federal Government's decision to support geriatrics. However, aside from the programmatic funding of the VolkswagenStiftung on ageing plasticity about ten years ago, concentrated calls for proposals have remained rare overall, whereby foundation funding is more likely to go to existing research than being able to shape structures or extend thematic reach.

305 German National Academy of Sciences et al. (2015a).

IV. Current Priorities in Research on Ageing and the Life Course

IV.1 An Overview of Research on Ageing and the Life Course in Germany

The funding policies presented in the preceding chapter should be reflected in the discipline-specific and thematic foci of research on ageing and the life course in Germany. Based on publications and the research projects of the past decade represented in important databases, we now examine whether such foci can be identified and where possible deficits lie. For evaluation purposes, German research is compared with that of several European countries and the US and also judged against the strategic research challenges for research on ageing and the life course generally discussed internationally (see Section I.5). A large proportion of research is carried out in international academic exchange, so that an assessment of research on ageing and the life course in Germany against the backdrop of other countries' research seems worthwhile and necessary.

Research on ageing and the life course is not uniquely characterized as belonging to a discipline based on the respective journals and societies, or university faculties. The often-interdisciplinary nature of this research and the cross-sectional relevance of questions of ageing and the life course contribute to the lack of a restricted portfolio of scientific media on which an assessment of the distribution of this research field by discipline and topic could be based.[306]

Therefore, we assembled projects and publications with the help of relevant keywords. A keyword-based search yields a very large number of results that can be categorized according to disciplines or research fields using the publication databases' journal classifications. However, journals are often classified into several categories, so that a certain fuzziness remains. Publication formats are furthermore very different depending on the respective research fields and disciplines, which means that publication databases are also rather restricted in this respect.[307] The institutional affiliation of authors could in principle also be selected as an indicator of a main discipline, but this information is not available in all databases. A more detailed assessment of disciplinary affiliation could also be achieved by means of a detailed semantic description of the research field that would need to be made concrete in an iterative matching process with the respective publication's findings. The available thesauri (e.g. from GESIS on the social sciences or from the ZBW – Leibniz Information Centre for Economics) are not suitable for this specific purpose. Creating a semantic index and applying it to research on ageing and the life course has the scope of a research project in itself. However, it would be worthwhile to achieve systematic and updateable overviews of thematically-linked research in this, or some other manner to make cooperation of distant disciplines easier.

Furthermore, the DFG and EU funding databases are sources for evaluation of re-

306 Examples are the investigation of the lifespan of C. elegans in *Toxicology Letters*, mortality or medical topics in mathematical journals, or social inequalities and demographic developments related to agricultural economics.

307 The complete *Web of Science* databases of 2006–17 were analyzed.

search activities as well. However, the thematic sorting of the latter is also imprecise.

In order to balance these inaccuracies, we compare the content of research foci of research on ageing and the life course in Germany with those of other European countries (Sweden, Netherlands, UK, and France) and of the US to ascertain whether differences can be made out that are not only due to the restrictions (regarding discipline-specific presence in publication databases) common to the analyzed countries.

In a second step, we additionally carried out searches on two examples of subtopics that allowed detailed analyses. A shorter list of hits upon publication database searches made it easier to check and filter the publications' relationships to ageing and the life course. The subtopics were selected to ensure that they were significant for as many disciplines as possible and characteristic for current ageing research. The first subtopic was "Cognition and Dementia," and the second was "Poverty and Social Inequality," both in respect to ageing and the life course. The results were evaluated by experts.

Publications by Discipline

The search terms included the following dimensions of research on ageing and the life course:

- The state of being old (denoted by terms such as old, older, aged, senescent, centenarians, pensioners, life expectancy, etc.) and age(ing) (terms like ageing, age-correlated, etc.),
- the life course (lifelong, life span, longevity, etc.),
- terms encompassing several phases of life as well as old age (intergenerational, adulthood, etc.), and finally
- the discipline-specific expressions and entries (demographic, geriatric, gerontological, etc.).[308]

In recent years, the number of research articles on "ageing" in the narrow sense (only search terms: aging/ageing) has strongly increased, likewise the number of scientific publications. For example, in the biomedical domain, the number of publications with German participation has more than doubled from 2012 to 2015 alone.[309] Another example is the psychology of ageing in Germany. The increase in publications has been continual over the last fifteen years, whereby a two- or even threefold rise in the number of ageing-related publications can be seen in this time period.[310]

Research on ageing and the life course in Germany is characterized by a high proportion of biomedical publications in the entire publication output. This follows a general research trend and can also be seen in the benchmark countries of the US, Sweden, France, UK, and the Netherlands.[311] Within this spectrum, German researchers, compared to the other countries, publish more in biochemical and molecular-biological, genetic, pharmacological, and neuroscientific journals as well as in medical journals in the fields of surgery, cardiovascular diseases, and oncology. The country comparison also reveals that fewer German publications are on healthcare and geriatric research. Population-based health research is furthermore not often linked to social science. The medical subdisciplines are hardly associated with each other in questions of ageing and the life course. In the life sciences, research on ageing and the life course is generally strongly concentrated on diseases.

308 See Appendix for complete listing.

309 PubMed: Rising from about 800 in 2012 to over 1700 in 10/2016 (aging/ageing).

310 PubPsych: Rising from about 400 in 2004 to 1400 in 2014 (aging/ageing) with a European background; from about 100 in 2004 to about 300 in 2016 in Psyndex with a German background.

311 *Web of Science* search for years 2006–2016.

Another clear difference to the comparison countries lies in the weighting of social sciences and humanities in terms of publication numbers. Both research areas are proportionally much less represented in German research on ageing and the life course than they are in the UK, Sweden, and the Netherlands, in particular.[312]

Topical Priorities in the Individual Disciplines

Judged by the number of DFG-funded projects, topics related to ageing and the life course are also mainly found in the life sciences, with molecular-biological, neuroscience, and clinical-therapeutic orientations. Social and behavioral sciences only made up about half the number of life science projects. In the humanities, projects from educational research played a role, as did a few from law, ethnology, religious, and literature studies. [313]

In the following, the research fields are presented in more depth, and their content is evaluated with a view to their thematical foci and their deficits.

IV.1.1 Basic Research in Biology, Medicine, and Neurosciences

In **biology,** research on molecular-biological facets of cell ageing is also predominant in project funding. Beyond molecular and cellular biology, long-term influences on individual development, the association between reproduction and life expectancy and environmental influences on the life cycle of different species play a role. One focus was on the topic of environmentally induced ageing (SFB 2007-12). Ageing is also an important topic in the context of tumor research (SFB until 2013, Tübingen).

In the **neurosciences,** almost half of DFG-funded ageing research deals with pathological ageing, not only focusing on Alzheimer's dementia, neurodegenerative diseases, and cognitive impairment, but also on many other pathologies. Non-pathological changes across the lifespan are currently being examined in neuroscience projects on motivation, among others.

The lack of good ageing models in animal experimentation, the complexity of disease processes in chronic diseases of ageing, and the multimorbidity in old age, which are normally not accounted for in experimental research, are some of the topics that should be focused on. In biology as well as medicine, a systematic consideration of senescence as a biological process in its own right is lacking. Longitudinal studies are under-represented in basic biomedical research.

Besides the disease- and organ-centered approach, biomedical research needs to take an additional approach—which is only rarely pursued—focusing on the variability of biological, socio-economic, psychological, and cultural factors and their interactions. Ageing theories able to build a bridge to medicine are not taken into adequate account. The existing set of methods and research instruments remains very discipline-specific. This can change based on approaches of "systems medicine" and "systems biology," which consider the complexity of life processes by definition. Nevertheless, it remains to be said that ageing is often regarded as a special case in this context, rather than as a generally effective parameter that needs to be taken into account.

IV.1.2 Medicine

Medical ageing research is also strongly represented in DFG funding and concen-

312 Here we follow the *Web of Science* research categorization into sciences, social sciences, and arts & humanities as the three "domains," and the further categorization into "areas" that results from the database host's journal classification.

313 With the following search terms, but not referring to physical, technical, or other topics like ageing of buildings or materials etc.: Aging/Ageing, senescence, life expectancy, age, aging/ageing, elderly, older, life span, life course, end of life, life cycle, retirement, geriatr*, geron*. See detailed information in the Appendix. DFG funding of the last ten years.

trates on clinical-therapeutic approaches. Ageing and old age play a particular role in cardiovascular research, not least due to the significance of cardiovascular causes of death, in metabolism research, mainly due to type-II diabetes, in immunology, but also research on neurodegenerative diseases and cancer, for which the DFG has a special expert committee to probe the research field. The numbers of publications are especially high in journals on oncology and cardiovascular diseases. In view of this research support, it needs to be stated that progress in the treatment of these diseases does not match the expectations, even if enormous progress in understanding the processes behind these diseases has been made in the last decades.

Investigations of various external influences such as nutrition, physical exercise, or smoking sum up to less than a tenth of the total number of DFG projects. Projects on specific questions relevant in geriatrics, such as polypharmacy and multimorbidity in old age, are particularly meager (only two DFG projects); the still young DFG section "Geriatrics and Biogerontology" has only approved a relatively low number of projects on specific geriatric-gerontological questions, but more on ageing-relevant topics from public health, epidemiology, and related disciplines.

Although the separation between pediatrics on the one hand and geriatrics on the other is necessary from a practical perspective (at least in some cases), it counters a lifespan view on humans. This is also the case with respect to the extremely high degree of specialization of the separate medical disciplines. Trends such as personalized medicine further increase this fragmentation, which is sometimes extreme.[314] Nevertheless, such trends also represent an opportunity insofar as they reach beyond a genetic understanding of personalization, because the increasing density and depth of data and new statistical methods also allow for development of new concepts that can provide hitherto unknown foundations for research on health and illness in the context of ageing and the life course.

IV.1.3 Psychology, Social Sciences, and Economics

DFG-funded **psychological ageing research** mainly concentrates on cognition (as illustrated by the participation in the relevant SFB); **social-science** DFG projects are almost equally distributed among the four themes of work, family and partnership, education, and health. The investigation of inequality (across these fields) is well represented (also participation in a SFB). The DFG-funded twin study TwinLife at the Bielefeld and Saarland universities (since 2014) has great potential. It aims to clarify sociocultural and genetic influences, and their interactions, on social inequality. In the rather weakly represented ageing research carried out in **economics,** questions of welfare effects and wealth are at the fore.

Research on ageing and the life course in the social and behavioral sciences is fragmented; biographical phases such as childhood, youth, adulthood, disciplines such as demography, economics, psychology, educational science, and sociology, domains such as the career and working world, school and learning, development, social mobility, migration, etc. stand next to each other without much linkage.[315] In examining the phase of older age, for example, problem-oriented ageing research on issues such as functional impairments and the need for care, economics and social-policy oriented research on income and social security in old age, and psychological and gerontological research on topics such as cognitive competencies are mostly carried out in isolation, so that synergy effects in research and practice fail to

314 Thornquist E, Kirkengren AL (2014).

315 Mayer KU (2015).

materialize. This also applies to the evaluation of political interventions.[316] In international comparison, institutional contexts are hardly considered in research.

In life-course research, studies on younger adults, specifically their education, vocational training, and the labor market are predominant. So far, the consequences for older age are too rarely included in research. Partial exceptions are SHARE (via retrospective life-course data) and the GSOEP.

Data availability is good, but is underutilized by research so far. This applies to both GSOEP and the currently ongoing adult cohort studies (e.g. NEPS) as well as process-produced data, such as those of health insurances: in contrast to the public pension insurance with its own research data center and research support program, health insurances do not provide many data. It is to be expected that the research support provided by the innovation fund of the Federal Joint Committee of doctors and insurances [Gemeinsamer Bundesausschuss der Ärzte und Krankenkassen (G-BA)] will lead to improvements in the future.

State-of-the-art socio-economic variables have been widely neglected in data collections and analyses so far. The social sciences, in turn, hardly include biomedical variables. For example, consideration of the working world and working life is sorely lacking in health research. The concept of human resources could be utilized in an integrative manner across disciplines.[317] Without an improvement of data quality in this regard, the efforts to catch up with internationally recognized biomedical-epidemiological research are unlikely to be fruitful. To date, Germany is only involved in a small number of transnational research consortia (e.g. Lifepath or Lifebrain).

316 Walker J (2014); Beard J, Bloom D (2015).

317 Müller R, Senghaas-Knobloch E, Larisch J (2016).

In comparison to pioneering international studies in the field of ageing research, new theoretical models, updated methodological approaches in both empirical social research and biomedicine, as well as their linkage are lacking in Germany, along with studies comparing institutional contexts across different countries.

IV.1.4 Humanities

In the German-speaking humanities, the topic of old age and ageing has attracted interest since the 1970s. Initially, this focused on historic and culture-specific variety and variability of the lifestyles of ageing people and on the emergence of a specific life phase of "old age" or "retirement." In the 1990s, changes and continuities in the perceptions and assessments of old age and ageing moved into the focus of interest. Discourse-analytic approaches uncovered the coexistence of ambivalent interpretations of old age and ageing across eras and cultures, and examined how positive and negative attributions serve(d) as arguments in the relationship between the generations. In the past years, old age and ageing has also become more present in literature studies. Concepts, cultural constructions, and representations of old age and ageing as well as the processing of the experiences of old age and ageing are at the forefront. Similar topics are also examined by art history and media studies, whereby cooperation on the topic of old age and ageing currently also most frequently occurs among these disciplines.

However, in the historical disciplines in the narrower sense, the theme of old age and ageing plays a lesser role. Usually it only forms an aspect of a more comprehensive research question. A growing interest in old age and ageing can be seen in the study of the antiquity and the history of medicine, in the latter case in the context of the shift of professorship profiles to "history of medicine and medical ethics." Applied research on old age and ageing is

most likely in theology and religious studies, particularly in pastoral care studies.

In non-university research institutions with at least a partial focus on old age and ageing, the humanities and cultural studies are only represented marginally. Accordingly, there are hardly any medium- or long-term institutionalized research groups or centers in the humanities and cultural studies on the topic of old age and ageing. First approaches in this direction only exist in the form of interdisciplinary collaborations at some universities or faculties. The connection to international research networks is minimal.

In Germany, little use is made of the humanities' and cultural studies' great potential for knowledge-based and reflexive research on societal and individual ageing processes. There are particular problems in three domains:

- A lack of medium- or long-term institutionalized and thus continuous research;
- A lack of interdisciplinary linkage and integration that reaches beyond the closest neighboring disciplines in the humanities and cultural studies. The humanities and cultural studies hardly participate in the rare attempts to discuss interdisciplinarity in research on old age and ageing;
- Whereas the life phases of old age—likewise childhood and youth—at least form peripheral areas of research in the humanities and cultural studies, the view of the entire lifespan is hardly present at all.[318] This is what is most needed in this research field, and its lack represents a large obstacle for interdisciplinary cooperation with the social and behavioral sciences.

318 The Käte Hamburger International Centre in the Humanities, "Work and Human Lifecycle in Global History," at HU Berlin is an exception.

