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Views on Aging and Cognitive Abilities in Midlife and Old Age: The Case of Attitudes Toward Own Aging

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The greatest discovery of my generation is

that a human being can alter his life by altering his attitudes of mind.

William James (1842-1910)

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List of Publications

1st Publication (Paper 1)

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2nd Publication (Paper 2)

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3rd Publication (Paper 3)

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Extended Abstract

Objectives. In the face of population aging, the high relevance of identifying favorable conditions, individual resources, and malleable factors to promote cognitive health in old age is unwavering (Deary et al., 2009). Longitudinal research in the last decade suggests that individual beliefs towards age and aging possess remarkable developmental relevance to shaping the actual aging process. As such, evidence underlines the importance of views on aging for health and longevity in old age (Westerhof et al., 2014). Building on the emerging longitudinal work that also suggests associations with memory (Levy, Zonderman, Slade, & Ferrucci, 2012; Stephan, Sutin, Caudroit, & Terracciano, 2016) and pathological brain changes (Levy et al., 2016), the aim of the present dissertation is to explicitly combine the two research traditions of views on aging and cognitive aging. Main reasoning is that negative views on aging constitute a substantial risk factor for cognitive aging that has been rather neglected by the classical literature on age-related cognitive decline. In three individual papers, this dissertation addresses four major questions. First, do people with more negative views on aging show accelerated cognitive decline over time (Paper 1, 3) and have higher odds of developing dementia in old age (Paper 2)? Second, addressing issues of bidirectionality, do cognitive abilities and respective loss experiences—objective change as well as subjective complaints—also contribute to a more negative evaluation of the aging process (Paper 3)? Third, which long-term pathways mediate the relationship between views on aging and cognitive development (Paper 2)? And, fourth, do effects differ depending on individual factors like gender or age group (Paper 1, 3)?

Methods. Data came from the population-based Interdisciplinary Longitudinal Study of Adult Development (ILSE; Sattler et al., 2017). ILSE is an ongoing German cohort study starting in 1993/94 with four completed measurement occasions. Two birth cohorts, a midlife group (1950-52; n = 502; M_{age} = 43.7 at baseline) and an old age group (1930-32; n = 500; M_{age} = 62.5 at baseline) were reassessed after 4 years (1997/98), 12 years (2005/06), and 20 years (2014/16)

with longitudinal response rates of 78.7% and 56.9 % after 12 and 20 years, respectively. Measurements in the present thesis include the widely used Attitude Toward Own Aging scale (ATOA) to assess individual views on aging (Lawton, 1975), well-established cognitive indicators of fluid and crystallized abilities (e.g., WAIS-R; Tewes, 1991), an expert-based clinical diagnosis of participants' cognitive status, and a range of control variables (e.g., sociodemographics, genetic and health variables, control beliefs, leisure activities).

Drawing on the older birth cohorts (1930-32; n = 500) and 12 years of observation in Paper 1, overall and gender-specific latent change score models were applied to investigate the impact of ATOA on rate of decline in fluid and crystallized abilities and whether this impact differed for men and women. In a cognitively healthy subsample of the old age cohort (n = 260), Paper 2 examined whether more negative baseline ATOA increased the risk of developing mild cognitive impairment (MCI) or Alzheimer disease (AD) within 12 years by means of logistic regression. Moreover, leisure activities and control beliefs were examined as possible mediators of the association. Making use of both birth cohorts and 20 years of observation, Paper 3 targeted issues of bidirectionality between ATOA and cognitive development. A multigroup latent growth curve model examined longitudinal associations of ATOA, performance-based cognitive measures, and subjective cognitive complaints contrasting mid- and later life.

Results. First, as expected, negative ATOA was a risk factor for accelerated cognitive decline, predicting change in fluid abilities—but not in crystallized performance—over 12 years (Paper 1) and over 20 years (Paper 3). Moreover, negative baseline ATOA was associated with a 31% higher risk of developing dementia within a 12-year follow-up (Paper 2). These effects emerged after controlling for sociodemographic, various health, as well as genetically relevant indicators and thus seemed to be robust over up to two decades of observation. Second, there was no long-term association between (change in) cognitive abilities and subsequent change in

ATOA. Paper 3 revealed instead that cognitive complaints rather than objective cognitive decline were an important correlate and precursor of changes in ATOA. Higher cognitive complaints were substantially related to worsening in ATOA, indicating that the subjective awareness of cognitive loss matters more for attitude formation than objectively measurable decline. Third, testing empirical pathways that were assumed to operate between ATOA and cognitive impairment, evidence for a mediating role of leisure-activity level and control beliefs was scarce (Paper 2). Finally, results illustrated the important consideration of the individual factors gender and age group. Gender-specific analyses showed a stronger association between ATOA and decline in fluid abilities for men, even after controlling for health and education (Paper 1). Moreover, findings indicated that the predictive effect from ATOA on cognitive decline gained developmental relevance with increasing age. That is, ATOA predicted cognitive change over 20 years in old age but not in midlife (Paper 3).

Conclusion. Overall, the results of this dissertation suggest that negative views on aging accelerate cognitive decline and pose a threat for dementia in later life. Taken together with other recent studies, there is robust evidence to conclude that views on aging deserve to be considered as a meaningful risk factor of cognitive decline alongside other established risk factors. This underlines the need of exploiting the emerging potentials and improving views on aging in individuals, communities, and society via targeted interventions and public health practices as a rewarding avenue to promote cognitive health in old age. One important direction for future research therefore is to evaluate whether and how findings can be transferred into efficient intervention strategies. Such interventions on malleable psychological risk factors offer promising low-cost options. Dissertation findings further suggest that interventions may also explicitly treat subjective cognitive complaints. Focusing on individuals already in midlife may prevent them from developing even more complaints and even more negative age views as they age. Another major task for future research is to empirically identify underlying mechanisms, for example, by using measurement burst designs on daily activities and health behaviors to

track back what people with more positive views on aging actually do and experience throughout their days. Understanding how negative views on aging accelerate cognitive decline is pivotal to validate and anchor the predictor effect as well as to inform prevention efforts.

Chapter 1 – General Introduction

Decline in cognitive function is a normal part of becoming older and differs considerably between individuals (Lindenberger, 2014; Schaie, 2005b). Severe cognitive deterioration in old age is associated with poor quality of life, loss of autonomy, and impairment in activities of daily living (Diehl & Willis, 2003). These observed age-related changes and their adverse implications come with a lot of public concern and influence societally held beliefs about age and aging. Cognitive decline and dementia are considered two of the most feared aspects of growing older (Kessler, Bowen, Baer, Froelich, & Wahl, 2012). Moreover, common views on aging reflect the impact of getting older on cognitive function by portraying older adults as forgetful, senile, less competent, and cognitively inferior compared to younger individuals (Hummert, Garstka, Shaner, & Strahm, 1994; Kite, Stockdale, Whitley, & Johnson, 2005). There is wide agreement that beliefs about the aging process influences behavior toward older adults, leading to age discrimination on both personal and institutional levels (Hess, 2006).

However, do such beliefs also affect one's *own* aging processes? Views on aging strongly influence a person's self-concept as well as expectations about his or her future life (Rothermund & Brandtstädter, 2003; Thomae, 1970) thereby "creating a developmental context" (Kornadt & Rothermund, 2015, p. 121) able to hinder or further personal outcomes. Unlike other social groups facing stigmatization (e.g., gender or race), most people will experience the group of "older adults" from both an in-group and an out-group perspective: as we grow older, we become members of the former out-group, and views on aging increasingly tend to color how we see ourselves (Kornadt & Rothermund, 2015). This transition forms a rather unique psychological process, because negative views may influence development by turning into self-fulfilling prophecies (Wurm, Diehl, Kornadt, Westerhof, & Wahl, 2017).

Notably, prevalent beliefs characterizing cognitive development primarily as uncontrollable decline fail to comply with prominent conceptual ideas of life-span psychology, that is, development comes with multiple directions and dimensions. Baltes (1987, 1997) has argued that *multidirectionality* and *plasticity* are key principles of life-span development. The domain of cognitive development can serve as a prime example to illustrate multidirectionality and plasticity showing large within-person plasticity in terms of age-related cognitive change (Baltes, Lindenberger, & Staudinger, 2006) as well as great between-person differences. Plasticity is also evident on a sociocultural level (Willis, Schaie, & Martin, 2009); due to great improvements in health care and education, later born cohorts show higher levels of cognitive functioning, also known as the Flynn effect (Flynn, 1984, 2007).

The multidirectional nature of development with increasing interindividual variability into old age points to the role of individual goal-directed actions and beliefs in shaping development (Greve & Thomsen, 2019). Similarly, Staudinger (2015) argued that "exploiting the plasticity of aging may require a personalized approach" (p. 195). Hence, in more molar sense, human development should be seen as the result of the intertwining of biological, cultural, and individual factors (Baltes et al., 2006). Individuals are expected to contribute by their actions and choices to the process and outcome of growing older (Brandtstädter & Rothermund, 2003).