IV.1.5 Engineering Sciences and Geography

Engineering Sciences

Most projects in the engineering sciences were made possible by direct federal funding, mainly by the BMBF.[319] The very few projects with DFG funding belong to the field of AAL and medical technology. Although much has been invested into the field of ageing and technology, it has by no means been comprehensively investigated.

Individual users' (mental and physical) resource balance and the promotion of developmental potential across the lifespan by utilization of technology seems to be under-researched and insufficiently considered. Technology should target an appropriate balance between environmental support and self-initiated processing to achieve a balanced level between cognitive under- and overload.[320] There remains a backlog in research and development.

User-oriented design is a common approach in the engineering sciences: in concrete applications, it hardly reaches the standards of user participation in medicine, psychology, and the social sciences. Neither needs assessment nor evaluation studies with larger numbers of cases that match the criteria of health technology assessments and are accordingly captured in databases are available yet. The efficacy and safety of medical products/quality-of-life technologies should be established in studies before market launch, but user observations (post-marketing) should also be carried out, reflecting another deficit of current research funding.[321] Viable and purchasable market solutions for older people's daily lives,

319 Systematic overview and evaluation of research projects 2005–15. Jokisch M, Wahl HW (2015).

320 Lindenberger U, Mayr U (2014); Lindenberger U et al. (2008).

321 The German Network for Evidence-based Medicine [Netzwerk Evidenzbasierte Medizin e.V. (DNEbM)] and HTA.de is demanding centralized approval and early benefit assessment for medical devices; DNEbM (2014).

caregiving by relatives, or in professional provision of care and geriatrics have not been achieved.[322]

Beyond the target of an application in health, care, and domestic daily life, aspects such as life-course-oriented use/development of technology in the working world are also missing.[323] The significance of internet use for social (intergenerational) relationships or health information as well as the growing importance of wearables for health monitoring and prevention also seem under-examined.[324]

Furthermore, interdisciplinary alliances like the Center for Research and Education on Aging and Technology Enhancement (CREATE) in the US or the Osaka Institute of Technology (OIT) in Japan are lacking.

Geography

Only few **human geographic** DFG projects examine mobility in the life course and the adaptation of cities and regions to demographic changes.

In planning and regional studies, demographic change mainly plays a role as a factor influencing regional development, regarding infrastructures and public services—for example—but also ecology.[325] With the help of indicators such as regional life expectancy, ageing and the life course are predominantly considered as facets of (general) demographic change. These indicators also include regional and international migration as well as birth rates. Regional studies have a deficit in adapting to the differentiation and further development of indicators such as life expectancy as discussed in other disciplines in the context of concepts of a healthy lifespan or of changes of productivity and education across cohorts.

Beginnings of a life-course perspective exist for individual mobility. Research on the significance of the local environment for ageing processes should include biogerontological and neuroscience perspectives. Systematic studies of the effects of different residential forms and the local physical environment on cognitive ageing are lacking, for example.[326]

Overall, the influence of local environment on individual development and performance capacity on the one hand and the effects of regional distributions of productivity and further economic and other resources on the options for creative regional development on the other represent two under-examined fields that suggest collaboration between researchers in regional studies, economics, social, behavioral, and health science.[327]

IV.2 Interdisciplinary Research on Ageing and the Life Course: Two sample cases

As explained above, ageing research has very much changed in the course of its development. For example, it not only examines older people or the phase of older age, but also earlier phases of adulthood or even the entire life course. At present, it is often turning to determinants, preconditions, or risk factors that influence ageing trajectories and their outcomes. It is thereby in direct contact with research that does not necessarily count itself as ageing or life-course research but is of great benefit to the field. The thematic areas that are highly relevant for both individual and societal shaping of life courses, particularly regarding quality of life and well-being, are social inequality and cognition.

322 Künemund H (2015).
323 For an overview, see, e.g. Mühlenbrock I (2016).
324 Linner T et al. (2017), Mostaghel R (2016).
325 ARL (2016).
326 Wahl HW, Iwarsson S, Oswald F (2012).
327 Beetz S et al. (2009).

IV.2.1 Research on Ageing and the Life Course in the context of Poverty and Social Inequality

In health sciences, economics, and sociology, investigating poverty and social inequality both in terms of its consequences and its causes, plays an important role. In the more recent past, the topic has also spread to the life sciences and neurosciences as well as psychology. Why is "social inequality" a phenomenon relevant to many disciplines and cannot be sufficiently explained by one discipline alone? And what part does the life course play in this context?[328]

Very early influences already have an effect on social differences in further life trajectories. Conventional education and psychological competencies such as motivation—which are acquired in early childhood, or not—are decisive for occupational and personal success in the long term (35 years later, or even more)[329,330] The access to education also affects health and provision for old age throughout the life course via the occupational and economic opportunities that it provides.[331]

How far-reaching unfavorable socio-economic conditions in early and earliest (e.g. intrauterine) childhood are for physical, mental, and psychological health in early and middle adulthood, has been shown extensively in findings from cohort studies from the UK and the Scandinavian countries.[332] For example, in Sweden, growing up with a single parent doubles the risk of suicide or being admitted to hospital with an alcohol-related illness before the age of 18.[333] In middle adulthood, one's occupational position and the quality of work, measured with established work stress models, are important determinants of health at retirement age.[334] They also influence one's ability to carry on with a socially productive activity after retirement.[335]

Although research on social inequality in Germany has intensified over the past years[336], this topic is particularly rarely investigated from a life-course and ageing perspective as compared to other European countries. Whereas German social-science publications on ageing make up about half of those from the UK, for example, those connecting ageing and the life course with social inequality only reach a third of those from the UK. In comparison with German publication numbers, Swedish and Dutch healthcare research, sociology, psychology, and occupational and environmental medicine fare excellently in terms of numbers. Within ten years, Swedish and Dutch researchers have published just as much in these disciplines, or more, than their colleagues in Germany.[337] In light of the much lower numbers of researchers in those countries—15%, resp. 20% of the German count[338]—it is plausible to claim that considerably less is invested into this research area in Germany, both in terms of personnel and of programs and infrastructures in which such research can be carried out, and therefore the attraction of these research topics suffers. The lack of funding programs and research personnel in biomedical research on ageing and inequality also contributes to the weak showing of research on inequality in Germany. While biomedical research in Germany is generally characterized by high publication numbers, the

328 Fasang AE, Mayer KU (in press).

329 In 2010, Heckman and colleagues extrapolated data that were originally collected up to the age of 40 to the age of 65 using other longitudinal studies.

330 García JL et al. (2017); Kricheldorff C, Tesch-Römer C (2013).

331 Mahne K et al. (2017).

332 Kuh D, Shlomo YB (2004).

333 Weitoft GR et al. (2003).

334 Stansfeld SA (2006).

335 Wahrendorf M et al. (2016).

336 Overview of recent developments: Fasang AE, Mayer KU (in press).

337 Evaluation of *Web of Science*.

338 OECD (2016). Only researchers from the public or non-profit sector in full-time equivalents.

topic of inequality is under-represented. In contrast, the UK, France, and the Netherlands are very strongly represented in the relevant life-science disciplines (reproductive biology, physiology, endocrinology, and neurosciences, immunology, and molecular biology, by journal classification) as compared to Germany.[339]

In more than half of the publications, the focus of inequality research related to ageing and the life course is on the link between inequality and health. Studies on social inequality in specific diseases such as cancer, on socio-economic status and health condition, on the risk factors of smoking and alcohol consumption, and on social differences in healthcare predominate. About one fifth of publications concern economic inequality issues such as income and pension development, the role of working environments, and human capital. Family, migration, gender, and intergenerational social mobility are further topics that are just as frequent as research on education and social inequality.[340]

As many DFG projects show, the topic of "Social Inequality" can be divided into separate facets such as the transition from school into work or smokers' health. Ideally, it illustrates the complexity of the ageing process as it is essential to examine the interactions between biological and contextual factors as well as the influences of a person's attitudes and behavioral patterns across the lifespan with respect to social inequality and its consequences if one wants to elucidate causality. A recent example of a promising and extensive project is the DFG-sponsored long-term study TwinLife, carried out at the universities of Bielefeld and Saarland and involving social, behavioral, and life sciences. The study examines biological as well as social causes and captures the consequences of social inequality in domains such as education, labor market, health, or social participation. Longitudinal studies are essential to determine the factors influencing unequal opportunities. This applies to education as much as to health, or the effects of economic or social-policy interventions.[341] Further approaches of biopsychosocial research of inequality in the life course could result from psychological happiness research, the research on subjective well-being, on resilience, and the quality of life.[342]

Taken together, Berlin, Munich, and Heidelberg are the sites with most publications in this field.

IV.2.2 Brain and Behavioral Plasticity—Cognition

Cognitive ageing research has emerged as a further field involving many disciplines, from biology, psychology, neurosciences, linguistics to philosophy and computer science. Since the 1960s, behavioral scientists have shown that people increasingly distinguish themselves from each other as they grow older (beginning in young adulthood), including the development/ageing of their cognitive abilities. Ever since, a large part of developmental psychology has been working on explaining these differences and utilizing their findings to optimize developmental and ageing trajectories.[343]

The discovery that functional and structural plasticity of the brain cannot be separated and any learning is associated with

339 This is confirmed by Lampert T, Hoebel J (2019), who state that older age has only gradually moved into the range of health-related inequality research; cf. Simonson J, Vogel C (2019).

340 There are thematic overlaps with health, economics, and education. See Appendix for the search terms used in the *Web of Science* evaluation.

341 German National Academy of Sciences Leopoldina et al. (2016). For an exemplary overview on health inequality in old age using SOEP and "Gesundheit in Deutschland aktuell" [GEDA – German Health Update], see Lampert T, Hoebel J (2019).

342 Haushofer J, Fehr E (2014). For example: Fritsche I, Jugert P (2017); Headey B, Muffels R, Wagner GG (2010); Pinquart M, Silbereisen R (2009); Dragolov G et al. (2016).

343 Baltes PB, Lindenberger U, Staudinger UM (2006); Lindenberger U (2014).

changes of the structure of the brain was highly relevant to the understanding of cognitive development. In contrast to earlier textbook opinions, the brain changes throughout life, and the potential for such change determines performance. The most extreme expression of this mutability is reflected in the adult neurogenesis seen in the hippocampus, a brain region that is centrally involved in higher learning processes.[344] Brain plasticity is dependent on many influences, ranging from genetics, physiology, and socio-economic situation to environmental conditions. All of these factors interact with each other and largely coincide with the lifestyle-related risk and resilience factors for neurodegenerative diseases on the one hand, and pathological ageing on the other. The molecular biology and physiology of plasticity of the ageing brain has not yet been conclusively resolved. First approaches are available from the examination of the effects of physical activities on brain ageing,[345] and they include both mouse and human models.

Experimental neurobiological research on cognition provides the basis for observational and interventional studies, which are necessary to understand the specific physiological features of the ageing human in health and illness.[346] A core question asks how physiological plastic processes and the extremely slow pathological processes of neurodegenerative diseases are intertwined and interact with each other. Neurodegenerative diseases are highly complex and require highly interdisciplinary research approaches, just as physiological ageing research does.

With respect to publication numbers, basic biomedical research predominates in cognitive ageing research at present (cf. Appendix). However, the proportion of social and behavioral science research is much larger in the UK and the Netherlands than in the other benchmark countries.[347] In Germany, publications in neuroscience, biochemistry, molecular biology, pharmacology/pharmaceutics, and radiology and nuclear medicine journals are particularly strongly represented, whereas behavioral sciences, psychology, and psychiatry also contribute considerably in the Netherlands and the UK.[348] The latter disciplines can also occur in the gerontology/geriatrics category (in the *Web of Science*), in which German research is highly represented. Furthermore, it becomes clear that worldwide, research on ageing-related cognition is mostly focused on pathological phenomena. Normal cognitive ageing is only treated in about one fifth of publications. The examined countries do not differ much in this respect. The lowest proportion of publications on non-pathological processes can be seen in Sweden, with about 15%. Across countries, 27% of publications on this topic in the social and behavioral sciences focus on normal cognitive ageing; in the humanities, where only few publications could be identified in this way, the proportion is 70%. In both Germany and France, neuroscience publications on normal cognitive ageing are particularly frequent. In Germany, high numbers of publications in the general category of biology, psychology, and medicine (subject category gerontology/geriatrics) and in molecular biology and biochemistry are striking. The topics of memory (about 14%) and/or learning (about 10%) are rather less represented.[349] In comparison, France and the Netherlands have many publications on these topics in the neurosciences and behavioral sciences and in psychiatry and

344 Eriksson PS et al. (1998).

345 Obri A et al. (2018); Bherer L, Erickson KI, Liu-Ambrose T (2013).

346 Voss MW et al. (2013).

347 Journal categorization by research fields according to *Web of Science*.

348 Disciplines according to journal classification by subject category in *Web of Science*.

349 The search was carried out with the term in both German and English. In the case of "learning," an exact evaluation with keywords is impossible because too many false positive topics such as machine learning and age-differentiated learning (but not trajectories) are captured.

gerontology/geriatrics. In comparison to the other European countries, Germany produced particularly many publications on the facet of plasticity. These are mainly to be found in the neurosciences, behavioral sciences, and psychology as well as molecular biology and biochemistry.

IV.3 Conclusions: Topical Foci of Current Research on Ageing and the Life Course

By Research Fields

Research on ageing and the life course in Germany is characterized by a high proportion of biomedical publications. This follows a general trend that can also be observed in the benchmark countries of the US, Sweden, France, UK, and the Netherlands.[350] In comparison to these countries, German research publishes more in biochemistry/molecular biology, genetics, pharmacology, and neuroscience journals as well as medical journals in the fields of surgery, cardiovascular diseases, and oncology. Publications in the fields of healthcare provision and geriatrics are relatively under-represented.

In the life sciences, ageing research is generally strongly concentrated on diseases, which hampers research on healthy ageing. The humanities, social, and behavioral sciences are proportionally much less represented in German research on ageing and the life course than in the UK, Sweden, and the Netherlands (measured by respective proportions of publications). Population-related healthcare research is hardly linked to research in the domain of social and behavioral sciences, as is also the case for research on inequality.

Biomedical ageing research—mainly basic research—is characterized by strong institutional concentration, namely involvement in DFG Collaborative Research Centers [*Sonderforschungsbereiche*] and other group formats. Nevertheless, there are also gaps in this area: geriatrics was long neglected and is now supported slightly more, after a long period of advocacy by the Robert Bosch Stiftung. Research on areas such as the provision of healthcare or public health still appears weak; likewise cooperation with other research fields seems underdeveloped.[351] Trends such as personalized medicine further intensify the sometimes extreme fragmentation.

In engineering sciences, the establishment of networks with their respective foci, such as the Fraunhofer AAL Alliance, stand out. Assistive and environment technologies are mainly developed for medical and health applications, and preventive use has not been studied much so far. Interdisciplinary cooperations are restricted to biomedicine. Collaborations beyond this focus and across research fields are necessary to bring technologies into everyday life. The efficacy of technological developments has hardly been investigated, whereby long-term intervention studies for this purpose are lacking. In addition, adequate structures and medium-term funding for interdisciplinary research is not available for technology transfer into industry and for standardization to bring prototypes onto the market.