In the context of cognitive aging, accumulating research suggests that genetic, environmental, health, and lifestyle factors, particularly physical and cognitive engagement, contribute significantly to individual differences in cognitive aging (Hertzog, Kramer, Wilson, & Lindenberger, 2008; Yaffe et al., 2009). Cognitive performance differences are already quite pronounced in adulthood and even increase in later life (Baltes, 1987; Nelson & Dannefer, 1992; Schaie, 2005b). Consequently, the value of chronological age as an indicator of a person's cognitive state is limited (e.g., Baltes et al., 2006) and may lead to false judgments if relying solely on someone's age.

Developmental psychologists have argued that age (per se) has no explanatory power when investigating change processes, but at best serves as a placeholder for numerous biological and cultural influences that are related to aging (Wohlwill, 1970). Nevertheless, driven by widespread negative views on aging, people often attribute causal power to chronological age and use it as a serious explanation for experienced changes in cognitive functioning. The harm therein is that blaming age for such unwanted alterations, particularly in the context of cognitive aging, may also lead to doubting one's personal control and opportunity to counteract. Indeed, negative images of aging foster less agentic views of the later years, conveying a reduced sense of individual responsibility and downplaying the importance of an active lifestyle (Stewart, Chipperfield, Perry, & Hamm, 2016).

The relevance of this area of inquiry is further underlined by current societal challenges: Demographic change and the aging of most industrialized societies seem to come with increasing negativity of age stereotypes (Ng, Allore, Trentalange, Monin, & Levy, 2015; North & Fiske, 2015) as well as with higher absolute counts of cognitive decline and dementia—eventually despite decreasing prevalence (Nichols et al., 2019). Alzheimer disease has become a major cause of disability for today's society, calling for the need to study modifiable risk factors and to develop early interventions to delay cognitive decline (Park & Festini, 2017). Irrespective of pathological aspects of aging, normal cognitive aging can also be considered a major health and social issue with financial, personal, and societal burdens (Deary et al., 2009). In conclusion, more research illuminating factors that are malleable and contribute to individual differences in cognitive aging is of utmost importance from a public health perspective (Deary et al., 2009).

In light of these considerations, this dissertation aims to combine two key research fields of the psychology of aging that are clearly interwoven, but whose longitudinal connections have received limited empirical consideration thus far: views on aging and cognitive aging. Encouraged by some well-received publications addressing adults' individual views on aging and their memory

over time (Levy et al., 2012; Stephan et al., 2016), the current work sees strong momentum in further connecting research on views of aging and cognitive aging. In particular, the proposition is that views on aging have not yet received sufficient attention as a potential risk factor for cognitive decline. In three individual papers, the current research examines whether positive or negative views on aging help to better understand the pronounced interindividual differences in normal aging as well as their predictive effect on cognitive pathology over long observational intervals.

Views on Aging – Theoretical and Conceptual Considerations

Research about views on aging has experienced an upswing within the last decades and important steps have been made in broadening our understanding of the antecedents, consequences, and plasticity of views on aging. In particular, conceptual frameworks have been developed that relate and integrate key constructs of views on aging, highlight pathways that might explain associations with developmental outcomes, and build connections to life span-oriented models of developmental regulation (Diehl et al., 2014; Diehl & Wahl, 2010; Levy, 2009; Wurm et al., 2017).

In the previous literature, the various conceptualizations have been subsumed under overarching umbrella terms such as “images of aging” (Staudinger, 2015), “awareness of aging” (Diehl et al., 2014), or “views on aging” (Wurm et al., 2017). Broadly, two basic perspectives can be differentiated: (1) more general perspectives that refer to socially shared beliefs about the process of aging at large and older people as a group, often called *old-age stereotypes*; and (2) *subjective aging*-related views that primarily refer to personal experiences and evaluations of one’s own age and aging (Diehl et al., 2014; Staudinger, 2015; Wurm et al., 2017). As will be illustrated in more detail, both perspectives are inextricably intertwined; for example, societal views on aging play a central role for individual aging expectations at all ages (Lineweaver & Hertzog, 1998) and older adults’ views of their own aging process often reflect internalized societal beliefs and stereotypes about aging (Kornadt & Rothermund, 2011; Levy, 2009).

Given the plethora of different subjective aging concepts (for a review, see Diehl et al., 2014), only constructs that have been most frequently linked to cognitive functioning find in-depth evaluation in the present dissertation, i.e., age stereotypes and subjective age. In addition, special emphasis is put on the construct of attitude toward one's own aging, a widely used indicator of subjective aging that is the empirical indicator of views on aging in the three research papers of this dissertation in Chapter 2 to 4. The following section introduces these three concepts, their characteristics, respective measures, and common research application.

Age Stereotypes

Stereotypes are defined as societally shared cognitive representations and beliefs that reduce the characteristics of a specific population into a simple and unidimensional pattern (Popham & Hess, 2016) and guide perception of and behavior toward stereotyped groups of individuals. *Age stereotype*s refer to the process of aging and the group of older adults. Although negative stereotypes seem to be more common in Western societies, empirical evidence underlines that age stereotypes are multidimensional and comprise both positive (e.g., wise, warm-hearted) and negative (e.g., forgetful, helpless) elements (Hess, 2006; Hummert et al., 1994; Kite et al., 2005). Compared to younger individuals, older people tend to have more nuanced and more positive stereotypes towards old age and their age peers, suggesting that stereotypic representations are further refined by gathering own aging experiences (Brewer & Lui, 1984; Hummert et al., 1994).

Possibly because cognitive abilities form a core of age stereotypes (Staudinger, 2015), research in the field has been dominated by studying effects on memory. Initially, associations between one's aging attitudes and behavior were investigated by assessing self-referent beliefs like control or self-efficacy as proxies for aging attitudes (Hess, 2006). As such, higher control and higher self-efficacy have been repeatedly linked to better memory performance or maintained functioning (Heckhausen & Baltes, 1991; Hultsch, Hertzog, & Dixon, 1987). More direct ways to

measure the effects of age stereotypes have been considered by means of implicit or explicit experimental priming (cf. Hess, 2006): In the 1990s, Becca Levy was among the first to examine the effects of age stereotype activation on memory performance (1996). Many subsequent studies replicated the harmful impact of negative age stereotype activation on a range of outcomes, including memory as well as other cognitive dimensions (Abrams, Eller, & Bryant, 2006; Lamont, Swift, & Abrams, 2015), physiological stress (Levy, Hausdorff, Hencke, & Wei, 2000), walking speed (Hausdorff, Levy, & Wei, 1999), and handwriting (Levy, 2000). It is assumed that age stereotypes exert their influence via unconscious as well as conscious processes (Hess, 2006). Implicit activation due to subtle aging-related cues results in automatic tendencies to act in assimilative ways to the activated concepts (ideomotor processes; Bargh & Chartrand, 1999). Alternatively, referring to the notion of *stereotype threat* (Steele, 1997), the explicit activation of negative age stereotypes (e.g., older people are forgetful) can impair performance (e.g., on a memory test) when stereotyped individuals are put in the position of potentially confirming the negative stereotype (Hess, Auman, Colcombe, & Rahhal, 2003).

According to the influential *stereotype embodiment theory* (Levy, 2009), societal and cultural age stereotypes are internalized already at a very young age, often operate on an unconscious level, are continuously reinforced throughout one's lifespan, and become salient as individuals identify themselves as old (Kornadt & Rothermund, 2011, 2015; Levy, 2009). These self-relevant views on aging then increasingly affect actual aging experiences and behavior via multiple pathways (Diehl et al., 2014; Kornadt, Voss, & Rothermund, 2017; Wurm et al., 2017). Thus, age stereotypes are contextually integrated into a life-span perspective, later infusing subjective aging experiences.

Subjective Age

Subjective age or *felt age,* in other words, how old a person feels, is a simple but empirically well-established indicator of subjective aging (e.g., Montepare, 2009). Typically, after a period of feeling older in adolescence, individuals start feeling younger than their actual age in their late-

20s. On average people feel about 20% younger relative to their chronological age throughout their adult lifespan (Rubin & Berntsen, 2006). This phenomenon may be seen as a self-enhancement strategy by protecting individuals against negative age stereotypes and threats experienced due to aging (Teuscher, 2009).

In historically important seminal work, Kastenbaum and colleagues (1972) proposed a multi-dimensional approach of assessing subjective age in multiple domains. In addition to felt age, they suggested the categories of 'do age', 'look age', and 'interest age'. The idea of a multidimensional view of subjective age was later adopted again by other authors (e.g., Montepare, 1996; Uotinen, Rantanen, & Suutama, 2005) but has never found broad recognition or empirical use in psychological aging research; only felt age has become a well-established and widespread indicator. Despite the conceptual limitations involved in a rather simplistic one-item approach (for a critical review, see Diehl et al., 2014), felt age possesses remarkable predictive power for a variety of developmental outcomes, including health, well-being, functional ability, and cognitive function (Stephan, Caudroit, Jaconelli, & Terracciano, 2014; Stephan et al., 2016; Westerhof et al., 2014).

Attitude Toward Own Aging

Another prominent measure of views on aging is the construct of *attitude toward own aging* (ATOA), albeit different labels have been applied in the literature, such as "aging satisfaction" (Kleinspehn-Ammerlahn, Kotter-Grühn, & Smith, 2008) or "aging self-perceptions" (Moor, Zimprich, Schmitt, & Kliegel, 2006). ATOA reflects a mixture of socially and culturally shared beliefs about the aging process including age stereotypes, as well as individual experiences and expectations related with one's own aging (Diehl et al., 2014; Hess, 2006; Levy, 2009). Moreover, ATOA is assumed to operate at a rather low level of awareness, which may make it a particularly powerful influencing factor for behavior (Diehl et al., 2014; Hess, 2006; Levy, 2009).

ATOA usually refers to the eponymous scale developed by Lawton (1975) as a subscale of the Philadelphia Geriatric Center Morale Scale (PGCMS) that—together with the two other subscales *Agitation* and *Lonely Dissatisfaction*—was intended to measure well-being in later life. However, the ATOA subscale has often been used as a sole indicator to capture a rather global evaluation of one's own aging process (Miche, Elsässer, Schilling, & Wahl, 2014). Although ATOA in itself may be seen as potentially multidimensional, the ATOA subscale was introduced and psychometrically tested as a unidimensional scale. Five items capture the subjective evaluation of changes in quality of life ("Things keep getting worse as I get older" and "As I get older, things are better/worse than I thought they would be"), energy level (e.g., "I have as much pep as I had last year"), perceived usefulness ("As you get older you are less useful"), and happiness ("I am as happy now as when I was younger") because of getting older (Lawton, 1975). The scale comes with a binary answering format (yes or no), which also applies to how the instrument was used in the present work. It should be mentioned that some studies like the Berlin Aging Study (Kleinspehn-Ammerlahn et al., 2008) and the German Aging Survey (Jung & Siedlecki, 2018) have decided to apply a 5-point Likert scale format to each item.

In terms of psychometric quality, ATOA has been found to be valid and reliable (Jung & Siedlecki, 2018; Miche et al., 2014). Miche and colleagues (2014) found at least partial strong measurement invariance (e.g., equal factors structure, loadings, and intercepts) of the scale over time, but not across two different age groups of middle-aged and older adults. In contrast, using a broader age range, as in the sample by Miche et al. (2014), and a Likert scale answering format, other analyses showed metric (i.e., equal factors structure and loadings) but not strong measurement invariance across age groups (Jung & Siedlecki, 2018). This same study also found evidence for construct validity in a German sample, indicating that ATOA represents a dimension of individual differences distinct from measures of well-being like life satisfaction or the Positive and Negative Affect Scale (Jung & Siedlecki, 2018).

ATOA has been found to become more negative as individuals grow older. For example, in a sample of older adults aged 70 to 104 years from the Berlin Aging Study, ATOA gradually declined over the 6-year time interval (Kleinspehn-Ammerlahn et al., 2008), which is consistent with 12-year findings by Miche et al. (2014). However, previous studies did not find between-person heterogeneity in within-person decline of ATOA among adults aged 60 years and above (Kotter-Grühn, Kleinspehn-Ammerlahn, Gerstorf, & Smith, 2009; Miche et al., 2014), while pronounced interindividual differences in rate of decline were observed in a midlife sample (Miche et al., 2014).

In previous longitudinal research, positive ATOA was associated with a number of important developmental outcomes in old age, such as better subjective (Moor et al., 2006) and objective health (Westerhof et al., 2014), a healthy lifestyle and more preventive behaviors (Levy & Myers, 2004), and even longevity (Levy, Slade, Kunkel, & Kasl, 2002; Sargent-Cox, Anstey, & Luszcz, 2014). Notably, there have been no studies investigating long-term effects of ATOA on cognitive development.

Comparison of Views on Aging Concepts

Views on aging conceptualizations differ in their specificities and features (e.g., Diehl et al., 2014). For example, the level of processing involved in the subjective evaluations of aging can be placed along a continuum ranging from pre-conscious or implicit to conscious or explicit (Diehl et al., 2014). Age stereotypes and aging attitudes such as the ATOA scale are assumed to measure implicit views on aging, whereas subjective age relies on a more explicit judgment. Other conceptualizations, like *awareness of age-related change* (AARC) by Diehl and Wahl (2010), place more emphasis on the conscious reflection and evaluation of changes due to individual aging. For example, the AARC measure differentiates between age-related gains and losses in five different life domains.

Another important distinction can be made upon the dimensionality, e.g., unidimensional or multidimensional, of the construct. Although considered multidimensional in nature, subjective age and ATOA often rely on a unidimensional approach when empirically investigated; instead of separately considering aging experiences across various life domains (e.g., cognition, social relations, finance, or health) and differentiating age-related losses and gains, an individually-weighted global evaluation of aging experiences is assessed. Despite the differences in conceptualization, so far only a few studies have empirically addressed associations *among* various subjective aging concepts or a *comparative* perspective in terms of suitability in predicting developmental outcomes (Brothers, Miche, Wahl, & Diehl, 2017).

This thesis relies on the concept of ATOA because of various reasons. First, like subjective age, ATOA captures a rather global unidimensional evaluation of the individual aging process (Diehl et al., 2014) but comes as a psychometrically approved 5-item scale. Although no direct psychometric comparison with the single-item measure of subjective age exists, having a 5-item scale seems to be a more reliable and valid way to economically assess age views. Second, ATOA is a proven health-predictive indicator for a range of subjective and objective health outcomes, including mortality (e.g., Sargent-Cox et al., 2014; Westerhof et al., 2014). Given the sizeable association between health and cognition in old age (Wettstein, Wahl, Siebert, & Schröder, in press), ATOA is particularly suitable for this research focusing on cognitive aging.

To substantiate the assumed relation between ATOA and cognitive development, the next section provides a deeper insight into the current state of cognitive aging research regarding theoretical accounts on normal and pathological decline as well as plasticity and risk factors. For terminological clarity, it should be noted that the empirical part of this work focuses on ATOA, but it is often referred to as the broader notion of "views on aging". This is mainly because labels are not selectively used in the literature and empirical work regarding ATOA is somewhat limited.

Substantially linking ATOA to cognitive aging, therefore, requires recurring to the broader literature of views on aging.

The Search for Risk Factors of Differential Cognitive Aging

Cognitive abilities change as a normal process of aging. However, different cognitive abilities do not age uniformly. Instead, research suggests large heterogeneity in onset and rate of change in cognitive abilities among individuals as they age (Ghisletta, Rabbitt, Lunn, & Lindenberger, 2012; Schaie, 2005a; Wisdom, Mignogna, & Collins, 2012). In line with the principles of multidimensionality and multidirectionality of life-span psychology (Baltes, 1987), cognitive abilities like vocabulary, wisdom, and decision making remain rather stable or even improve as aging continues, while other cognitive components like memory, processing speed, and attention significantly decline over time (McArdle, Ferrer-Caja, Hamagami, & Woodcock, 2002; Verhaeghen & Cerella, 2002). Still, a great deal of interindividual variability characterizes the trajectories within both classes of cognitive abilities.

This chapter provides (1) a brief overview of theories on cognitive development over the lifespan; (2) explanatory models on why cognitive functioning declines with increasing age; (3) a short evaluation of challenges differentiating normal cognitive changes from pathological conditions, i.e., mild cognitive impairment and dementia; and (4) the current state of evidence on modifiable and non-modifiable risk factors of cognitive decline. Although this all reflects classic cognitive aging research, the rather new point made here is a discussion of age views as a so far much neglected modifiable risk factor of cognitive aging. Instead of providing an extensive overview of the literature on cognitive decline and pathology, the following section is purposefully reduced to a focused discussion on key aspects that seem relevant when aiming to propose a novel risk factor for cognitive decline in old age.

Two-Component Model of Cognitive Development

Originally introduced by Cattell and Horn (Cattell, 1963; J. L. Horn & Cattell, 1967), the *theory of fluid and crystallized intelligence* distinguishes two basic cognitive components to describe different patterns of cognitive change across the lifespan. This distinction was again further defined by Baltes and colleagues using the terms *mechanics* and *pragmatics* (Baltes, 1987; Baltes et al., 2006). Both approaches align in that cognitive development reflects two intertwined components: A *biological* component (fluid or mechanic) that is expected to decline after peaking in young adulthood, and a *cultural* component (crystallized or pragmatic) that is expected to increase with age—as long as maintenance and acquisition of knowledge outweigh age-related losses in biological potential (Lindenberger, 2001). Fluid abilities or mechanics encompass one's innate ability of processing and learning information or solving novel problems (Baltes et al., 2006). This also includes executive function, processing speed, memory, and psychomotor ability. Fluid abilities are more affected by the aging brain, in particular, the frontal lobe, and more vulnerable to aging than crystallized abilities (Baltes et al., 2006). Many fluid cognitive abilities like processing speed peak around the age of 30 and then decline progressively (Salthouse, 2009). In contrast, crystallized abilities or pragmatics "reveal the power of human agency and culture" (Lindenberger, 2001, p. 8852), referring to acculturated knowledge, skills like reading and writing, strategy learning, educational qualifications, and vocabulary. Crystallized abilities remain stable or even continue to grow until about 70 years (Gerstorf, Ram, Lindenberger, & Smith, 2013; Salthouse, 2009). Throughout life, both components are assumed to work synergistically. For example, using fluid intelligence to learn and reason about new things, the acquired information forms into knowledge about the world, thereby building up crystallized intelligence. Conversely, at advanced age, crystallized knowledge increasingly serves the function of buffering and compensating for the negative consequences of fluid decline (Lindenberger, 2001). This buffer function is, however, limited since

crystallized abilities or pragmatics also show patterns of decline at a very old ages beyond 80 years (Singer, Verhaeghen, Ghisletta, Lindenberger, & Baltes, 2003).