Besides the technological environment, the local environment (regional conditions, residence) plays an important role for the life course and ageing. The influence of the local environment on individual development and functioning, and effects of the regional distribution of productivity and further economic and other resources on regional development potential are little investigated to date. The collaboration of researchers in regional studies with economists, social, behavioral, and health scientists is obviously required, but hardly realized so far.

350 *Web of Science* evaluation for 2006–2016.

351 See Chapters II and III for details.

In the humanities, the life phases of old age—likewise childhood and youth—at least form peripheral areas of research, whereas the view of the entire lifespan is hardly present at all. This is the greatest requirement in this research field, and its lack represents a large obstacle for interdisciplinary cooperation with the social and behavioral sciences.

By Interdisciplinary Topics: Social Inequality and Cognition as Examples for Topics of Research on Ageing and the Life Course

Social inequality and cognition are two important research fields that are very closely associated to research on ageing and the life course. Particularly in the last decade, research on the complex causation of individual and historical trajectories of social inequality has made remarkable progress. In Germany, however, despite increases, relevant research is relatively rare. On the one hand, the proportion of publications among those in the social sciences and humanities is low, on the other, the topic of social inequality is hardly present in the biomedical disciplines. In this spectrum, the more overarching publications on environmental and occupational medicine or health provision are also rare. An important reason for research on inequality lagging behind is the paucity of biopsychosocial and cohort-comparative longitudinal studies. These are essential if the question of causal relationships between health or life expectancy and social inequality is to be answered conclusively, for example.

Lifespan cognitive development and ageing is currently being investigated with a focus on pathological ageing, but the large research fields distinguish themselves in this trend: In the social and behavioral sciences and humanities, healthy cognition is more frequently examined than in the biomedical sciences. Neuroscience publications are very highly represented. However, even in research on pathological cognitive ageing there is a lack of research reflecting the multi-level complexity of ageing processes and modeling the interactions between these levels.

Research on cognition also needs to take account of the biopsychosocial paradigm and further develop it. Investigations of cognitive ageing and its plasticity as well as medical-epidemiological questions on neurodegenerative diseases and learning, competence development, and memory across the lifespan would all benefit from this perspective.

V. Evaluation and Recommendations

First of all, central challenges and trends in research on ageing and the life course were presented from the perspective of the disciplines involved (Chapter I). This was followed by descriptions of the main funding programs and strategies in the EU, Germany, and important countries important in this research context to place German funding into the context of benchmark nations (Chapter II). The research activities in the various fields were then briefly summarized, with two subfields being presented in greater depth (Chapter III).

In the past 50 years, and until today, the medical and biological perspective is at the forefront of the investigation of ageing. Treatment and prevention of age-associated diseases and the fundamental biological mechanisms of human ageing were, and still are the predominant themes.[352] Nevertheless, the differences between the individual biological and medical disciplines are enormous.

The relative emphasis on life-science research in relation to other research fields is not a phenomenon that is specific to ageing research. Particularly in the US, but also in other countries, the life sciences have been strongly supported with public funds over the last two decades, even though representatives of the field acknowledge that biomedicine alone is unable to answer biological and medical questions of ageing and call for a broader scope of research activities.[353] In Germany, the growth of DFG funds in the life sciences (in general) has been much stronger than in the other fields in the past years.[354] They receive 34% of the approved DFG funds, reflecting the largest share for a research field.[355] The engineering sciences (in general) benefit even more from public funding, via direct federal project funding (without institutional support). In 2011-13, their support grew to about 46% of the funds, from about 37% in 2008-10. [356]

What Has This Funding Policy Meant for German Research on Ageing and the Life Course?

The extent of life-science funding is reflected both in publication numbers and the setting of topics in research on ageing and the life course by institutions. Thus, a high proportion of biomedical publications characterizes this research in Germany. This is in line with a general trend that is also observed in the benchmark countries of the US, Sweden, France, the UK, and the Netherlands.[357] However, within this spectrum, German research publishes disproportionately frequently in biochemistry/molecular biology, genetics, pharmacology, and neuroscience journals as well as medical journals in the fields of surgery, cardiovascular diseases, and oncology in comparison to those countries.

352 See Chapters II and III for details.

353 Merrill SA (2013); Varmus H (2000).

354 In comparison of the periods 2008–10 and 2011–13, the life sciences received about 300 million EUR more, whereas the funding of the natural and technological sciences as well as the social sciences and humanities grew by about 100–140 million EUR; cf. DFG (2012); DFG (2015).

355 In 2011–13, the technological sciences received about 2.6 billion EUR more than in the previous three years, whereas the natural sciences received 700 million EUR more and the life sciences received about 400 million EUR more. Funding for the social sciences and humanities decreased; cf. DFG (2012); DFG (2015).

356 DFG (2012); DFG (2015).

357 Analysis of *Web of Science* for 2006–16.

In contrast, publication activities in the fields of healthcare provision and geriatrics are relatively under-represented.

In the life sciences, research on ageing and the life course is generally strongly focused on diseases, thereby making the investigation of healthy ageing difficult. However, two tendencies can be observed that may counteract this in a positive manner. First, concepts such as "regenerative medicine" and "systems biology," which have inspired many research programs and the founding of new institutions worldwide (including Germany), are genuinely interdisciplinary and intrinsically open for aspects reaching beyond the disease context in which the research is being carried out. Age dependency and ageing itself are, or will be, important variables in this context. The data centeredness of such projects, often based on omics technologies or involving large-scale cohort studies can provide space for re-analyses under age-relevant aspects, even if these were not a priori at the center of attention at the time of data collection.

Second, it can be seen that the growing accentuation of "translation" in biomedical research regarding an orientation towards applications does not replace old slogans like "bench to bedside," but complements and qualifies them with high visibility. In the positive case, translation emphasizes the bidirectionality between basic science and medical and clinical application, and the complexity of this interaction. As many challenges for the healthcare system are related to old age, aspects of ageing need to be better integrated for completion of future models. The concentration on individual diseases is also being loosened and leaves space for more open consideration of other aspects. However, these potentials also need to be utilized.

A clear difference in comparison to the benchmark countries can be seen in the weighting of the social and behavioral sciences, and humanities. These research fields are proportionally much less represented within German research on ageing and the life course than in the UK, Sweden, and the Netherlands. Population-associated health research is also hardly linked to social and behavioral science, as also shown for research on social inequality.

Research on inequality relating to ageing and the life course is dominated by the association to health; the older part of the population has only recently come into focus.

In research on cognition related to ageing and the life course, life-science publications predominate in all of the benchmark countries. However, the proportion of social-science publications is much greater in the UK and the Netherlands than in the other countries. Cognitive ageing research on pathological phenomena is preponderant. The compared countries are hardly distinguishable in this respect. The topics of memory and/or learning are also rarely represented in this field.

Biomedical ageing research—mainly basic research—is characterized by a strong institutional concentration, that is, involvement in DFG Collaborative Research Centers [*Sonderforschungsbereiche*] and other group formats. Nevertheless, there are also gaps in this area: geriatrics, the provision of healthcare, or public health still appear weak, likewise cooperation with other research fields seems underdeveloped.[358] Trends such as personalized medicine further intensify the sometimes extreme fragmentation.

In engineering sciences, long-term intervention studies to test the efficacy of technological developments are lacking as well as cooperation with research in the humanities, social and behavioral sciences. Assistive and environment technol-

358 See Chapters II and III for details.

ogies are mainly developed for medical and health applications, and preventive use has not been studied much so far. Adequate structures and medium-term funding for interdisciplinary research is not available for technology transfer into industry and for standardization to bring prototypes onto the market.

Besides the importance of professional perspectives and the insufficient linkage of research disciplines in ageing research, the question of whether the present types of funding and contextual conditions in Germany are suitable at all needs to be discussed (see below). The US is a particularly important point of reference for European researchers due to the annual budget for ageing research of more than 1.5 billion US$ (in proportion to its population, ageing research in Germany would have to receive 400 million EUR to match that sum) and the unique institutionalization of research and funding under the roof of the NIA.[359]

V.1 Does Current Funding Meet the Challenges of Research on Ageing and the Life Course?

Against the backdrop described above, this section now provides a summarizing evaluation. Its aim is to determine whether German funding policies are adequate for the scientific challenges facing research on ageing and the life course in terms of content, how those challenges could be (even) better met, and which successful examples from the international funding landscape might serve as good models.

Thematic Contents: How Can the Priorities on Disease and Care in Old Age and on Technological Assistive Systems Be Adequately Complemented?

Comparing the distribution of funds for research on ageing and the life course across disciplines, biology, medicine, and the engineering sciences receive the largest shares. Only rarely are alliances with the social and behavioral sciences formed as required by a biopsychosocial approach. The support of this approach would also set an important counterpoint against the fragmentation of research within biomedicine and thereby offer the opportunity to expand the contents of this research.

Health research has benefited from the "Health Research Centers" (centers for research on various important diseases). However, there is no overarching initiative to integrate the perspective of ageing and the life course and adequately extend the range of involved disciplines. Topics related to ageing and life course are thus most likely in the field of neurodegenerative diseases (DZNE). In DFG funding and the foci set by other research organizations, biomedicine also dominates, with a limited range of disciplines represented (with exceptions, e.g. longevity research); this even applies within the mostly technological research of the Fraunhofer-Gesellschaft, which mainly makes links to ageing via health technology topics.

Funding of overarching biopsychosocial research remains an exception. The behavioral and social sciences, and humanities are usually missing, but they are essential to disentangle the influences of culture-historical, institutional, and behavioral factors on health and the course of ageing. Beyond health, further important domains of life such as work, family, and learning influence ageing trajectories significantly. Imagining the life course as a line, the goal is not only to correct its downward slope (disease and functional impairments), but also to avoid decline in

359 The greatest portion of the NIA budget benefits the life sciences, especially research on Alzheimer's disease, which is one of the US's priorities in health and ageing research. This is expressed by the priority set in the National Alzheimer's Project Act passed in 2011, in which the fight against Alzheimer's disease and related types of dementia was promised until 2025. ASPE (2016).

the first place, and move this line up from early onwards by supporting a person's potential. Research on processes serving the maintenance of levels of functioning achieved deserves just as much funding as research on processes leading to ill health and frailty.[360] Both aspects are relevant for the individual as well as society, saving costs and achieving improvements.

Technological applications for support in old age are promising elements of environmental adaptation and of the promotion of social participation in the face of ageing-related impairments. However, despite high investments into its development via EU and BMBF funding, neither have recognizably viable and affordable market solutions for the daily life of the elderly, caregiving by relatives, or in professional care and geriatrics been achieved nor does the research in this field seem to have developed the relevant disciplinary links that could foster the development of the applications' efficacy (e.g. via user support). Beyond the application in the domain of physical impairments, further important topics, such as building up individuals' potential or changing the working world, are neglected.

Research Agendas and Evaluation: Are the Consequences of Priority-Setting Assessed?

The research policies emphasizing ill health, caregiving, and technological assistance systems probably first reflect the conviction that illness plays the most important role in old age and that coping with morbidity exclusively lies in the realm of research of pathology. In contrast, the established strengths of old age and ageing remain confined to the shadows of the research environment. There appears to be a lack of belief that these strengths actually exist and that their better understanding can also open up opportunities to promote them further and thereby ease and support individuals' ability to cope with pathology.[361] Second, economic interests like those of pharmaceutic, medical-technological healthcare, and IT industries, are likely to play a role. Third, it finally needs to be taken into account that the cumulative effects of funding priorities over many years are reflected here, which heavily influence disciplines' development status and their capacity to carry out successful research.

In EU research funding, it is particularly noticeable that many science-based, research-strategic memoranda have been developed on an EU budget, but that program development has only actually referred to them in a few exceptional cases.

In Germany, in turn, the Federal Government developed an ageing research agenda that was neither strongly based on science nor led to academic debate (e.g. with professional associations and funding agencies). Funding of the field of research on ageing and the life course in Germany was not, and is not, determined by an overarching strategy guided by research. Evaluations of the individual building blocks of the agenda; for example, competency maintenance across the lifespan, cross-generational housing, and raising quality of life via technological innovations for caregiving services, have not taken place. Program evaluations have not been carried out, to the detriment of further development of research. In the context of the topic of technologies for old age, prototype development, piloting, and case studies have benefited from funding, but the dissemination and implementation as well as the evaluation of efficacy in controlled studies with sufficiently large samples are lacking, and thus the decisive step for both application (and feedback into research) and scientific integration cannot take place.

Research funded by governmental departments, like the acknowledged employ-

360 Nyberg L et al. (2012).

361 Aspinwall L, Staudinger UM (2003).

ment research linked to ageing and the life course examining questions of participation and providing longitudinal data, makes important contributions to ageing research. However, the potential for synergy in research on ageing and the life course that could be achieved by linking across the Federal Ministries according to an overarching strategy is by no means fulfilled. This would not hamper the role of departmental research in supporting the respective Federal Ministry in its specific tasks, but rather complement it. The British What Works centers could provide suggestions on how research evidence can be systematically evaluated and prepared for political decisions and also utilized for citizen participation and public discourse.

It is imperative to push for the regular evaluation of the research priorities set for a limited period of time. Especially for topics with direct relevance to the well-being of every single person, the mandatory criterion should not only refer to the quality of research, but also to the priorities set by citizens as well as decision-makers and parliamentary representatives in dialogue with researchers. Experience with participatory processes and scientific evidence are available, from the Dutch National Research Agenda or from the EU's Responsible Research and Innovation (RRI) projects, for example. Other examples are the local networks of geriatric-clinical research and ambulatory care provision in France or public participation in the prioritization of treatment costs in Germany. Particularly the systematic evaluation of societal and individual gains resulting from investments into R&D in the field of ageing research as a whole (not only with a view to health and technological assistance) is an important precondition for promising public participation in decisions about the funding of applied research.

Examples from other countries such as France and the UK show that a central impulse from the government or parliament, in the shape of a national program, is of great significance for research productivity and direction. The parliamentary and societal debate on funding priorities should also follow up on important initiatives such as the further advancement of welfare indicators (Enquete-Kommission "Wachstum, Wohlstand, Lebensqualität" [Study Commission "Growth, Welfare, Quality of Life"]).

Funding of Research Alliances: What Do They Achieve With Respect to Interdisciplinarity?

In the research community, the view is now widespread that in ageing research, the study of trajectories across time and in historical comparison as well as dynamic interactions among multifarious factors that cannot be examined by a single discipline, contribute significantly to the increase of knowledge. Viewing the research topics shows that ageing and developmental trajectories are important questions in numerous research fields. Nonetheless, there are few impulses in Germany to combine these elements, learn from another, and approach both basic and application-oriented questions of normal ageing and its potentials collaboratively. The experiences of other countries show that the boundaries between disciplines need to be actively dismantled, as made possible by funding schemes and establishing infrastructure and repositories of research instruments.

Current assessment and analysis methods allow an increasingly complex representation of ageing and life courses. For this purpose, life, social, and behavioral sciences, and the humanities need to collaborate. For example, the National Institute on Aging in the US formulated the goal to study ageing as "an intricate web of interdependent genetic, biochemical, physiological, economic, social, and psychological factors."[362] Further examples from the US include the founding of "Transdisciplinary Collaborative Centers for Health Dispari-

362 NIA (2016b).

ties Research“[363] in health research as well as ageing research centers combining engineering sciences and cultural studies at George Washington University, the CREATE Consortium involving four American universities (Miami etc.), or in Japan (Osaka Institute of Technology).[364] The American science academies have made extensive statements on the potentials and new findings of biopsychosocial ageing research.[365] The British “New Dynamics of Ageing” program was also a pioneer in the funding of interdisciplinarity.

Which Approaches to Interdisciplinarity Exist in Alliance Funding of German Research on Ageing and the Life Course?

The topical alliances within the Leibniz Association are thematically broad and thereby provide positive impulses for the involved institutions. Ensuring funding for personnel infrastructure and research support—at least for pilot studies—is essential to maintain and extend the alliances’ dynamics from initial networking to joint development of new topics and research pathways.

The positive potential of DFG funding to allow for studies initiated by researchers needs to be emphasized. However, DFG funds are too rarely used for broadly based ageing research that combines the large research fields (life, social, behavioral, engineering sciences, cultural studies, and the humanities) interdisciplinarily.[366] The funded discipline-specific ageing research projects mainly stem from medicine, biology, and the neurosciences, followed by the social sciences and psychology. Although ageing and the life course are integrated into some interdisciplinary projects or group formats as a facet or subproject, on the whole, each of these projects or groups is more likely to take a discipline-specific than an interdisciplinary perspective. Furthermore, there is currently no designated group funding (e.g. *Exzellenzcluster* or *Sonderforschungsbereich*) on the topics of ageing and the life course. The humanities and cultural studies are extremely poorly represented in DFG-funded ageing research, and it is astounding that there are hardly any DFG projects in the legal sciences; for instance, on changes in social law with respect to ageing and the new shaping of life courses and careers.

In the Joint Programming Initiatives funded by the EU research program that are influenced by both science stakeholders and the Federal Government in terms of content, ageing and the life course is integrated cursorily and unsystematically at best, even in obvious cases (e.g. JPI Healthy Diet for a Healthy Life with funding of the research on malnutrition in the elderly and on cognition, stress, and nutrition across the life course), or they receive relatively small budgets (e.g. JPI MYBL or DIAL). Strategic impulses from statements on the further development of research on ageing and the life course, like that of Futurage, have not been considered in EU funding. However, a positive example is provided by the JPND, which is financially well provided for and also supports the hitherto insufficient fine-tuning of national and European research aims.[367] This JPI has also built up a register of global cohort studies on neurodegenerative diseases and analyzed their technical features to make it easier to use data across national borders.[368]

The “Allianz für Menschen mit Demenz” is a positive German example of coordination (lacking elsewhere) with research institutions and professional associations, scientific benchmarking of national de-

363 NIMHD (n.d.).

364 Czaja SJ et al. (2001).

365 NRC (2012); NAS (2018).

366 According to a study by the DFG on the distribution of its reviewers’ disciplines, this is not due to potential differences in chances of success in comparison of applications for discipline-specific and related projects versus applications combining disciplines with more distance between each other. Deutsche Forschungsgemeinschaft (DFG) (2013b).

367 JPND (2017).

368 JPND (2013).

mentia strategies, and auditing of the realization of at least its own agenda,[369] even if its research returns have not yet been evaluated. Furthermore, the agenda for dementia research states the need for interdisciplinary collaboration between clinical research, basic biological research, the social and behavioral sciences, and epidemiology. The concrete realization of this collaboration should be evaluated as well as examining which conditions benefit or obstruct interdisciplinarity.

Researchers from the engineering sciences, biomedicine, social and behavioral sciences, and the humanities regard interdisciplinarity reaching beyond the direct overlapping of closely related disciplines as an important step for successful research. However, without infrastructural and research-political support, it will not be possible to take that step. In Germany, there is currently a lack of appropriate risk-taking funding formats that provide research budgets for longer periods of time and that move new interdisciplinary developments, which are often riskier, into the foreground.

V.2 Research Infrastructure

Adequate research infrastructure is an important condition both for research itself and also for political and societal organization. The establishment of research data centers that enable the use of official data and are accredited by the German Data Center [Rat für Sozial- und Wirtschaftsdaten, RatSWD] according to uniform standards can be assessed as positive. Besides consistent access, they also provide standards in data documentation, data protection, and user consultation.[370] Longitudinal studies should be better harmonized and more easily linked to official and georeferenced environmental data.[371]

Population-wide longitudinal studies that are also adequate for national comparisons are essential for the detection of causal relationships and historical changes for ageing. They are the "large appliances" of research on ageing and the life course that not only supply new insights but also serve evidence-based policy advice. However, their long-term funding is not secured under the given research funding schemes. In the past years, several important longitudinal studies were established in Germany,[372] but they do not cover the entire lifespan. The best way to keep up with top-level international research is to push for interleaving and equal treatment of the social and behavioral sciences with biomedical research. Innovations in extensive data collection and further expansions indicate the urgency of appropriate infrastructural adaptations and personnel development. Criticism is due given the insufficiency of sustained research infrastructures that can offer space and long-term financial security for truly interdisciplinary ageing research. Virtual research alliances are not an equivalent substitute.

In medical care, the available scientific evidence on treating older people is insufficient. In the future, clinical studies on medication prescribed to people over the age of 65 years, and especially over the age of 80 years, should also represent these age groups appropriately and carry out age-related benefit-risk assessments. Other study methods that can represent the needs and demands of medical care for the elderly such as pragmatic studies including patients' reality of life, multi-component interventions (complex interventions), and observational studies should be promoted in a targeted manner. As such studies have not yet been sufficiently advocated by the pharmaceutical industry, more public funds need to be made available for them.[373]

369 DZA (2013).

370 RatSWD (2010).

371 German National Academy of Sciences Leopoldina et al. (2016).

372 Ibid.

373 For details: Ibid.

In the social sciences and humanities in particular, it is becoming clear that university research programs on ageing and the life course are missing and that hardly any concentration has taken place within research at extramural institutions. Catching up with international research in the social and behavioral sciences necessitates the funding and revitalization of research fields that are oriented towards programmatic, cross-disciplinary integration of research and on linkage across life courses.

V.3 Recommendations for the Further Development of Research on Ageing and the Life Course in Germany

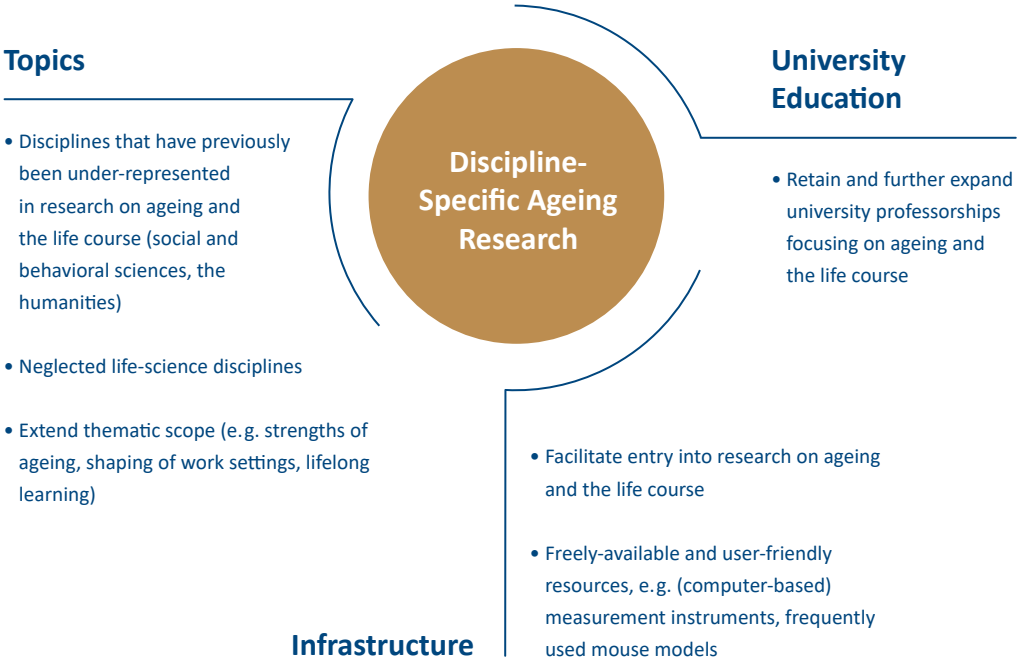
In this section, we identify fields of action and instruments to open up the research potential in Germany and catch up with the top tiers of international research. Furthermore, both basic and applied research on ageing and the life course also has an important role to play in shaping society and individual lives. We sketch the research-political conditions needed to achieve both goals. We address these desiderata to the entire gamut of funding agencies, umbrella organizations of research institutions, universities as well as research associations. We are convinced that a coordinated and adequate response is possible in dialogue between these organizations and researchers competent in this field.

We see opportunities for a strengthening of the German research landscape in these six areas:

Figure 2. Opportunities to Strengthen Research on Ageing and the Life Course

	Research Topics	Research Infrastructure	Education and Training
Discipline-specific	• Funding of research on ageing and the life course	• Preconditions for research on old age/ageing (humans/animals) • Establishment of freely accessible resources for research on ageing and the life course (measurement instruments, mouse models of old age, etc.)	• Expansion of discipline-specific professorships with a focus on ageing and the life course
Interdisciplinary	• Funding and incentives for biopsychosocial research (i.e. across the life, technological, social, behavioral sciences, and the humanities) as innovative research with elements of risk • Targeted, consensus-based search for research gaps by task forces and funding agencies	• Longitudinal studies up to very old age and beginning before birth/conception • Long-term funding • Methods Centers • Multidisciplinary alliances of research institutions	• Training in interdisciplinary research on ageing and the life course starting at the postdoc level • Acquisition of competencies in making use of inter-disciplinary longitudinal studies or in applying different ageing paradigms in biology

Figure 3. Strengthening Discipline-Specific Ageing Research



Strengthening Discipline-Specific Ageing Research: Topics, Infrastructure, and Training

Ageing and the life course are topics of pivotal importance for both research and society, but research in Germany in this field is under-represented in comparison to other fields, and also to several other European countries and the US. To start, topics revolving around ageing and the life course should therefore be strengthened in discipline-specific research funding. Without broadly-based and excellent discipline-specific ageing research, internationally-competitive interdisciplinary research is impossible. Discipline-specific research funding should therefore concentrate on those disciplines that are under-represented in research on ageing and the life course so far, such as the social and behavioral sciences, cultural studies, and domains of the life sciences that have not been included to date. Individual disciplines differ in their respective needs for further development (cf. Chapter III). It is necessary to retain and further expand the number of university professorships focusing on research on ageing and the life course. Likewise, it should be ensured that the central disciplines involved in research on ageing like biology, medicine, psychology, sociology, or economics represent the topic adequately in their curricula. Impulses from European cooperation initiatives such as DIAL and JPI MYBL (Chapter II) could be taken up and strengthened in a targeted manner. In order to make it easier for researchers to get involved with research on ageing and the life course, it is advisable to make available freely-accessible and user-friendly resources; for example, established (computer-based) measurement instruments or frequently used mouse models of old age (e.g. Black 6, 24 months and older), as is done by NIA/NIH in the US. The harmonization of measurement instruments and research paradigms would also benefit the comparability of findings.

The thematic range of funding needs to be extended. So far, financial support has concentrated on selected sub-fields of the life and engineering sciences. The neglect of other research domains (even within these fields) obstructs essential research on questions such as the maintenance of competencies and functioning into highest ages, in a society of longer lives with a proportion of people aged over 65 years that currently stands at about 21% and will reach 32% by 2060. This challenge can not only be met by treating illnesses, but rather requires research efforts on—for instance—how to shape work to accommodate longer lives and on making lifelong learning an integral part of the education system. Furthermore, the concentration of funds on understanding and treating individual diseases needs to be complemented by funding incentives for research focusing on the conditions that foster the strengths and unleash the positive plasticity of ageing.

Orienting Funding Programs Toward Interdisciplinarity

In Germany, research funding and research infrastructure for the social, behavioral, engineering, biomedical sciences, and the humanities are, to a large extent, characterized by strong compartmentation. This separation between the disciplines is without doubt necessary to promote excellence within *discipline-specific* ageing research but it is not sufficient in terms of breaking the frontiers of ageing research in the 21st century. Funding formats and research infrastructure bringing disciplines together must simultaneously exist to do justice to the complexity of human ageing and the life course. Cooperation and synergies—as exemplified by research on cognition or social inequality—can extend the boundaries of knowledge. This requires studying the biopsychosocial reality of human ageing in historical and cultural comparison, which can only be successful if interdisciplinary research is fostered.

Special funding formats are needed to set incentives and opportunities to organize interdisciplinary cooperation in new topical fields. Funding agencies and research institutions still have to develop appropriate processes and quality criteria for this type of research proposal.[374] This concerns mechanisms of resource allocation and distribution and practical responsibility in disciplinarily-ordered faculties and research institutions, visibility in scientific journals and associations, granting of funds, and career opportunities for researchers.