Theoretical Accounts on Normal Cognitive Aging

Several reasons for age-associated cognitive decline have been discussed in the literature. One prominent theory refers to *reduced processing speed*, which describes a general slowing of information processing causes age-related deficits in working memory and other cognitive tasks (e.g., Birren, 1965; Salthouse, 1996). Salthouse (1996) argued that age-related changes in processing speed lead to cognitive impairments, particularly in two fundamental mechanisms: performing operations *under time pressure* or *simultaneously*. Moreover, *limited resources*, that is the amount of attentional resources available for cognitive processing declines with age (Craik & Byrd, 1982), and *inhibitory deficits*, less efficient inhibitory mechanisms to separate irrelevant from relevant information result in working memory deficits (e.g., Hasher & Zacks, 1988; Park, 2000; Rabbitt, 1965), were proposed to account for age-related cognitive decline. Despite being criticized as rather descriptive (Light, 1988), these early theoretical explanations were considered to be "surprisingly insightful" and are still relevant today, along with more recent approaches that emphasize neural factors (Park & Festini, 2017, p. 82). In their brief review on cognitive aging research over the past 50 years, Park and Festini (2017) noticed a shift in theorizing from single-mechanism theories to developing multifactorial models that also account for individual differences (Hertzog, 1985; Salthouse, 1996). Notably, despite the multifactorial nature of age differences in cognition, Park and Festini (2017) also gathered substantial empirical evidence that "speed was confirmed as perhaps the most important contributor to age differences" (p. 86). Although agreeing that it is not the single and universal reason for cognitive decline, processing speed has repeatedly been found to explain the largest portion of variance in age-related cognitive differences (Park & Festini, 2017; Verhaeghen & Salthouse, 1997).

Pathological Cognitive Aging – Alzheimer Disease and Mild Cognitive Impairment

Dementia is a clinical syndrome characterized by considerable cognitive decline (Mayeux & Stern, 2012). Mainly affecting memory and other cognitive functions such as language, orientation, motor skills, or learning, impairments also strongly hinder behavioral, social, and professional functioning (Chertkow, Feldman, Jacova, & Massoud, 2013). As an umbrella term, 'dementia' refers to cognitive impairment caused by a myriad of underlying conditions (Cheng, 2016) with Alzheimer disease (AD) being the most common; AD accounts for more than 60% of all dementias (Kalaria et al., 2008). In Germany, about 1.7 million people currently suffer from dementia and most of them are affected by AD, specifically (Bickel, 2018).

AD is the result of a complex process of progressive neurodegeneration that occurs over decades (Sperling et al., 2011). Advances in neuroimaging offer the valuable possibility to examine neurobiological underpinnings of pathological changes in cognition. Identification of biomarkers linked to AD have contributed to better differentiation and tracking of the transition from normal cognitive aging to pathology. AD is characterized by the accumulation of extracellular beta-amyloid neuritic plaques, which starts in the synaptic structures and then extends to cells, undermining neural networking and leading to neural loss and function. In addition to beta-amyloid plaque formation, AD is also characterized by the accumulation of intracellular tau-related neurofibrillary tangles, reactive microgliosis (i.e., proliferation of macrophages in the central nervous system), and white matter functional loss (Jack et al., 2013; Reitz & Mayeux, 2014; Sperling et al., 2011).

Etiological mechanisms underlying these severely negative brain changes remain unclear, but are probably caused by both environmental and genetic factors (Reitz & Mayeux, 2014). Unfortunately, despite the increasing potential to map in vivo biomarkers by use of improving imaging technology, a definitive diagnosis of AD is only possible on autopsy. The National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA; Dubois et al., 2007) has formulated criteria that allow

for "possible" or "probable" diagnosis in a living individual. They request a multidimensional diagnostic procedure that integrates information from cognitive testing, imaging techniques, biomarker identification, and medical examinations (e.g., to quantify progressive decline and to exclude alternative etiologies).

In 1999, Petersen and colleagues introduced the term *mild cognitive impairment* (MCI) to meet the symptomology of a prodromal stage of dementia. MCI refers to a transitional state of decreased cognitive functioning that lies between the changes observed in normal and pathological cognitive decline, and is associated with an increased risk of developing dementia (Petersen, 2004; Petersen et al., 1999). A definitive diagnosis of MCI remains challenging, because MCI encompasses a heterogeneous group consisting of several subtypes (Gauthier et al., 2006) with about one half reverting to normal functioning or remaining in the state of MCI and the other half progresses to dementia within five years (Mitchell & Shiri-Feshki, 2009; Petersen et al., 2014). However, such statistics should be treated with caution. Since there is currently no diagnostic standard available for MCI, conversion rates and prevalence vary considerably (Mitchell & Shiri-Feshki, 2009). Despite efforts to achieve standardization, a variety of concepts and criteria still exist (Gunzelmann, 2008).

This lack of consistency illustrates the difficulties in drawing a clear line between age-appropriate and impaired functioning. The heterogeneity of cognitive changes in old age combined with the great amount of between- and within-person fluctuations of healthy adults further complicate classification (Ziegenhorn & Heuser, 2005). Researchers have also used the term *continuum of AD* to describe the temporal course of a gradual neurodegeneration from normal aging, to preclinical decline, to MCI, and finally, to AD (Petersen et al., 1999; Sperling et al., 2011). Notably, converging evidence from genetic at-risk and aging cohorts suggests that the underlying neuropathological changes, such as the accumulation of beta-amyloid plaques and tau fibrils, appear to begin prior to old age. More precisely, hypothetical models on the temporal course of AD-related pathology

assume an early deposition of beta-amyloid protein decades before symptom onset, followed by tau-related neurodegeneration and observable hippocampal volume loss that precede subtle cognitive impairment and clinical manifestations (Jack et al., 2013; Sperling et al., 2011). The temporal lag between the pathophysiological processes and observable clinical manifestations of AD is thought to be influenced by individual factors such as *cognitive reserve* (Jack et al., 2013; Stern, 2012). The concept of cognitive reserve proposed by Stern (2002) was based on the recurrent observation that some people are more resilient to severe neuropathological damage than others and are able to maintain function despite detrimental neurobiological constellations. The assumption is that the threshold for the clinical expression of underlying brain damage is moderated by the brain's ability to actively cope with and compensate for these neural deficits (Stern, 2009, 2012).

Evidence on Cognitive Plasticity and Risk Factors for Cognitive Decline

Given the absence of curative pharmaceutical treatment and the associated socioeconomic and individual costs of cognitive decline, further investigation of its risk factors has become a major research goal, with the hope of eventually impacting the course of cognitive impairment, preserving daily functioning, and delaying dementia onset (Cummings, Doody, & Clark, 2007; Cummings, Morstorf, & Zhong, 2014; Wimo et al., 2017). Knowledge derived from ongoing cognitive aging research and a growing body of longitudinal studies like the Seattle Longitudinal Study (Schaie, 2005a) constantly stimulates the study on factors accounting for the large variability in cognitive and brain function in older adults, resulting in a vast amount of literature. In the following, risk factors for normal and pathological changes are presented in one, because these factors are mainly the same for both given that cognitive decline actually reflects a continuum of changes from normal to AD (also see Dixon & Lachman, 2019).

A summary of the current state of evidence requested by the World Dementia Council (Baumgart et al., 2015) and other recent reviews concluded that family history and genetic susceptibility genes like apolipoprotein E (ApoE) ε4 allele are among the strongest risk factors for cognitive decline and AD (Reitz & Moyeux, 2014). There is a higher prevalence of AD in women, suggesting an association between female gender and risk of cognitive decline in old age, although this may just be related to longer life expectancy (Bickel, 2018).

An important early modifiable influence for later cognitive health is higher formal education (Baumgart et al., 2015). With regard to factors that are modifiable through individual behavior and lifestyle change in mid- and later life, regular physical activity, cognitive activity, and management of cardiovascular risk factors—specifically diabetes, smoking, obesity, and hypertension in midlife—reduce the risk of cognitive decline (Baumgart et al., 2015; Reitz & Moyeux, 2014). Physical activity is perhaps the most established protective factor for cognitive aging, by boosting neuroplasticity and cerebral perfusion (Cheng, 2016). Which type or duration of exercise maximizes cognitive health is less clear, however, and still a subject of ongoing research (Dixon & Lachman, 2019). In addition, engaging in cognitively stimulating activities has benefits for cognitive functioning in later life (Hertzog et al., 2008). Systemic reviews on cognitive intervention studies further indicate improvements of cognitive functioning in healthy and impaired adults but support is limited that effects generalize or transfer across domains (e.g., Hertzog et al., 2008; Reijnders, van Heugten, & van Boxtel, 2013). Furthermore, there is strong evidence that a healthy diet protects against cognitive decline (Baumgart et al., 2015; Reitz & Mayeux, 2014). Social engagement or, conversely, loneliness and isolation also relate to cognitive decline and impairment (for a recent review, see Boss, Kang, & Branson, 2015), possibly through stimulating cognitive activities involved in social interactions like talking and collaborating (Dixon & Lachman, 2019).