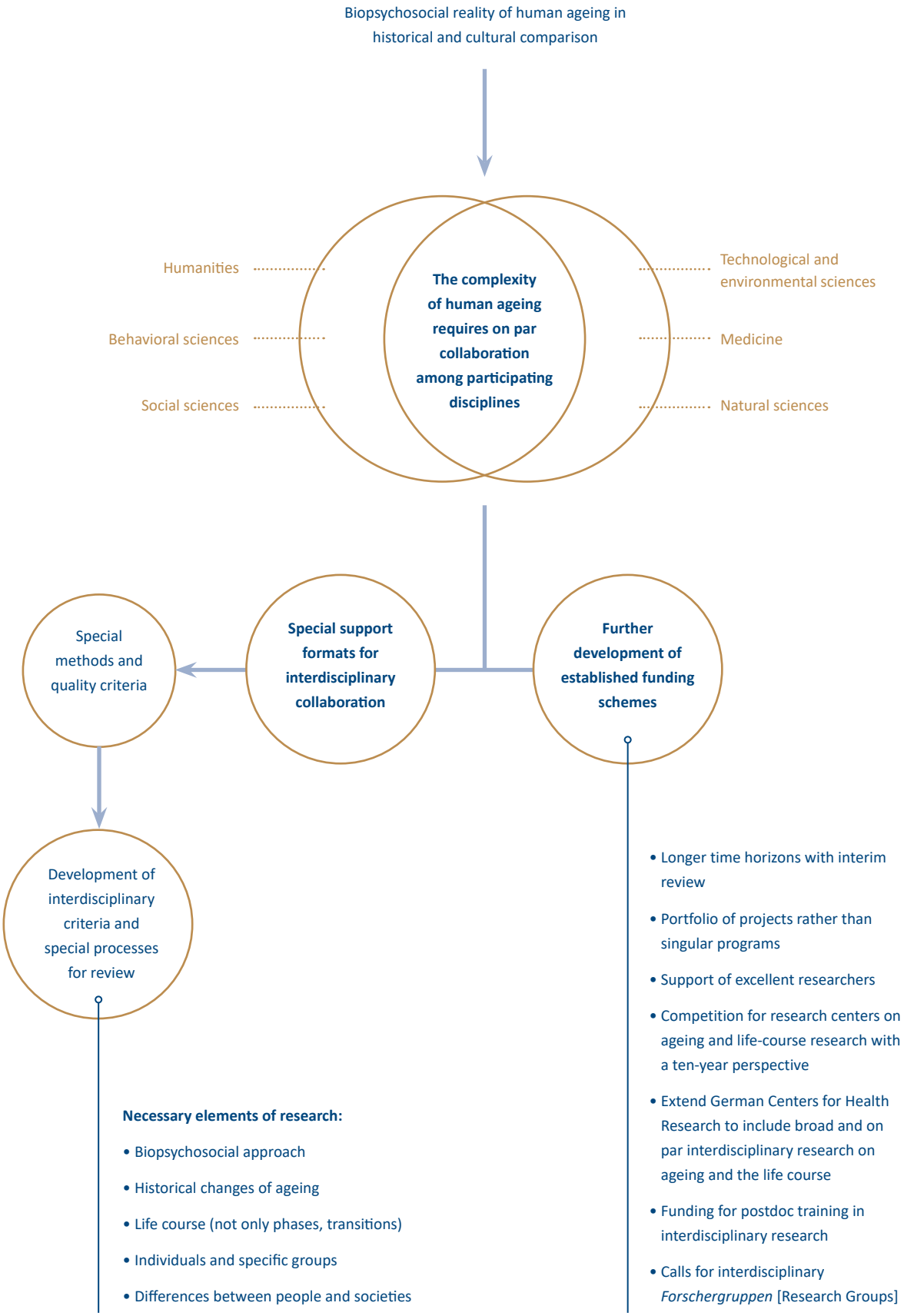
Using Funding Schemes of Established Funding Programs

Special conditions are needed so that researchers can not only work with divided responsibilities but also collaborate in an integrated fashion: These include adequate topics and geographical proximity or at least a coordinating infrastructure. We regard straightforward network funding (which is restricted to regular meetings and mutual information and does not include resources for intensive, integrated collaborative research projects) as a positive first step in this context, but by no means does it suffice. A new complex field of research requires sufficient start-up funds for coordination and integration to develop productively and compete internationally. Institutionalized program funding is an important instrument to achieve that goal. A longer time horizon with interim review, a stable portfolio of projects rather than singular programs, and/or the support of excellent researchers have proven promising.[375] Short-term,

374 E.g. Gleed A, Marchant D (2016); Staudinger UM (2015).

375 Derrick EG, Falk-Krzesinski HJ, Roberts MR (2012). Examples for this are the long-term support provided by the Robert Bosch Stiftung, which ranges from projects to professorships, or the research support provided by the Deutsche Rentenversicherung (the German pension insurance system), each in a narrow thematic/discipline-specific field; other examples are the Swedish ageing research centers and the centrally available and extensive range of standardized measurement instruments and training courses in the use of interdisciplinary longitudinal data on offer via CLOSER in the UK or NIH in the US, for example.

Figure 4. Orient Funding Programs Towards Interdisciplinarity



smaller scale, mostly discipline-specific projects on ageing and the life course do exist. However, what is needed is a nationwide call for establishing research centers with a renewable ten-year perspective. This funding scheme for research on ageing and the life course has been successful in other European countries like Sweden as well as the US. The networks of German Centers for Health Research have elaborated coordinating and integrative structures that allow for joint research. This approach could be used as a blueprint for the establishment and expansion of interdisciplinary research on ageing and the life course encompassing a broad spectrum of disciplines representing a biopsychosocial approach.

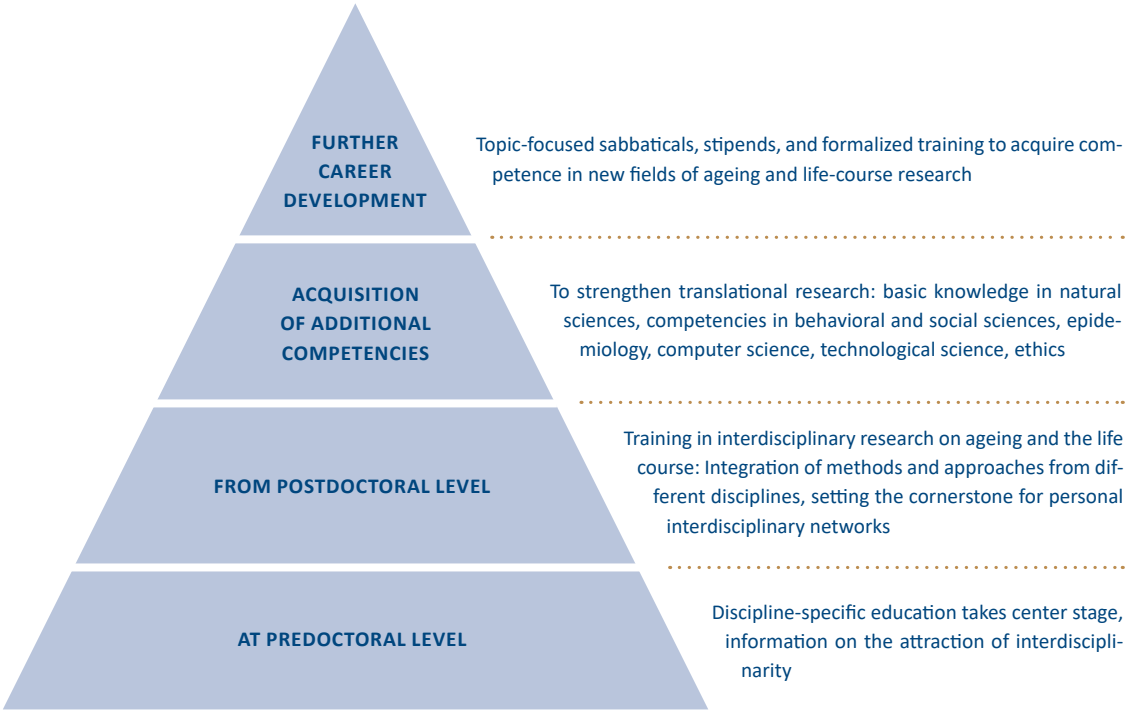
Furthermore, it would be helpful to develop more attractive funding formats that enable collaboration across many disciplines over longer periods of time. In analogy to support by the Howard Hughes Medical Institute (HHMI), which completely funds individual researchers within their institutions for five years, broad interdisciplinary research groups could be sponsored, while individuals scientists are based in different institutions; for instance, using virtual institute formats. This model could also include attractive funding schemes for postdoctoral training. In this context, it would make sense for the DFG to make additional specific calls for *Forschungsgruppen* [research units] to strengthen an entire interdisciplinary research area (as was the case for public health). The success of such research groups could provide the basis for universities to subsequently establish broadly interdisciplinary research centers revolving around ageing and life-course topics. Furthermore, interdisciplinary ageing research that has demonstrated excellence in integrating a broad spectrum of relevant disciplines could be made visible and honored by launching a high-ranking award for interdisciplinary research.

Education and Training in Interdisciplinary Research on Ageing and the Life Course

Discipline-specific education needs to be at the center of attention up to the PhD level graduation to guarantee broad and deep discipline-specific knowledge and skills. However, from the postdoc level onwards training in interdisciplinary research has focused on the challenges of research on ageing and the life course needs to be available. Such programs—which have proven themselves internationally[376]—promote a basic understanding of other disciplines (with their different perspectives, tools, and language addressing the same research question) and help to diminish mutual prejudices, they support the ability to integrate methods and approaches of several disciplines and can set the cornerstone for personal interdisciplinary networks. The thematic focus on ageing and the life course, together with a thorough foundational disciplinary education, are important preconditions for such postdoctoral training. Furthermore, in order to strengthen translational research, it is pivotal to acquire competencies in the behavioral, social, engineering, and computer sciences, epidemiology, ethics, etc. in addition to the basics in natural science. For later career development, instruments such as topic-centered sabbaticals, stipends, and also formalized training courses should be used to gain specific competencies in the fields of research on ageing and the life course.

376 Institute of Medicine (2000); NAS (2005); Bachrach C, Robert S, Thomas Y (2015).

Figure 5. Education and Training in Interdisciplinary Research on Ageing and the Life Course



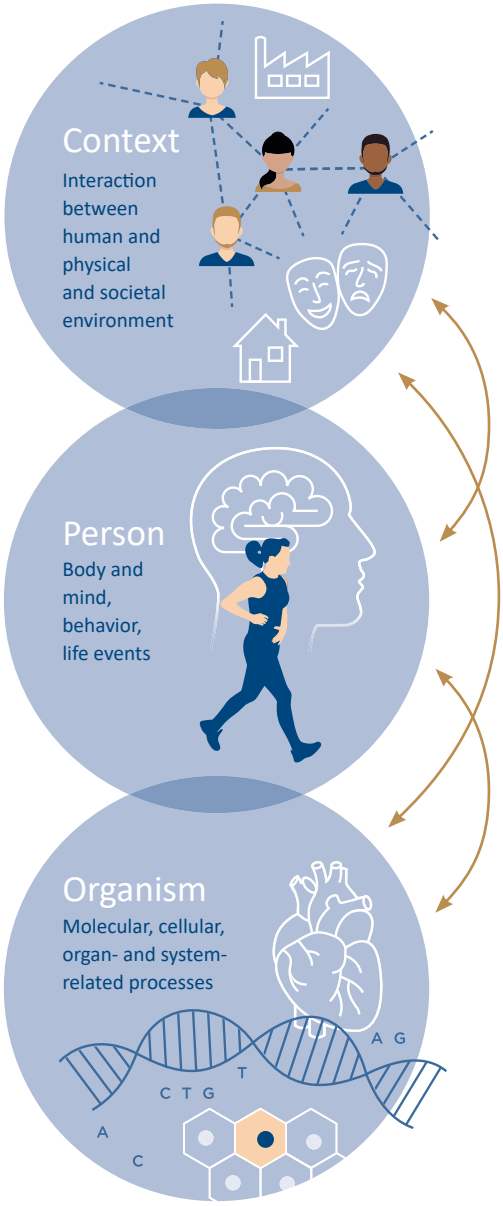
Models and Development of Quality Criteria

The development and maintenance of functional capacities, conditions for the success of health prevention and disease progression as well as the effects of prenatal conditions on later life success, and social inequality are examples of complex phenomena that unfold over long periods of time and in which different domains of life such as education, work, family, health, and the physical environment overlap. We can now understand the development and consequences of such complex processes better than ever before because we can analyze the interactions of cells and organisms, social groups, and societal institutions. For interdisciplinary research oriented towards the life course, it is essential that those involved agree on a joint "meta-theoretical point of view." In research on ageing and the life course, the minimal consensus could comprise:

- selecting a biopsychosocial approach (Figure 6);
- taking historical changes of human ageing into account;
- examining both the individual and aggregates of individuals;
- taking the large differences among people and societies into account; and
- studying the life course (in addition to separate phases or transitions).

Developing such a model (or several) should be supported. It can serve as a starting point for the development of interdisciplinary review criteria, but also promote the standardization of data collection. Advancing models and quality criteria spawns new research as well as enhancing existing work.

Figure 6. Biopsychosocial Model of Research on Human Ageing and the Life Course



Establishing Data Collection and Analysis, Methods Centers, and Training Programs for Interdisciplinary Researchers

Research integrating across disciplines can and should make use of the opportunity to link diachronic and population-wide data with experimental data, as this has sometimes been done in GSOEP by integrating a classical population survey approach with paradigms of behavioral economics or neuropsychology,[377] but so far there have been only few attempts to link with paradigms in biology. This would be extremely fruitful as a springboard to join the life sciences with the social and behavioral sciences and could expand on the current prioritization of the life and medical sciences. A specific funding impulse for interdisciplinary longitudinal studies involving multiple disciplines on equal terms would be helpful in this context.[378]

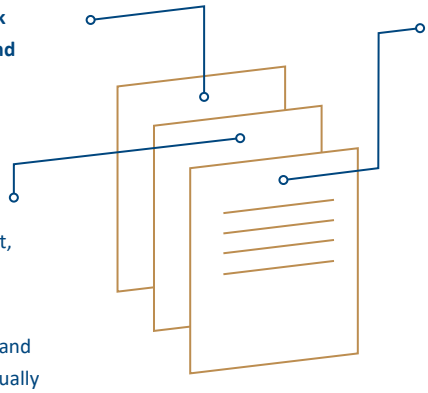
We see innovation potential in the long-term funding of cohort studies. The adult NEPS cohort of the should be followed into very old age because it holds central significance to understand the educational and occupational trajectories of adults in Germany. In the long run, it would be very important to initiate cohort-comparative longitudinal studies that begin before—or at least at—conception and reach until the end of life. Biomedical, behavioral, and social-science variables should be equally represented in the data collection. An umbrella organization combining national longitudinal studies has proved itself in the UK (CLOSER). Such an association promotes joint data analyses and the development of competence among researchers. As the starting capital of such an association, the large German studies would benefit from stronger national and international visibility and use of their data, but also from analyses that connect the different data sets. Hence, the development of (interdisciplinary and diachronic-experimental) data sets and analyses as well as the training for researchers at different career stages should become a new task for these methods centers. The breadth of required methods and paradigms is too large to be covered by a single center.[379] An integrating education and training center for interdisciplinary longitudinal studies could also be established by announcing a DFG Priority Programme [*Schwerpunktprogramm*].

377 E.g. Schimmack U (2009).

378 For extensive information on the potentials of population-wide longitudinal studies for research and societal change, see German National Academy of Sciences Leopoldina et al. (2016).