Stress has also been shown to have harmful effects on health and cognition, and is associated with higher levels of cortisol section and inflammation (Dixon & Lachman, 2019; Lupien, Maheu,

Tu, Fiocco, & Schramek, 2007). Converging studies also suggest a link between depression and cognitive decline (e.g., Barnes, Alexopoulos, Lopez, Williamson, & Yaffe, 2006); however, it is still under debate whether depression actually increases an individual's risk or is rather an early sign of the underlying neuropathological changes (e.g., Baumgart et al., 2015). Further, psychological constructs like anxiety (Gimson, Schlosser, Huntley, & Marchant, 2018; Gulpers et al., 2016), worry (Pietrzak et al., 2012), and certain personality traits are associated with accelerated cognitive decline. For example, there is some suggestion that people with higher neuroticism and less stable personality traits are at increased risk of developing AD (Kuzma, Sattler, Toro, Schonknecht, & Schröder, 2011; Terracciano, Stephan, Luchetti, Albanese, & Sutin, 2017).

Considered an at-risk condition, subjective reports of cognitive decline build a key criterion of MCI and prodromal AD (Dubois et al., 2007; Petersen, 2004). The related question to what extent subjective cognitive complaints do reflect and predict cognitive decline and even future impairment has attracted much attention and controversy in the cognitive aging literature. Work by Jessen and colleagues, among others, show that subjective cognitive complaints are related to higher counts of AD biomarker and increased risk of future MCI and AD (Jessen et al., 2014; Jessen et al., 2010). Similarly, recent cross-sectional and longitudinal reviews found small but significant associations between cognitive complaints and current impairment as well as future cognitive decline (Burmester, Leathem, & Merrick, 2016; Mendonca, Alves, & Bugalho, 2016; Mitchell, Beaumont, Ferguson, Yadegarfar, & Stubbs, 2014). However, it is also assumed that cognitive complaints are strongly associated with psychological factors such as personality traits or anxiety (Hülür, Hertzog, Pearman, & Gerstorf, 2015; Pearman, Hertzog, & Gerstorf, 2014; Tobiansky, Blizard, Livingston, & Mann, 1995; Verhaeghen, Geraerts, & Marcoen, 2000).

To summarize, although chronological age is undoubtedly linked to normative changes in brain structure and function that impede cognitive abilities (e.g., Giles et al., 2003; Moscovici,

1988), "adult cognitive development is variable across and malleable within persons" (Lindenberger, 2014, p. 572). The contribution of modifiable lifestyle factors to cognitive health in later life is an encouraging sign of the agentic impact of individuals on cognitive plasticity. Many of the identified factors related to healthy lifestyle habits (physical activity, diet, non-smoking) are assumed to have a more indirect effect on cognitive functioning through their beneficial impact on cardiovascular health. Engaging in cognitive and social activity seems to be more directly linked to cognitive health by strengthening neural efficiency and plasticity (Chen, 2016; Hertzog et al., 2009). So far, however, psychological factors have received only limited attention even though they may contribute to between-person differences and even within-person variability in cognitive decline (Bartres-Faz, Cattaneo, Solana, Tormos, & Pascual-Leone, 2018; Wilson & Bennett, 2017). In their review on enrichment effects on adult cognitive development Hertzog and colleagues (2008) conclude that "too little is known also about the extent to which [...] positive attitudes and positive beliefs foster healthy lifestyles that facilitate cognitive enrichment" (Hertzog et al., 2008, p. 44). By now, the growing amount of evidence emphasizes the potential of views on aging being an essential developmental resource in old age. More positive views on aging and ATOA have been empirically linked to a variety of beneficial factors contributing to cognitive health in old age like favorable lifestyle habits (Levy & Myers, 2004), better health (Westerhof et al., 2014), motivational aspects (Hess, Growney, O'Brien, Neupert, & Sherwood, 2018), as well as biological and physiological processes (Stephan, Sutin, & Terracciano, 2015).

Research in the last two decades identified a number of modifiable factors related to cognitive health by either directly improving brain health or by contributing to a stronger cognitive reserve. Cognitive reserve comprises a malleable entity depending on an interaction of innate individual differences and life experiences that can be enhanced, for example, by engaging in purposeful activities (Stern, 2012; Willis et al., 2009). Such relevant exposures include but are not limited to cognitive ability in early life, educational attainment, occupational complexity, physical exercise,

cognitive activities, and social engagement (Stern et al., 2018). Many of these factors are also discussed in connection with views on aging, therefore, age views may be linked to normal and pathological cognitive decline. The underlying rationale is that views on aging constitute a complex set of resources associated with differences in cognitive reserve and may affect the risk of cognitive pathology. Within the next two sections, this assumption is further delineated by first referring to existing empirical evidence linking views on aging and cognitive abilities and by then presenting a conceptual pathway model.

Linking Views on Aging and Cognitive Abilities

After arguing as to why ATOA is an interesting underestimated risk factor for normal and pathological cognitive aging, this section aims to provide a comprehensive overview about the current state of empirical investigations linking the two central concepts of the present work, views on aging and cognitive abilities. To do so, early experimental work and pros and cons of a longitudinal research approach (as endorsed in this dissertation) are addressed. Then available longitudinal endeavors in the field are reviewed.

Based on her interest in the role of self-stereotyping on individual performance, Levy's seminal study (1996) found harmful effects of age stereotype priming on memory, memory self-efficacy, and aging attitudes. Specifically, negative effects were only found for older but not younger participants. This led to the notion that stereotypes must be self-relevant to be impactful (Levy, 1996), since self-relevance of age stereotypes does not exist in younger individuals. To date, the paradigm has been tested in different settings, using implicit and explicit measures of stereotype activation, across different age groups, and applying a variety of cognitive domains. Drawing on this work, two meta-analyses concluded that older people consistently perform worse on cognitive tests when confronted with negative age stereotypes, with both memory tasks as well as non-memory tasks (Horton, Baker, Pearce, & Deakin, 2008; Lamont, Swift, & Abrams, 2015). This

implies that the classic observation of age differences in memory and cognition may in part be explained by exposure to negative age stereotypes (e.g., Hess, 2005), indicating not only biological factors but also psychological expectations and images of old age may lead to impaired abilities in older adults. These findings are especially relevant given the pervasive nature of negative age stereotypes regarding cognition (Hummert et al., 1994; Kite et al., 2005), the lifelong exposure to negative age stereotypes that infuse aging expectations already among younger adults (Haslam et al., 2012; Levy & Leifheit-Limson, 2009), and the high value placed by aging adults on cognitive functioning (Dixon & Hultsch, 1983).

Obviously, not only *short-term* effects due to stereotype activation in experimental settings are important, but also differences in personally held beliefs about age and aging that may lead to *long-term* consequences. The matter of cognitive decline is reflected in many societal age stereotypes and likely colors *personal* views on aging and expectations as well (Diehl & Wahl, 2010; Kornadt et al., 2017). Social psychology stresses the power of individual expectations and perceptions on future outcomes, which may turn into self-fulfilling prophecies by facilitating or hindering certain actions (Merton, 1948). Specifically, theoretical and empirical approaches on correlates of views on aging (Levy, 2009; Wurm et al., 2017) show substantial overlap with the studied modifiable risk factors of cognitive decline presented earlier, further underlining the reasoning that views on aging and cognitive development may be attached over time.

Importance of a Long-Term Perspective

Although there is robust evidence on the short-term effects of negative age stereotypes on cognitive performance, work that empirically tested the *long-term* effects of views on aging on cognitive trajectories was rare at the beginning of this thesis. Addressing the link between views on aging and cognitive aging from a longitudinal perspective is important because of four primary reasons. First, the strength of experimental designs clearly lies in their potential to maximize in-

ternally valid cause-effect interpretations due to highly standardized, rather unconfounded test situations. However, experimental as well as cross-sectional designs are limited when studying long-term change of functions, differential change dynamics across long time spans, and antecedent-consequent relationships in long-running developmental processes (Schaie & Hofer, 2001). Longitudinal studies are necessary to learn how variables change intraindividually (or not), interact over time, and over different life phases (Schaie, 2005b; Schaie & Hofer, 2001). Second, and more specifically, it seems relevant to adopt a developmental perspective when jointly investigating subjective aging and cognitive aging trajectories, as both domains are in need of a life-span perspective. For example, theoretical as well as empirical work underlines that early as well as later life experiences influence views on aging (e.g., Diehl et al., 2014; Levy, 2009; Wurm et al., 2017) and cognitive performance (e.g., cognitive reserve). Third, given the heterogeneity in time of onset and course of decline in cognitive functioning, long time intervals with multiple measurement occasions are needed to extract prompt or delayed associations between views on aging and cognitive functioning. As initial cognitive and neuropathological changes begin to appear prior to old age, longitudinal endeavors should enroll individuals earlier in the lifespan, before these changes begin to occur (Wilson & Bennett, 2017). Fourth, empirical evidence has shown large between-person variability in subjective aging experiences during midlife, suggesting that observational periods should be extended to include this time period (Miche et al., 2014).

Even though a longitudinal approach was chosen here, two major challenges exist in longitudinal inquiries. Longitudinal studies often have to deal with *selective study attrition*, i.e., participants who are healthier, wealthier, better educated, and have higher cognitive abilities are more likely to remain in the study (Van Beijsterveldt et al., 2002). Moreover, *practice effects* in terms of cognitive functioning may occur due to multiple test occasions. As a result, participants may be able to improve or stabilize their performance in spite of a possible ‘natural’ or ‘true’ cognitive decline (Salthouse, 2010). Still, the advantages of longitudinal studies are believed to outweigh

their limitations (Hertzog et al., 2008) and the challenges associated with longitudinal designs are again considered in the overall discussion in Chapter 5.

Views on Aging and Cognitive Development in Later Life: The Essence of Existing Longitudinal Evidence

In this section, available longitudinal studies linking views on aging and cognitive abilities over time are narratively reviewed.[1] Studies were included if they fulfilled the following criteria of a) being a longitudinal study on views on aging and cognitive functioning with at least two measurement occasions and b) focusing on major operationalizations of views on aging (age stereotypes, subjective age, ATOA, and self-perceptions of aging) as an antecedent or outcome in relation to normal cognitive aging or cognitive pathology.

Table 1.1 lists the respective studies according to the following criteria: Study design, sample size, observational time span, applied measurement tools of views on aging, cognitive testing procedures, focus of the analyses, and main findings. Studies were also grouped into (a) those addressing normal cognitive aging (8 studies; upper part of the table) or (b) those focusing on cognitive pathology such as MCI and dementia (4 studies; bottom part of the table). Instead of presenting the different studies in detail here, the objective with Table 1.1 is to provide an overview of existing research in the field, to summarize and integrate the current state of evidence, and to help identify major research gaps.

Views on aging served as a predictor of cognitive outcome in most studies (n = 9), while two papers concentrated on the role of cognitive performance in explaining change in views of aging

[1] Notably, the majority of studies were published in recent times, during the preparation of this thesis, and had not been available at the time of writing and publishing the individual papers presented in Chapters 2 and 3. The literature considered in these two Chapters thus reflects the state of empirical evidence at that time, while a comprehensive overview including most recent findings is given here.

over time (Hughes & Lachman, 2018; Kleinspehn-Ammerlahn et al., 2008). Only one study examined the bidirectional relationship between processing speed and subjective aging over three years (Seidler & Wolff, 2017; Stephan et al., 2016) and one tested reverse effects of memory on changes in felt age over 4 years (Seidler & Wolff, 2017; Stephan et al., 2016). Across all studies and independent of the used measures of views on aging or cognition, more negative views on aging were significantly related to lower test performance in episodic memory and executive function (Stephan et al., 2014), steeper memory decline (Levy et al., 2012; Stephan et al., 2016), accelerated decline in verbal fluency (Robertson, King-Kallimanis, & Kenny, 2016; Smith, Desai, Slade, & Levy, 2018), lowered processing speed (Seidler & Wolff, 2017), and a higher risk of future cognitive impairment (Levy, Slade, Pietrzak, & Ferrucci, 2018; Stephan, Sutin, Luchetti, & Terracciano, 2017, 2018). Analyses were generally controlled for effects of age, gender, educational or socioeconomic background, and a variety of objective or self-rated health variables.

Importantly, the picture is less clear when it comes to reverse effects; existing studies yielded mixed results. Two studies investigating correlates of change in subjective age and ATOA after 10 years were not able to detect a predictive effect based on performance in various cognitive tests (Hughes & Lachman, 2018; Kleinspehn-Ammerlahn et al., 2008). Another study found no relationship between level or change in memory on change in subjective age over 4 years (Stephan et al., 2016). In contrast, findings by Seidler and Wolff (2017) indicated a bidirectional link between self-perceptions of aging and processing speed across three years. The age of participants included in these samples ranged from early adulthood to old age.

All four studies focusing on pathological cognitive decline were published more recently, after 2016. Presenting results from two analyses, Levy and colleagues (2016) found a significant relationship between age stereotypes and Alzheimer biomarker; participants with more negative age stereotypes had a three times higher rate of volume decline in hippocampal brain matter over 10 years and a greater accumulation of amyloid plaques and neurofibrillary tangles at autopsy (Levy

et al., 2016). In the other studies, feeling older (Stephan et al., 2017, 2018) or more negative ATOA (Levy et al., 2018) at baseline increased the risk of cognitive impairment (defined as diagnosis of dementia or MCI based on a cognitive screening and/or self-reported diagnosis from a doctor) over a 4-year interval. In terms of study length, other than the 10-years observational study, all three other studies linking views on aging to cognitive pathology spanned over 4 years.

Table 1.1

Overview of Existing Longitudinal Studies Linking Views on Aging and Cognitive Outcomes

Study	Sample	Cognitive Domain	Views on Aging Measure	Focus and Main Results
A) Normal cognitive aging				
Hughes & Lachman (2018) Prospective study 10 years	Midlife in the United States (MIDUS) N = 3427 32-84 years	Memory Executive function Via telephone Only once at t2	Subjective age	Focus: change in subjective age over time • Neither episodic memory nor executive function related to change subjective age change when including functional health • Controlling for age, gender, education, chronic health problems
Kleinspehn-Ammerlahn et al. (2008) Longitudinal study 10 years	Berlin Aging Study N = 846-1285 70-104 years	General intelligence Only once at t1	ATOA Subjective age	Focus: change in views on aging over time • Baseline cognition predicted levels of ATOA and subjective age but not changes in both measures • Controlling for age, gender, socioeconomic status, illness, loneliness
Levy et al. (2012) Longitudinal study Up to 38 years	Baltimore Longitudinal Study of Aging (BLSA) N = 395 22-77 years	Memory	Age stereotypes	Focus: change in memory over time • More negative baseline age stereotypes predicted steeper decline in memory performance over time • Controlling for age, gender, race, depression, education, marital status, illness, self-rated health

Study	Sample	Cognitive Domain	Views on Aging Measure	Focus and Main Results
Robertson et al. (2016) Longitudinal study 2 years	Irish Longitudinal Study on Ageing (TILDA) N = 5896 50-93 years	Memory Verbal fluency	Self-perceptions of aging	Focus: change in cognition over time • Negative self-perceptions of aging predicted decline in verbal fluency and self-rated memory, but not objective memory performance • Controlling for age, gender, employment, education, marital status, health, self-rated health, loneliness, mood
Seidler & Wolff (2017) Longitudinal study 3 years	German Aging Survey (DEAS) N = 8198 40-93 years	Processing speed	Self-perceptions of aging	Focus: bidirectional analyses • Bidirectional associations between self-perceptions of aging and processing speed • Controlling for age, gender, education, place of residence, number of illnesses
Smith et al. (2018) Longitudinal study 10 years	Survey of Health, Ageing and Retirement in Europe (SHARE) European Social Survey (ESS) N = 2620 > 70 years	Memory Verbal fluency	Age status in a given country (single item)	Focus: effects of country-level age status on cognitive performance • Older individuals living in countries with higher age status had better cognitive performance over time compared to lower age status countries • Controlling for age, gender, education, self-rated health at baseline (depression status in a subsample)
Stephan et al. (2014) Prospective study 10 years	MIDUS N = 1352 50-75 years	Memory Executive function Via telephone Only once at t2	Subjective age	Focus: link to cognition 10 years later • Feeling younger associated with better episodic memory and executive function • Controlling for age, gender, education, marital status, disease burden, BMI and physical activity
Stephan et al. (2016) Longitudinal study 4 years	Health and Retirement Study (HRS) N = 5809 > 50 years	Memory	Subjective age	Focus: change in memory over time; second-tier: change in subjective age over time • Feeling younger predicted slower decline in immediate and delayed recall over 4 years • Memory level and change unrelated to change in subjective age • Controlling for demographics, metabolic and vascular covariates (mediated by depressive symptoms)

Study	Sample	Cognitive Domain	Views on Aging Measure	Focus and Main Results
B) Cognitive impairment				
Levy et al. (2016) Longitudinal study up to 10 years	BLSA N = 52 (Study 1) M_{age} = 68 N = 74 (Study 2) Post mortem	Alzheimer biomarker • Hippocampal volume (Study 1) • Amyloid plaques (Study 2)	Age stereotypes	Focus: link to biomarkers of AD over time • Negative age stereotypes related to steeper rate of volume decline in hippocampus (study 1) and greater accumulation of amyloid plaques and neurofibrillary tangles at autopsy (study 2) • Controlling for age, gender, education, health variables, baseline cognition
Levy et al. (2018) Longitudinal study up to 4 years	HRS N = 4765 > 60 years	Dementia diagnosis based on a cognitive screening via telephone	ATOA	Focus: greater risk of future dementia • Negative ATOA related to greater risk of future dementia • Controlling for age, gender, education, race, cardiovascular disease, diabetes, baseline cognitive performance, and APOE
Stephan et al. (2017) Longitudinal study up to 4 years	HRS N = 5748 > 65 years	Cognitive impairment based on a cognitive screening via telephone	Subjective age	Focus: greater risk of future cognitive impairment • Feeling older as a risk factor for subsequent dementia and cognitive impairment without dementia • Controlling for age, gender, education, smoking, diabetes • Mediated by physical inactivity and depressive symptoms
Stephan et al. (2018) Longitudinal study 4 years	National Health and Aging Trends Study (NHATS) N = 4262 > 65 years	Dementia diagnosis based on either: a) Reported diagnosis b) Screening interview c) Cognitive test performance	Subjective age	Focus: greater risk of future dementia • Feeling older increased risk of incident dementia • Mediated by depressive symptoms (link reduced to non-significance after inclusion of depressive symptoms) • Controlling for demographics, baseline cognition, hypertension, diabetes, smoking, physical activity

With regard to the measures of views on aging, the majority of studies looked at *individual* differences in subjective age (n = 6), age stereotypes (n = 2), ATOA (n = 2), or self-perceptions of aging (n = 2), whereas one study explored different views on aging on *country* level. For this purpose, Smith and colleagues (2018) combined information on age status in different European countries from the Survey on Health, Ageing, and Retirement in Europe with cognitive performance data from the European Social Survey. Findings on country level match those derived from individual level: Participants living in countries with higher old age status—that is, more positive views on aging—showed more favorable cognitive aging trajectories over ten years controlling for age, gender, education, and self-rated health (Smith et al., 2018).