379 CLOSER (2016b); German National Academy of Sciences Leopoldina et al. (2016).

Figure 7.
Building up Data Collection and Analysis as well as Methods Centers



Make use of new options to link diachronic, population-wide, and experimental data

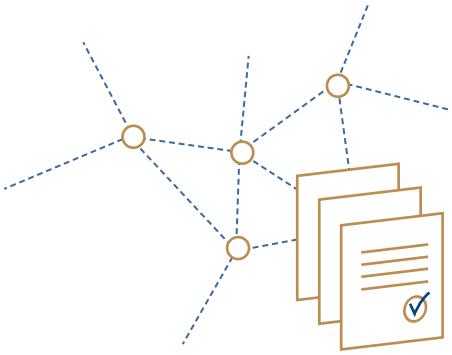
Long-term funding of cohort studies:

- that begin before, or at least at, conception and reach until the end of life
- where biomedical, behavioral and social-science variables are equally represented

Umbrella organization combining national longitudinal studies:

- joint data analyses
- joint development of competence
- greater national and international visibility and use of data
- better interlacing of analyses across studies
- further development of data sets and analyses

Figure 8.
Evaluating Application-Oriented Research and Making Output Available



- Systematically summarize, evaluate, and publicize research results
- Evaluate measures and programs to enhance evidence basis for policy-making, in both research funding and respective policy fields
- Policy- or implementation research for life-course-related policy-making

Evaluating Application-Oriented Research and Making Output Available

Application-oriented and basic research should be linked with each other reciprocally. Beyond healthcare, this concerns technology, education, labor market research, urban development, social, and culture policy, etc. The essence of findings from longitudinal studies should be publicized widely and inform the continued development of the welfare state, which requires that findings are pruned and placed in perspective.[380] For policy-making to become evidence-based, it is essential that both in the area of research policy and policy-making in general, agenda setting and legislation are systemically evaluated. So far, there is a lack of policy or implementation research to encourage, assess, and anchor ageing- and life-course-related policy-making. Moreover, policy-making and society would benefit if the results of the many research fields were comprehensibly and systematically summarized and publicized. Many topics such as societal cohesion (see research on social inequality) or individual cognitive development and quality of life across the life course concern all members of soci-

380 Summary of the upcoming tasks regarding transfer activities: WR (2016).

ety and require timely interventions, as from a policy perspective they can only be shaped in the medium or long term. This requires a continued dialogue with researchers and the application of scientific findings. The British What Works centers can be considered successful models for the testing and pre-processing of research results. One option would be to entrust a government departmental research institution with such a task, as these are experienced in application-oriented research and policy advice, at least regarding department-specific questions. Research institutes of the Leibniz or Fraunhofer Association would also be possible candidates due to their greater independence.

Appendix

I. People Involved

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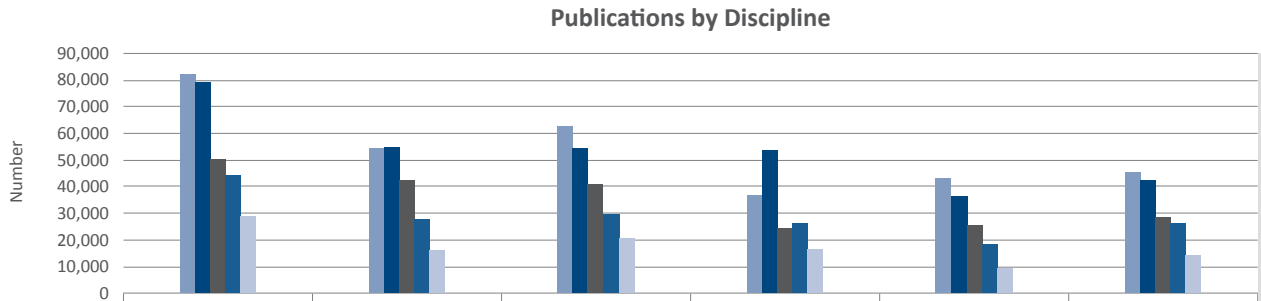
III. Tables

Search Terms 'Aging':			Further Search Terms:				
General Search Terms			Cognition	Neurodegener-ative Diseases and Alzheimer's[1]	Neuronal Plasticity/ Networks	Memory and Learning[2]	Social Inequality
adulthood	Langlebigkeit	Rente	*cogniti*	*degener*	Cortex	Alzheimer	inequality
age-associated	Lebensalter	Rentner	*brain*	palliati*	Kortex	hippocamp*	Ungleichheit
age-correlated	Lebensende	retire*	Verstand	*verletz*	nerv*	lern*	Armut
aged	Lebenserwar-tung*	Ruhestand	*kogniti*	Schädigung	*plasticity	remind*	disparit*
ageing	Lebenshälfte	senes*	*neuro*	dement*	*synap*	dement*	disadvantage
age-related	lebenslang*	Weisheit	“theory of mind”	*patho*	cortical	Demenz	Benachteiligung
aging	Lebenslauf	Widow	*hirn*	*disorder*	"neuronales Netzwerk"	Gedächtnis	poverty
aging-related	Lebensrück-blick*	wisdom	Mind	krankhaft*	dentrit*	erinner*	
Ältere	Lebensspanne	“developmental regulation”	“native Theorie”	Störung	kortikal	memor*	
alternd*	Lebensverlauf*	“end of life”		demenz*	"neuronal network"	learn*	
alters	Lebensverläufe	“fourth age”		*damage*	*plastizität	rememb*	
altersabhängig*	lifelong	“höheres Alter”		*injur*			
altersassoziiert	lifespan	“later life”		*schaden			
alterskorreliert*	longevity	“life course”		disturb*			
centenarians	long-lived	“life expectan-cy”		Alzheimer			
demogra*	Entwicklungs-regulation*	“life history”					
Elderly	Erwachsenen-alter	“life review”					
geron*	geriatr*	“midlife”					
Grandparent	middle-aged	“old age”					
Großeltern	nonagenarian	“third age”					
hochaltrig*	octogenarian	”life span”					
intergenera-tional*	Pension*						

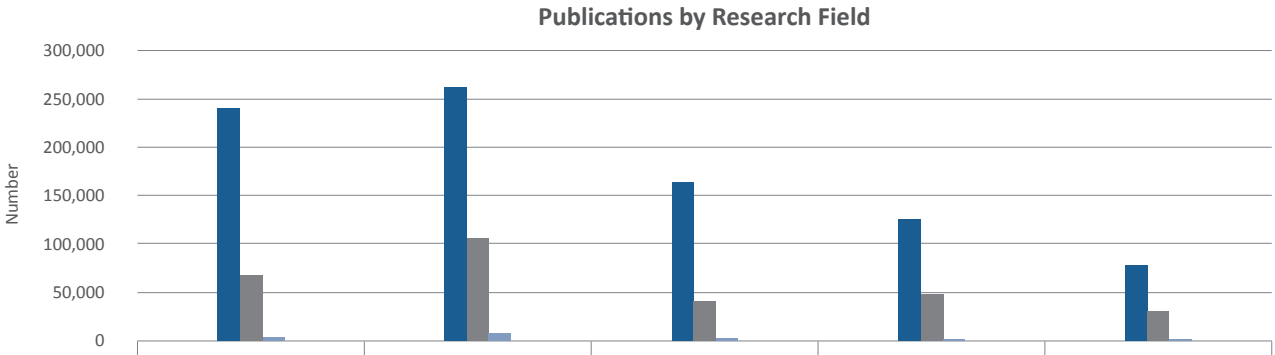
All search terms were linked by the Boolean operator 'OR.' * Wildcard in the search for an unlimited number of characters or none. Quotation marks for exact search terms. 1 Linked with AND and NOT. 2 Excluded (linked to 'NOT') – Machine and "medical students."

III.2 Journal Publications in Ageing and Life Span Research

a. Total Number



	Geriatrics & Gerontology	Pharmacology & Pharmacy	Biochemistry & Molecular Biology	Pediatrics	Surgery	Cardiovascular System & Cardiology
Germany	81,830	54,317	63,025	37,029	43,301	45,426
UK	79,279	54,668	54,288	53,508	36,296	42,648
France	50,249	42,486	40,634	24,665	25,344	28,501
Netherlands	44,373	27,565	29,406	25,903	18,412	26,355
Sweden	28,910	16,163	20,640	16,232	9,125	14,331



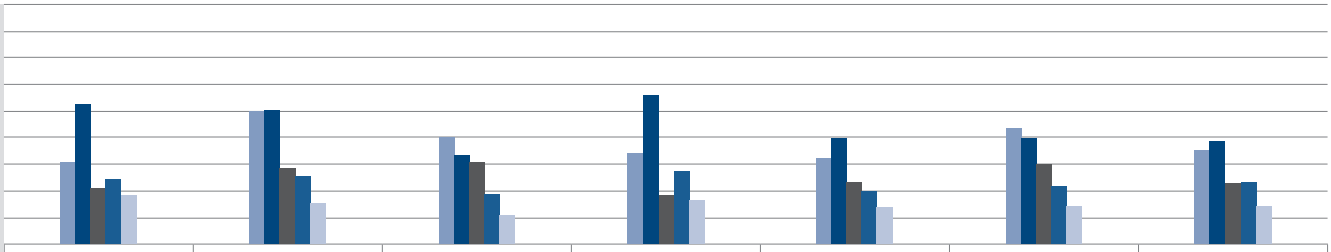
	Germany	United Kingdom	France	Netherlands	Sweden
Science & Technology	240,110	261,802	163,800	125,863	78,986
Social Sciences	66,970	105,847	40,911	47,999	30,962
Arts & Humanities	4,132	8,841	2,659	1,940	1,183

Thematic search cf. search terms (table 1).

Period 2006-2017.

Disciplines and Research Fields according to Web of Science.

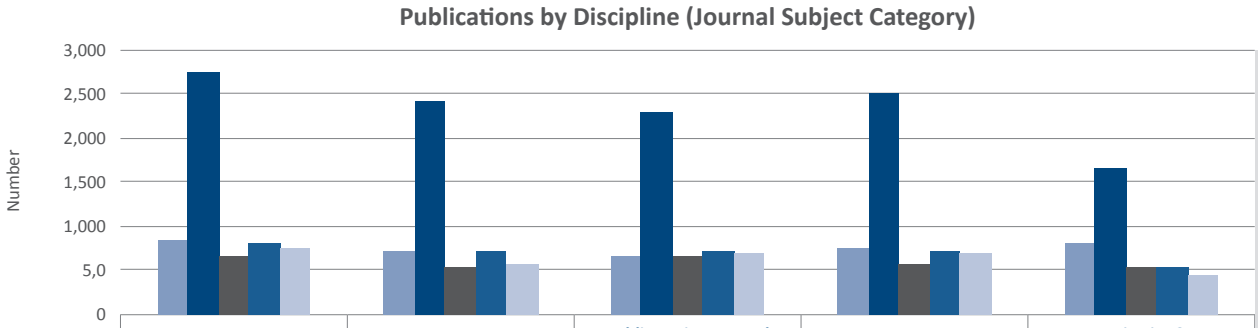
Publications by Discipline



Healthcare Sciences Services	Neurosciences & Neurology	Oncology	Psychology	Pathology	Genetics & Heredity	Mathematics
30,345	49,625	40,304	34,046	32,552	43,835	35,121
52,490	50,399	33,692	55,940	39,561	39,867	38,365
20,803	28,546	30,390	18,040	23,207	30,158	22,461
24,672	25,692	18,854	27,482	19,693	21,533	23,225
17,996	15,433	11,022	16,311	13,593	14,108	14,015

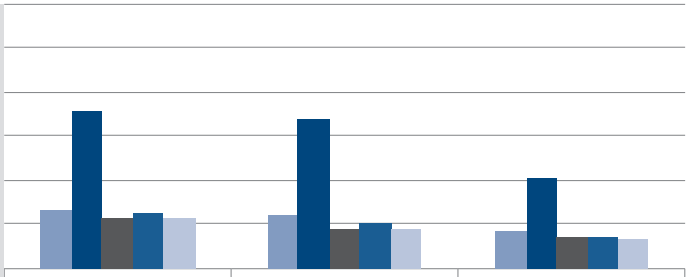
b. Journal Publications in the Thematic Field Ageing, Life Course, and Social Inequality

	Science & Technology	Social Sciences	Arts & Humanities
Germany	2,279	1,718	61
UK	5,259	4,603	154
France	1,585	1,159	30
Netherlands	1,635	1,353	54
Sweden	1,339	1,158	26



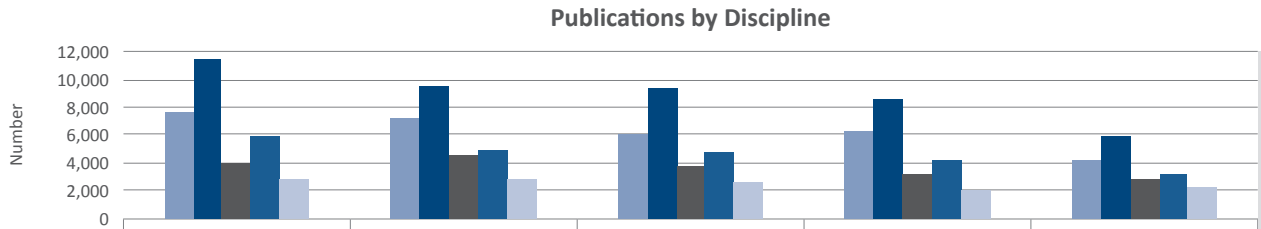
	Healthcare Sciences Services	Psychology	Public Environmental Occupational Health	Sociology	Geriatrics & Gerontology
Germany	832	711	679	750	828
UK	2,755	2,425	2,305	2,519	1,650
France	675	537	654	579	533
Netherlands	808	726	722	719	555
Sweden	754	580	700	703	464

Publications by Discipline (Journal Subject Category)



Demography	Pediatrics	Mathematics
663	596	411
1,795	1,706	1,014
565	437	360
637	507	351
572	453	316

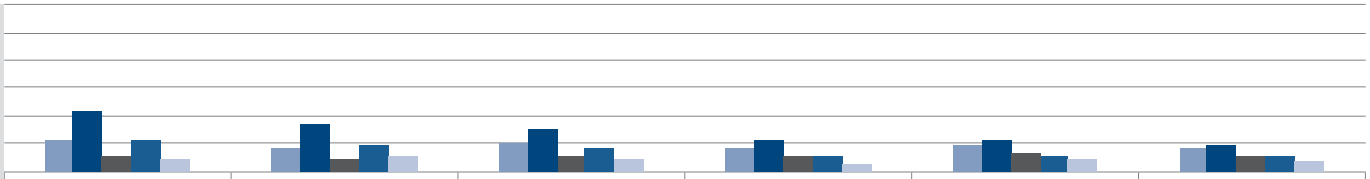
c. Journal Publications in the Thematic Field Ageing, Life Course, and Cognition



	Psychology	Neurosciences & Neurology	Psychiatry	Behavioral Sciences	Geriatrics & Gerontology
Germany	7,582	7,300	6,018	6,208	4,201
UK	11,395	9,521	9,254	8,481	5,837
France	3,993	4,557	3,792	3,240	2,912
Netherlands	5,836	4,985	4,764	4,117	3,307
Sweden	2,797	2,754	2,604	2,035	2,251