In conclusion, there is considerable evidence speaking to the long-term association of views on aging and cognitive abilities, particularly in the direction that views on aging predict normal and pathological cognitive development. Regarding the reverse direction, findings on how cognitive abilities shape views on aging are scarce and inconclusive (Hughes & Lachman, 2018; Kleinspehn-Ammerlahn et al., 2008; Seidler & Wolff, 2017; Stephan et al., 2016), and thus call for further empirical investigation. Most studies reported data from large population-based and well known longitudinal aging studies, such as the Baltimore Longitudinal Study of Aging (Ferrucci, 2008), the Health and Retirement Study (Sonnega et al., 2014), and the Berlin Aging Study (Delius, Düzel, Gerstorf, & Lindenberger, 2017). Although this body of work relies on impressive sample sizes, the scope of cognitive test batteries and quality of cognitive diagnoses seem less elaborate. First, the cognitive diseases AD and MCI in this set of studies were typically diagnosed using brief screening tests. Although accuracy of screening tools continues to improve due to research on optimizing cut-off criteria, it still cannot compare to multimethodological assessments of clinical expert (Tsoi, Chan, Hirai, Wong, & Kwok, 2015). Thus, research linking views on aging to expert-based diagnoses of cognitive impairment is desired to strengthen study effects. Second, most studies can be qualified as secondary data analyses; that is, they were restricted to

the available cognitive data in terms of width of domains assessed, retesting procedures, and observational time spans. To date, two studies investigated effects on memory performance over 4 years (Stephan et al., 2016) and up to 38 years (Levy et al., 2012). Other cognitive domains were either addressed without available baseline assessments (Stephan et al., 2014) or over rather short time spans of 2 (Robertson et al., 2016) or 3 years (Seidler & Wolff, 2017). Hence, additional research illuminating the effects on cognitive changes beyond memory on a broader range of abilities is desirable. Furthermore, given that studies able to address change trajectories (because both cognition and views on aging had at least been measured twice) comprised longitudinal follow-up periods only up to 4 years (however, see Levy et al., 2012), longer time spans are needed to better understand longitudinal dynamics and evaluate sustainability of effects. In sum, this recent research has clearly enhanced our understanding of the link between views on aging and cognitive development in later life but considerable questions remain unanswered. Before these open research questions are further addressed, the next section concentrates on how views on aging translate into cognitive developmental outcomes and vice versa.

Toward a Conceptual Model Linking Views on Aging and Cognitive Abilities

Originating from the presented conceptual and empirical material linking views on aging and cognitive functioning, this section serves to integrate different lines of reasoning to drive the current research (Figure 1.1). In particular, the framework incorporates influential theories on short-term cognitive function, long-term mechanisms postulated by stereotype embodiment theory operating between views on aging and developmental outcomes, and conceptual reasoning offered in a theoretical paper on views on aging by Wurm and colleagues (2017). In order to consider different research approaches (experimental vs. longitudinal), short-term effects (vertical path of the Figure) are separated from long-term associations (horizontal path). Yet, this is more an analytical separation, since both processes may be clearly intertwined in everyday life.

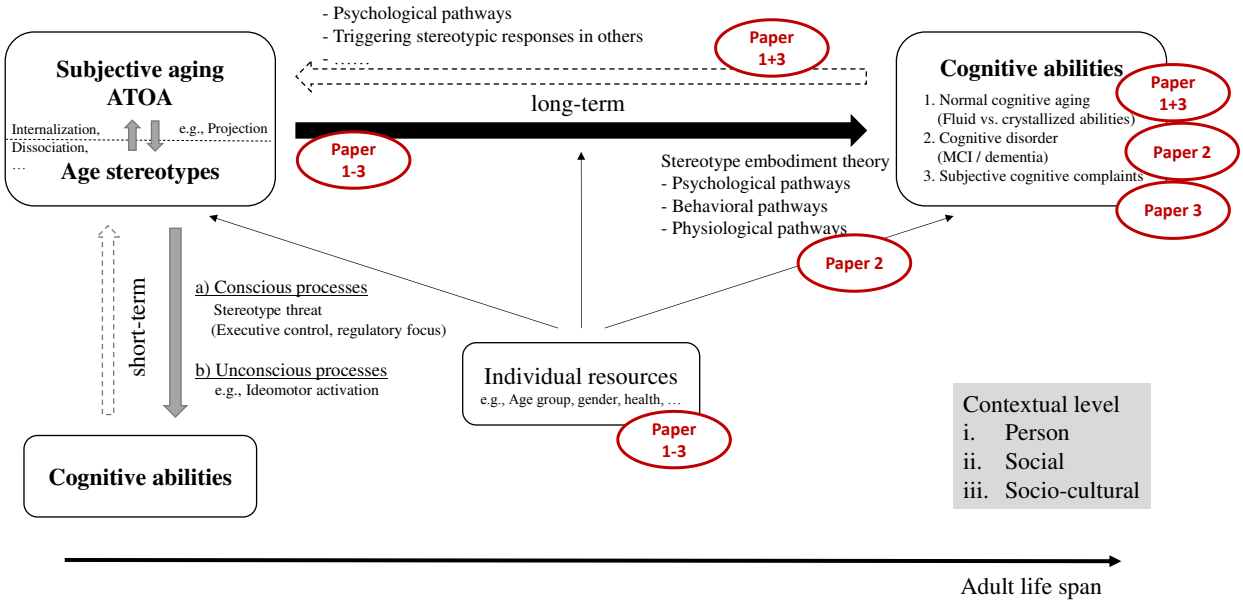

Figure 1.1. Conceptual model linking views on aging to short-term and long-term cognitive abilities with illustrated contributions of Paper 1-3 of the present dissertation.

As depicted in Figure 1.1, views on aging relate to short-term and long-term cognitive abilities. This direction of effect has received much more scientific attention so far, also regarding explanatory theoretical models on mediating pathways that, in part, have already been tested in empirical work. Moreover, views on aging do not only shape cognitive abilities but are assumed to be altered by cognitive performance or change in cognitive function leading to a complex reciprocal dynamic. Another basic assumption is that views on aging, cognitive aging, as well as their connection can differ due to individual resources or variables like gender, age group, and health or genetic variables. For a more holistic view—though not further pursued in this dissertation—it seems of note that these complex interrelations can be embedded into different contextual levels. Albarracin and Shavitt (2018) argue to contemplate attitudes within (a) the person context, (b) the social context, including mass media and social networks, and (c) the socio-historical context, including generational and cultural aspects.

Effects of age stereotypes have been predominantly studied in experimental study designs, but also bear important long-term consequences for cognitive development through processes of self-stereotyping and internalization (Kornadt, Voss, & Rothermund, 2015; Kornadt et al., 2017). In

this dissertation, the main emphasis is placed on how views on aging translate to cognitive outcomes from a long-term perspective, since there have been few systematic conceptual and empirical efforts on this so far.

Short-Term Effects of Views on Aging on Cognitive Abilities

Conceptual reasoning suggests pathways operate below and above one's threshold of awareness (Hess, 2006; Wurm et al., 2017). Although ideomotor processes (i.e., implicit stereotype activation results in automatic tendencies to engage in similar behaviors with a more direct impact on behavior without conscious intervention) have been discussed (Bargh & Chartrand, 1999), research on stereotype threat dominates the literature linking age stereotypes to cognitive performance. Many studies have repeatedly shown that under threat conditions when negative age stereotypes are explicitly invoked older adults perform worse on memory and other cognitive tests compared to non-threat conditions (e.g., Brubaker & Naveh-Benjamin, 2018; Chasteen, Bhattacharyya, Horhota, Tam, & Hasher, 2005; Hess et al., 2003). Summarizing previous findings, stereotype threat effects are greater for those who (a) identify with the stereotyped group; (b) value stereotyped abilities; (c) believe the test is diagnostic of stereotyped abilities; and (d) are aware of the negative implications of the stereotype (Hess, 2006). Interestingly, the effect of age stereotypes on memory performance was also found in a within-subject design study (Brubaker & Naveh-Benjamin, 2018). The authors concluded that stereotype threat is not a global phenomenon but situational in nature, varying within individuals depending on the specific context and condition that eventually increase the salience of age stereotypes.