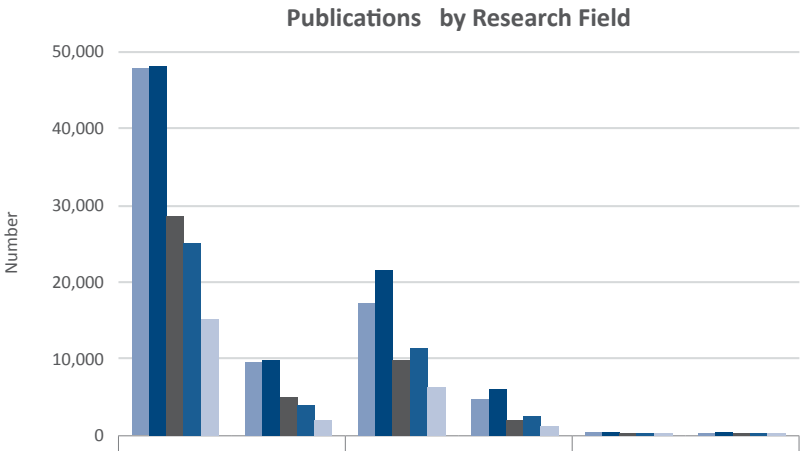
	Science & Technology	Social Sciences	Arts & Humanities
Germany	11,330	8,282	194
UK	16,374	12,606	312
France	6,674	4,459	97
Netherlands	8,425	6,465	87
Sweden	4,514	3,142	54

Publications by Discipline

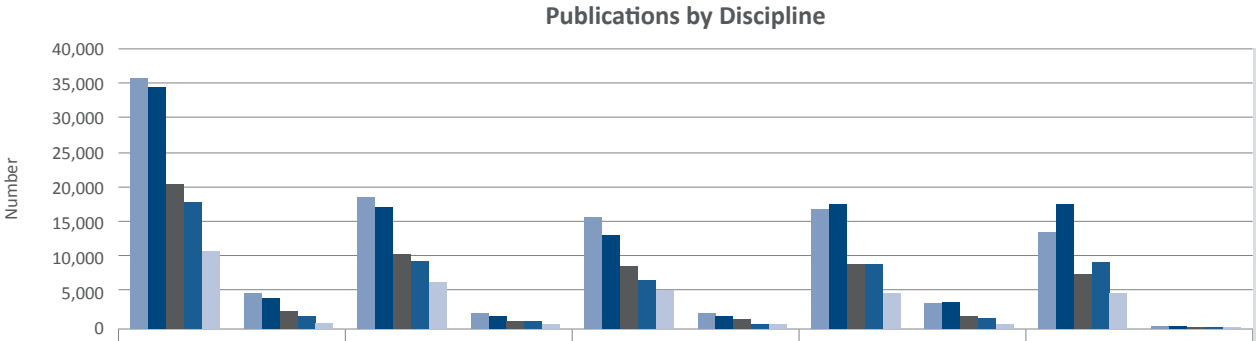


Pediatrics	Health Care Sciences Services	Mathematics	Pharmacology & Pharmacy	Biochemistry & Molecular Biology	Physiology
2,195	1,774	2,042	1,645	1,957	1,602
4,340	3,398	2,993	2,226	2,258	1,964
1,162	991	1,157	1,146	1,208	1,082
2,183	1,913	1,698	1,153	1,164	1,101
839	1,058	875	600	1,000	695

d. Ageing, Life Course, and Cognition – pathological and non-pathological phenomena

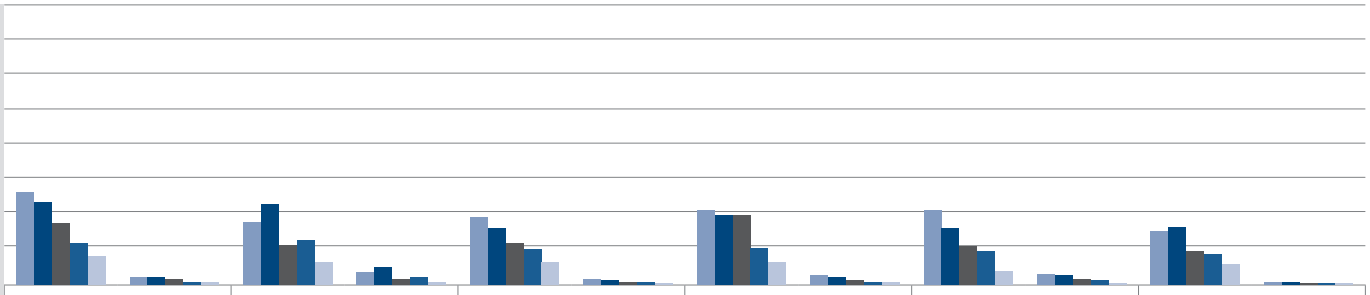


	Science & Technology		Social Sciences		Arts & Humanities	
	pathological	non-pathological	pathological	non-pathological	pathological	non-pathological
Germany	47.837	9.453	17.306	4.789	344	214
UK	48.151	9.759	21.632	6.175	420	344
France	28.561	5.085	9.937	2.171	189	106
Netherlands	25.004	3.987	11.485	2.528	115	98
Sweden	15.228	2.161	6.259	1.182	74	54



	Neurosciences & Neurology		Geriatrics & Gerontology		Biochemistry & Molecular Biology		Behavioral Sciences		Psychiatry	
	pathological	non-pathological	pathological	non-pathological	pathological	non-pathological	pathological	non-pathological	pathological	non-pathological
Germany	36,254	5,099	19,024	2,294	16,296	2,236	17,347	3,764	14,168	338
UK	35,014	4,390	17,590	1,781	13,474	1,741	18,012	4,016	18,039	462
France	20,936	2,598	10,816	1,068	9,047	1,280	9,381	1,675	7,910	171
Netherlands	18,216	1,849	9,903	964	7,003	645	9,288	1,650	9,456	192
Sweden	11,109	955	6,811	562	5,468	519	5,032	709	5,159	99

Publications by Discipline



Pharmacology & Pharmacy		Pediatrics		Cardiovascular System & Cardiology		Genetics & Heredity		Radiology, Nuclear Medicine & Imaging		Pathology	
pathological	non-pathological	pathological	non-pathological	pathological	non-pathological	pathological	non-pathological	pathological	non-pathological	pathological	non-pathological
13,397	1,187	9011	1,699	9,717	788	10,744	1,254	10,749	1,637	7,589	316
12,012	975	11,589	2,436	8,267	604	9,952	975	8,193	1,224	8,391	389
8,883	729	5,886	886	5,971	435	9,971	696	5,566	729	4,850	223
6,020	422	6,474	1,086	5,137	302	5,261	367	4,881	605	4,455	177
4,100	279	3,122	436	3,224	182	3,211	330	1,903	235	2,930	89

III.3 Junior Research Groups

Funding organization	Junior research group program	Project title	Institution
German Research Foundation	Emmy Noether Programme	Nonsteroidal anti-inflammatory drugs (NSAIDs) in Alzheimer's disease: Mechanism of action and therapeutic potential	Universitätsklinikum Düsseldorf
German Research Foundation	Emmy Noether Programme	Paid work beyond retirement age in Germany and Britain: Sociological analyses of atypical combinations of employment and old age pensions	University of Bremen
German Research Foundation	Emmy Noether Programme	Toward a structural and functional basis for changes in brain signal variability with age	Max Planck Institute for Human Development, Berlin
German Research Foundation	Emmy Noether Programme	Aging of hematopoietic stem cells and the epigenetic drift: A pathway to rejuvenation	Ulm University
German Research Foundation	Emmy Noether Programme	Wiring new neurons within adult brain circuits	Central Institute of Mental Health (CIMH), Mannheim
Max Planck Society	MPI Postdoc Program	Population Health, Labor Demography, or Fertility and Well-Being	Max Planck Institute for Demographic Research, Rostock

III.4 Graduate Programs

Funding organization	Title of graduate program	Institution	Participating disciplines
German Research Foundation	ProMoAge – Protein Modification: A Key Mechanism for Ageing	Martin Luther University Halle-Wittenberg/ Friedrich Schiller University, Jena	Medicine (Heart Surgery); Molecular Biomedicine; Molecular Cell Biology
German Research Foundation	Cellular and Molecular Mechanisms in Aging (CEMMA)	Ulm University	Molecular Medicine, Dermatology and Allergology, Neurology, Internal Medicine, Applied Physiology, Experimental Cancer Research, Molecular Virology, Physiological Chemistry, Obstetrics and Gynaecology
German Research Foundation	Impact of Adverse Childhood Experience on Psychiatric and Somatic Disorders Across the Lifespan	Heidelberg University/ Central Institute of Mental Health, Mannheim	Psychosomatic Medicine and Psychotherapy, Neuropsychology and Clinical Psychology, General Psychology, Neuroimaging, Public Health, Medicine, Psychopharmacology, Childhood and Adolescent Psychiatry, Addiction Medicine, Obstetrics and Gynaecology, Neurophysiology, Genetic Epidemiology in Psychiatry
German Research Foundation	Doing Transitions – The Formation of Transitions Over the Life Course	University of Tübingen/ Goethe University Frankfurt, Frankfurt am Main	Sociology, Educational Sciences, Family Studies, Aging Research
German Research Foundation	Bamberg Graduate School of Social Sciences (BAGSS) (PILLAR 1: Education, Personal Development and Learning from Early Childhood to Adulthood; PILLAR 2: Educational and Social Inequality Across the Entire Life Course)	University of Bamberg	Sociology, Economics, Psychology, Political Science, Educational Sciences
German Research Foundation	Microeconomic Determinants of Labour Productivity	Ludwig-Maximilians-Universität München	Microeconomics, Macroeconomics, Econometrics
German Research Foundation	The Dynamics of Demography, Democratic Processes and Public Policy (DYNAMICS)	Humboldt-Universität, Berlin/ Hertie School, Berlin	Sociology, Political Science, Demography, and other Social Sciences

Funding period	Link
2000 – 2010	http://gepris.dfg.de/gepris/projekt/5252314
2010 – 2017	http://gepris.dfg.de/gepris/projekt/166042976
Since 2016	http://gepris.dfg.de/gepris/projekt/310615419
Since 2015	http://gepris.dfg.de/gepris/projekt/279873534
2010 – 2017	http://gepris.dfg.de/gepris/projekt/186541016
	https://www.demogr.mpg.de/en/

Start/Term	Places	Link
2016	14 (sciences); 5 (medical students)	http://web.uk-halle.de/index.php?id=6491
2013 – 2022	10 (currently)	https://www.uni-ulm.de/med/cemma.html
2018	20 (currently)	http://www.grk2350.de/
2017	18 (currently, incl. 1 postdoc)	https://www.doingtransitions.org/
2012 – 2019	23 (currently, plus associates)	https://www.uni-bamberg.de/en/bagss/
2013 – 2022	14 (currently)	https://www.grk1928.econ.uni-muenchen.de/about/
2019 – 2023	35	https://www.sowi.hu-berlin.de/en/dynamics

Funding organization	Title of graduate program	Institution	Participating disciplines
Max Planck Society	MaxNetAging Research School (MNARS)	Max Planck Institute for Demographic Research, Rostock	Political Science, Law, Sociology, Anthropology, Economics, History, Art History, History of Science, Demography, Mathematics, Biology, Medicine, Cognitive and Brain Research, Psychology, and Human Development
Max Planck Society	International Max Planck Research School for Population, Health and Data Science	Max Planck Institute for Demographic Research, Rostock/University of Rostock	Demography, Epidemiology, Data Science (statistics, mathematical Modelling, data management)
Max Planck Society	International Max Planck Research School on the Life Course (LIFE)	Max Planck Institute for Human Development, Berlin/ Freie Universität Berlin/ Humboldt-Universität, Berlin/ University of Zurich/University Michigan/University of Virginia	Biology, Psychology, Sociology, Anthropology, Educational Sciences
Max Planck Society	International Max Planck Research School on Computational Methods in Psychiatry and Ageing Research (COMP2PSYCH)	Max Planck Institute for Human Development, Berlin/ University College London	Neuroimaging, Human Development, Computional Neuroscience, Cognitive and Brain Research
Robert Bosch Stiftung	Postgraduate Program “People with Dementia in Hospitals”	Heidelberg University	Sports Science, Neuropsychology, Healthcare Research, Psychology, Physiotherapy, Architecture, Epidemiology, Gerontology
Leibniz Association/Fritz Lipmann Institute	Leibniz Graduate School on Aging (LGSA)	Leibniz Institute on Aging – Fritz Lipmann Institute/ Friedrich Schiller University, Jena	Molecular Biology, Molecular Genetics, (Stem) Cell Biology, Developmental Biology, Neurobiology, or Systems Biology
University	“Age(ing): Cultural Concepts and Practical Realisations”	Heinrich-Heine-University Düsseldorf	Occupational Medicine and Social Medicine, Experimental Psychology, Forensic Medicine; English and American Studies, German Studies, Art History; Philosophy, Business Administration, Modern Japan, History of Medicine
University	Graduate Programme GradAB	Friedrich-Alexander-Universität Erlangen-Nürnberg/ Institute for Employment Research (IAB)	Labor Market Research
University	Gutenberg Research College “Transnational Social Support in Old Age”	Johannes Gutenberg University Mainz	Social Pedagogy, Ethnology

Start/Term	Places	Link
2007 – 2016 (beendet)	14	https://www.maxnetaging.mpg.de/research_school
2019	15	https://www.imprs-phds.mpg.de/
2002	24 in Berlin, 13 in Zurich, 10 in Michigan, 15 in Virginia (currently)	https://www.imprs-life.mpg.de/
2014	17 (currently)	https://www.mps-ucl-centre.mpg.de/en/comp2psych
2016	13	https://www.nar.uni-heidelberg.de/en/youngscholars/dementia/
2006	ca. 58 (currently, plus associates)	http://www.philo.hhu.de/en/research/aging-as/about-ageing.html
2012 – 2015 (beendet)	15	https://www.phil-fak.uni-duesseldorf.de/ageing/
	6	https://www.iab.de/en/ueberblick/graduiertenprogramm.aspx
2018	3 – 5	https://www.gnk.uni-mainz.de/

III.5 Master Degree Programs

Degree program	Institution of higher education	Specialization
Clinical Gerontopsychology (M.Sc.)	Chemnitz University of Technology	Clinical competencies for psychology of elderly people
Aging Societies (M.A.)	TU Dortmund University	Empirical social research
Gerontology (M.Sc.)	Friedrich-Alexander-Universität Erlangen-Nürnberg	Evidence-based diagnostics, counselling, intervention and research of aging; psychology, psychiatry, sociology of aging
Sport and Movement Gerontology (M.Sc.)	German Sport University Cologne	Physical and sports activity over the lifespan
Demography (M.Sc.)	University of Rostock	Demographic research
Gerontology (M.Sc.)	University of Vechta	Social gerontology
Applied Gerontology (M.A.)	APOLLON University of Applied Sciences	Management, health professions, social policy
Social Sustainability and Demographic Change (M.A.)	Dortmund University of Applied Sciences and Arts	Social sustainability

Link
https://www.tu-chemnitz.de/transfer/wissen/studiengaenge/geronto.php
https://www.tu-dortmund.de/studierende/studienangebot/alternde-gesellschaften-75/
https://www.fau.de/studiengang/gerontologie-msc/
https://www.dshs-koeln.de/studium/studienangebot/master/msc-sport-und-bewegungsgerontologie/
https://www.isd.uni-rostock.de/en/isd/studium/study-courses/msc-demography/
https://www.uni-vechta.de/studium/studienangebot/gerontologie-ma/
https://www.apollon-hochschule.de/fernstudium/master/master-angewandte-gerontologie/
https://www.fh-dortmund.de/de/fb/8/Master_Nachhaltigkeit.php

Healthy Aging and Gerontology (M.A.)	SRH Hochschule für Gesundheit, Gera	Healthy aging, learning
Education and Aging (M.A.)	Pädagogische Hochschule Karlsruhe (University of Education)	Education for older people
Social Work in an Ageing Society (M.A.)	Magdeburg-Stendal University of Applied Sciences	Social work for older people and over the lifespan
Social Gerontology (M.A.)	University of Applied Sciences Zittau/Görlitz	Semography, geriatrics, gerontopsychiatry, care, social law
Future (of) Aging: Applied Gerontology (M.A.) -Joint masters study program	Catholic University of Applied Sciences Freiburg/Hochschule Mannheim – University of Applied Sciences/ Katholische Stiftungshochschule München - University of Applied Sciences	Co-operative program of work and study over up to 10 years

	https://www.gesundheitshochschule.de/de/studium/master/gesundes-altern-und-gerontologie-m-a/
	https://www.ph-karlsruhe.de/studieren/studienangebot/master/geragogik
	https://www.hs-magdeburg.de/en/studies/masters-programmes/social-work-in-an-ageing-society.html
	https://www.hszg.de/en/academics/our-courses-of-study/masters/social-gerontology.html
	https://www.zukunft-gerontologie.de/

III.6 European Research Council individual funding (ERC grants) for research into ageing and life course, provided to grant recipients in Germany[1]

(Initial year of funding between 2008 and 2017)

Social Sciences/Humanities (9 Projects)					
Starting Grants					
AKRONYM	**Title**	**PI**	**Institution**	**Discipline**	**Term**
AGESPACE	Spatial Navigation – A unique window into mechanisms of cognitive ageing	Thomas Wolbers	German Center for Neurodegenerative Diseases, Bonn	The Human Mind and its complexity (SH4)	2014 – 2018
ApeAttachment	Are social skills determined by early live experiences?	Catherine Delia Crockford	Max Planck Institute for Evolutionary Anthropology, Leipzig	The Human Mind and its complexity (SH4)	2016 – 2021
APPARENT	Transition to parenthood: International and national studies of norms and gender division of work at the life course transition to parenthood	Daniela Grunow	Goethe University Frankfurt, Frankfurt am Main	Institutions, Values, Environment and Space (SH2)	2011 – 2016
LIFEINEQ	Lifespan Inequalities: Why the age-at-death distribution varies between countries and socioeconomic groups	Alyson van Raalte	Max Planck Institute for Demographic Research, Rostock	The Social World, Diversity, Population (SH3)	2017 – 2022
PREFERENCES	Understanding Preferences: Measurement, Prevalence, Determinants and Consequences	Armin Falk	University of Bonn	Markets, individuals, and institutions (SH1)	2009 – 2013
ROMI	Rates of Mortality Improvement	Roland Rau	University of Rostock	The Social World, Diversity, Population (SH3)	2011 – 2015
Consolidator Grants					
AUDADAPT	The listening challenge: How ageing brains adapt	Jonas Ferdinand Obleser	Universität zu Lübeck	The Human Mind and its complexity (SH4)	2016 – 2020
CORRODE	Corroding the social? An empirical evaluation of the relationship between unemployment and social stratification in OECD countries	Markus Gangl	Goethe University Frankfurt, Frankfurt am Main	Institutions, Values, Environment and Space (SH2)	2014 – 2019
Advanced Grants					
CRITICAL BRAIN CHANGES	Development and plasticity of multisensory functions to study the principles of age dependent learning plasticity in humans	Brigitte Roeder	Universität Hamburg	The Human Mind and its complexity (SH4)	2010 – 2016

1 Starting Grants: 2–7 years following doctorate, funding of up to 1.5 million euros; Consolidator Grants: 7–12 years following doctorate, typically up to 2 million euros; Advanced Grants: senior researchers, typically up to 2.5 million euros.

Life Sciences (41 Projects)					
Starting Grants					
AKRONYM	**Title**	**PI**	**Institution**	**Discipline**	**Term**
AgeingStemCellFate	The Role of Ectopic Adipocyte Progenitors in Age-related Stem Cell Dysfunction, Systemic Inflammation, and Metabolic Disease	Tim Julius Schulz	German Institute of Human Nutrition Potsdam-Rehbruecke	Physiology, Pathophysiology and Endocrinology (LS4)	2013 – 2018
Baby DCs	Age-dependent Regulation of Dendritic Cell Development and Function	Barbara Ursula Schraml	Ludwig-Maximilians-Universität München	Immunity and Infection (LS6)	2017 – 2022
CureCKDHeart	Targeting perivascular myofibroblast progenitors to treat cardiac fibrosis and heart failure in chronic kidney disease	Rafael Johannes Thomas Kramann	Uniklinik RWTH Aachen	Physiology, Pathophysiology and Endocrinology (LS4)	2016 – 2021
GENSTAGE	Genome Stability Mechanisms in Aging	Bjoern Schumacher	University Hospital Cologne	Cellular and Developmental Biology (LS3)	2011 – 2017
IlluMitoDNA	Illuminating the mechanisms of mitochondrial DNA quality control and inheritance	Christof Osman	Ludwig-Maximilians-Universität München	Cellular and Developmental Biology (LS3)	2017 – 2022
MetAGEn	Metabolic and Genetic Regulation of Ageing	Martin Denzel	Max Planck Institute for the Biology of Ageing, Köln	Physiology, Pathophysiology and Endocrinology (LS4)	2015 – 2020
MITOUPR	Mitochondrial unfolded protein response and the role in ageing	Aleksandra Trifunovic	University Hospital Cologne	Physiology, Pathophysiology and Endocrinology (LS4)	2013 – 2017
MU TUNING	Fine Tuning the Final Common Pathway: Molecular Determinants of Motor Unit Development and Plasticity	Till Marquardt	University of Göttingen	Neurosciences and Neural Disorders (LS5)	2012 – 2017
NOVA	Non-coding RNA in Vascular Ageing	Reinier Boon	Goethe University Frankfurt, Frankfurt am Main	Diagnostic tools, therapies and public health (LS7)	2015 – 2020
PrenatStressAging	Prenatal Stress and Programming of Newborn and Infant Telomere Biology and Cellular Aging	Sonja Entringer	Charité – Universitätsmedizin Berlin	Diagnostic tools, therapies and public health (LS7)	2016 – 2021
REPROWORM	Safeguarding Cell Identities: Mechanisms Counteracting Cell Fate Reprogramming	Baris Tursun	Max Delbrück Center for Molecular Medicine, Berlin	Cellular and Developmental Biology (LS3)	2015 – 2020
SENSORINEURAL	Elaboration and refinement of sensorineural dendritic architecture	Hernán López-Schier	German Research Center for Environmental Health, Helmholtz Zentrum München	Physiology, Pathophysiology and Endocrinology (LS4)	2008 – 2014
StemProteostasis	Mediation of stem cell identity and aging by proteostasis	David Vilchez Guerrero	University of Cologne	Physiology, Pathophysiology and Endocrinology (LS4)	2016 – 2021

Consolidator Grants					
AKRONYM	**Title**	**PI**	**Institution**	**Discipline**	**Term**
BrainModes	Personalized whole brain simulations: linking connectomics and dynamics in the human brain	Petra Ritter	Charité – Universitäts-medizin Berlin	Neurosciences and Neural Disorders (LS5)	2016 – 2021
DEPICODE	Decoding the epi-genetic signature of memory function in health and disease	André Fischer	German Center for Neurodegenerative Diseases, Bonn	Neurosciences and Neural Disorders (LS5)	2015 – 2020
DIABLO	Mechanisms of Developmental and Injury-related Axon Branch Loss	Thomas Misgeld	Technical University of Munich	Neurosciences and Neural Disorders (LS5)	2015 – 2020
DynaSens	Understanding the neural mechanisms of multisensory percep-tion based on compu-tational principles	Christoph Kayser	Bielefeld University	Neurosciences and Neural Disorders (LS5)	2015 – 2020
EMERGE	Epigenetic and met-abolic regulation of endothelial hetero-geneity	Michael Potente	Max Planck Insti-tute for Heart and Lung Research, Bad Nauheim	Physiology, Patho-physiology and Endo-crinology (LS4)	2018 – 2023
HMRI	Non-Invasive In-Vivo Histology in Health and Disease Using Magnetic Resonance Imaging (MRI)	Nikolaus Weiskopf	Max Planck Institute for Cognitive and Brain Sciences, Leipzig	Neurosciences and Neural Disorders (LS5)	2017 – 2022
MitoVin	Mechanism and Consequences of the Interplay between Mitosis and Human Papillomavirus Initial Infection	Mario Schelhaas	University of Münster	Immunity and Infec-tion (LS6)	2016 – 2021
MOSAIC	Relationship of Somatic Structural Variation Mosaicism to Aging and Disease Phenotypes	Jan Korbel	European Molecular Biology Laboratory	Genetics, Genomics, Bioinformatics and Systems Biology (LS2)	2016 – 2021
NeuroInCellNMR	In-cell NMR moni-toring of alpha-Syn-uclein aggregation in neuronal cells	Philipp Selenko	Forschungsverbund Berlin e.V.	Molecular and Structural Biology and Biochemistry (LS1)	2015 – 2020
PhaseAge	The chemistry and physics of RNP gran-ules: how they form, age and cause disease	Simon Alberti	Max Planck Institute of Molecular Cell Biology and Genetics, Dresden	Cellular and Develop-mental Biology (LS3)	2017 – 2022
PROTEODYNAMICS	Global Dynamics of Proteolytic Quality Control Networks in Stress Response and Aging	Thorsten Hoppe	University of Cologne	Cellular and Develop-mental Biology (LS3)	2014 – 2019
StressNetAdapt	Understanding evolutionary abiotic stress-network plas-ticity as foundation for new biotechno-logical strategies	Pascal Falter-Braun	German Research Center for Envi-ronmental Health, Helmholtz Zentrum München	Applied life sciences and non-medical biotechnology (LS9)	2017 – 2022

Advanced Grants					
AKRONYM	**Title**	**PI**	**Institution**	**Discipline**	**Term**
AMYLOID	Identification and modulation of pathogenic Amyloid beta-peptide species	Christian Haass	Ludwig-Maximilians-Universität München	Neurosciences and Neural Disorders (LS5)	2013 – 2018
AngioBone	Angiogenic growth, specialization, ageing and regeneration of bone vessels	Ralf Heinrich Adams	University of Münster	Cellular and Developmental Biology (LS3)	2014 – 2019
AngioInc	Endothelial long non-coding RNAs	Stefanie Dimmeler	Goethe University Frankfurt, Frankfurt am Main	Physiology, Pathophysiology and Endocrinology (LS4)	2016 – 2020
ANGIOMIRS	microRNAs in vascular homeostasis	Stefanie Dimmeler	Goethe University Frankfurt, Frankfurt am Main	Physiology, Pathophysiology and Endocrinology (LS4)	2009 – 2014
AXOGLIA	The role of myelinating glia in preserving axon function	Klaus-Armin Nave	Max Planck Institute of Experimental Medicine, Göttingen	Neurosciences and Neural Disorders (LS5)	2011 – 2016
BEYOND	Metabolic basis of neurodegenerative disease	Thomas Franz Erich Willnow	Max Delbrück Center for Molecular Medicine, Berlin	Physiology, Pathophysiology and Endocrinology (LS4)	2014 – 2019
COREMA	Cell division and the origin of embryonic aneuploidy in preimplantation mouse development	Jan Ellenberg	European Molecular Biology Laboratory	Cellular and Developmental Biology (LS3)	2017 – 2021
ERA	Experimental Research into Ageing	Linda Partridge	Max Planck Institute for the Biology of Ageing, Köln	Physiology, Pathophysiology and Endocrinology (LS4)	2011 – 2016
GENEMIT	Regulation of gene expression in mammalian mitochondria	Nils-Göran Larsson	Max Planck Institute for the Biology of Ageing, Köln	Molecular and Structural Biology and Biochemistry (LS1)	2011 – 2016
GEROPROTECT	Developing Geroprotectors to Prevent Polymorbidity	Linda Partridge	Max Planck Institute for the Biology of Ageing, Köln	Genetics, Genomics, Bioinformatics and Systems Biology (LS2)	2017 – 2022
META-GROWTH	Metabolic regulation of growth and body composition: key modulators of long-term health	Berthold Koletzko	Ludwig-Maximilians-Universität München	Diagnostic tools, therapies and public health (LS7)[1]	2013 – 2018
MyeliNANO	Myelinic nanochannels in neurodegenerative diseases	Klaus-Armin Nave	Max Planck Institute of Experimental Medicine, Göttingen	Neurosciences and Neural Disorders (LS5)	2016 – 2021
NUCLEAR CALCIUM	The biology of nuclear calcium: general principles of adaptations and strategies to develop a light-induced signaling enhancer	Hilmar Bading	Heidelberg University	Neurosciences and Neural Disorders (LS5)	2009 – 2014
OptoHear	Cochlear Optogenetics for Auditory Research and Prosthetics	Tobias Moser	Universitätsmedizin Göttingen – University of Göttingen	Neurosciences and Neural Disorders (LS5)	2015 – 2020
PROMETHEUS	Novel Cells for Organ Repair	Hans Schoeler	Max Planck Institute for Molecular Biomedicine, Münster	Diagnostic tools, therapies and public health (LS7)	2015 – 2020
StemCell-GerontoGenes	Longevity and aging associated genes that control self-renewal and function of adult stem cells during aging	Karl Lenhard Rudolph	Leibniz Institute on Aging – Fritz Lipmann Institute	Physiology, Pathophysiology and Endocrinology (LS4)	2013 – 2018

Physical Sciences/Engineering (2 Projects)					
Starting Grants					
AKRONYM	**Title**	**PI**	**Institution**	**Discipline**	**Term**
IHEARU	Intelligent systems' holistic evolving analysis of real-life universal speaker characteristics	Björn Wolfgang Schuller	University of Passau	Computer science and informatics (PE6)	2014 – 2018
Consolidator Grants					
BETACONTROL	Control of amyloid formation via be-ta-hairpin molecular recognition features	Wolfgang Hoyer	Heinrich-Heine-Uni-versity Düsseldorf	Synthetic chemistry and materials (PE5)	2017 – 2022

[1] The project has been classified under LS7 in accordance with the ERC keywords; however, the content of the project (metabolic regulation of growth and body composition, also with regard to the development of obesity over the life course) would indicate classification under LS4_5 (metabolism, biological basis for metabolism and related disorders) to be more fitting.

Source: https://erc.europa.eu/projects-figures/erc-funded-projects (as of December 2018)

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