Competing theories have been proposed to explain the underlying mechanisms responsible for stereotype threat effects (for a detailed overview, see Barber, 2017). For example, a shift to prevention regulatory focus leads older adults to pursue avoidance goals (Barber, 2017; Higgins, 1998). In contrast, the executive control interference hypothesis (Schmader, Johns, & Forbes,

2008) assumes that focusing on stereotype-colored expectations increases executive control interference and reduces elaborative strategies, lowering task performance (Brubaker & Naveh-Benjamin, 2018). Both accounts have found some empirical support also indicating that underlying mechanisms may vary as a function of age (Barber, 2017).

Long-Term Pathways between Views on Aging and Normal and Pathological Cognitive Decline

Whereas mechanisms and theories that explicitly link views on aging and cognitive performance have focused on age stereotypes and their impact on *short-term* cognitive performance, theoretical framework and knowledge on mechanisms connecting subjective aging with *long-term* outcomes in old age are still scarce (for a recent review, see Wurm et al., 2017).

Stereotype threat mechanisms may transfer into a developmental perspective by persistent, accumulated exposure to negative age stereotypes. Besides stereotype threat, stereotype embodiment theory (Levy, 2009) offers another useful life-span framework to better understand long-term mechanisms in the context of cognitive aging. According to Levy's tripartite pathways approach, subjective aging exerts its influence along three complementary but interacting pathways: *psychological*, *behavioral*, and *physiological*. Underpinned by existing empirical evidence, the overall assumption is that views on aging are associated with a range of risk factors for cognitive decline that, in turn, are linked to cognitive impairment in old age.

First, the *psychological* pathway claims that views on aging generate aging-related expectations, which then become self-fulfilling (Levy, 2009) and may motivate individuals to engage in activities that would be good for them (Wurm et al., 2017). For example, a study examining the consequences of attributing illness to "old age" showed that this line of thinking was maladaptive in terms of health motivation and subsequent health behavior over 3 years (Stewart et al., 2016). Underlying attitudes also seem to influence outcome expectancies and provide information about the controllability of assumed aging-associated outcomes (Lachman, Neupert, & Agrigoroaei,

2011). As such, perceived control—an important resource for aging adults (Baltes et al., 2006)—has already been shown to be a significant mediator relating views on aging and functional health (Levy, Slade, & Kasl, 2002; Wurm, Tesch-Römer, & Tomasik, 2007). Important for studying relations to cognitive health, longitudinal evidence links control beliefs to cognitive decline (e.g., Caplan & Schooler, 2003).

Whereas cognitive failures in younger years are commonly attributed to external sources independent of age (e.g., stress, distraction), they are often perceived as *age-relevant* in older age (Erber, Szuchman, & Prager, 1997). Consequently, older adults who experience cognitive failures and attribute these changes to age, rather than factors within their control, may be less likely to expend personal effort to counteract the decline, doubting that it will pay off. In line with this assumption, Hess' *Selective Engagement Theory* (Hess, 2014) highlights the importance of motivational factors for understanding cognitive aging effects. He argues that aging leads to increased costs (e.g., increased effort and fatigue effects) of cognitive activity that in turn affects selective engagement of cognitive resources and that this interplay may be shaped by individual views on aging. Indeed, a recent study found negative aging attitudes to be associated with increased salience of cognitive costs related to cognitively challenging activities, thereby reducing both motivation and actual behavior to engage in such activities (Hess et al., 2018).

Taken together, views on aging may affect how people anticipate, experience, interpret, and evaluate cognitive functioning by moderating goal setting and goal striving as well as influencing motivational aspects and self-efficacy beliefs. Acknowledging the important role for processes of adaptation, conceptual work (Diehl et al., 2014; Kornadt & Rothermund, 2015; Wurm et al., 2017) has explicitly tied views on aging with major theories of developmental regulation; namely, the motivational theory of life-span development (Wrosch & Heckhausen, 1996), the dual-process model of assimilative and accommodative coping (Brandtstadter & Renner, 1990), selective optimization with compensation (Baltes & Baltes, 1990), and Carstensen's socio-emotional selectivity

theory (2006). Although these life-span theories differ in their specification of relevant mechanisms, they converge in that adaptive self-regulation is achieved through engagement in processes of goal setting and goal pursuit, disengagement of unattainable preferences, or reengagement in valued alternative goals (Wahl, Siebert, & Tauber, 2017). Bolstered by increasingly unfavorable gain-loss ratios and shrinking resources in old age, people tend to select and pursue goals in which they expect to achieve at least some degree of success (Brandtstädter, 1998). As illustrated, this likely interacts with individually held views on aging as they infuse aging-related expectations, anticipated threats, as well as possible gains (Kornadt & Rothermund, 2015). For example, views on aging may impact when and why older adults engage in certain control strategies: "People with more negative views may switch too early to secondary control or accommodative modes and, in doing so, may underutilize their existing developmental reserve capacity" (Diehl et al., 2014, p. 16). Indeed, recent research indicates that links between views on aging and depression were moderated by self-regulation strategies (Dutt, Gabrian, & Wahl, 2018).

Second, the *physiological* pathway emphasizes the key role of stress and its harmful impact on cognitive functioning by a two-stage process (Levy et al., 2016). First, negative age stereotypes foster stress in terms of greater physiological stress reactivity in the face of challenging cognitive tasks (Levy et al., 2000). Further, negative ATOA has been shown to function as a vulnerability factor related to negative reaction to stressful events (Bellingtier & Neupert, 2018). Second, accumulated stress and secretion of stress hormones can damage the brain. That is, physiological and cardiovascular parameters such as high blood pressure and cholesterol levels in midlife have been associated to cognitive impairment in old age (e.g., McEwen & Gianaros, 2011). Other discussed biological mechanisms include systemic inflammation, assessed via levels of C-reactive protein, which has been associated with both subjective age (Stephan et al., 2015) and higher odds of cognitive impairment in old age (Noble et al., 2010). Subjective age has also been associated with cystatin C, a marker of kidney function (Stephan, Sutin, & Terracciano, 2019b) that is also related

to a variety of health outcomes in older adults as well as cognitive impairment and dementia (Yaffe et al., 2014).

Third, *behavioral* actions are expected to matter, too. Positive age views contribute to a healthier, more engaged lifestyle with several beneficial lifestyle habits, which in turn have been shown to be important contributors to maintaining cognitive health in old age. More precisely, positive views on aging were linked to higher physical activity (Emile, Chalabaev, Stephan, Corrion, & d'Arripe-Longueville, 2014; Wurm, Tomasik, & Tesch-Römer, 2010), more health-conscious behavior (Kim, 2009; Levy & Myers, 2004), lower risk of obesity (Stephan, Sutin, & Terracciano, 2019a), and more engagement in leisure activities at large (Hicks & Siedlecki, 2017). Such lifestyle factors, in particular cognitive and physical activity, reduce the risk of chronic diseases associated with cognitive decline and stimulate brain function (e.g., Chen, 2016; Hertzog et al., 2009) thereby affecting normal as well as pathological cognitive aging (for comprehensive overviews, see Bamidis et al., 2014; Cheng, 2016; Hotting & Roder, 2013). The positive impact of mental exercise on cognitive function has gained quite some attention outside the scientific community, leading to the term "use it or lose it" (Shors, Anderson, Curlik, & Nokia, 2012).

Directionality of the Effect between Views on Aging and Cognitive Development

Interestingly, previous work has more often conceptualized views on aging as a predictor of cognitive development than vice versa. However, decline in cognitive functioning may also be seen as playing a crucial role in the formation process of views on aging, given the prominence of cognitive age stereotypes. For example, expressing signs of cognitive decline may activate age stereotypes in others, provoking stereotype-influenced responses toward that person (e.g., stigmatization, overhelping; Hess 2006; Figure 1.1 dashed arrows). Being repeatedly treated as an older person may then feed back into one's awareness of aging and heightened monitoring of own age-related performances, reinforcing negative self-views. Moreover, realizing that one's own cogni-

tive abilities are decreasing might activate old age stereotypes, leading to a more negative subjective aging experience. Importantly, older individuals likely refer to their cognitive functioning and constantly monitor how well they are cognitively aging by comparing themselves with their peers as well as evaluating their own cognitive change process to internalized standards of 'cognitive normality'. Hence, change in everyday cognitive performance may indeed play an important formative role for aging attitudes, reflecting a complex reciprocal relationship between these factors (Levy, 2009; see also Diehl & Wahl, 2010; Hess, 2006).

The few studies empirically examining such bidirectional effects, however and as already shown above, have yielded mixed results either supporting reverse effects (Seidler & Wolff, 2017) or not (Hughes & Lachman, 2018; Kleinspehn-Ammerlahn et al., 2008). On a different note, change in views on aging may be more strongly related to personal experiences of cognitive decline—and less to objective measures of cognition. Reports about subtle changes in everyday cognitive function can offer valuable additional insight that enhances understanding of changes in views on aging. So far, however, no study has considered subjective cognitive complaints in addition to objective measures of cognitive function to explain changing age views. Although recent cross-sectional findings confirm moderately-sized connections between views on aging and cognitive complaints (Pearman et al., 2014), long-term associations have hardly been investigated. Thus, more research is needed to better understand the role of objective and subjective cognitive factors potentially shaping views on aging.

Factors Influencing the Association between Views on Aging and Cognitive Development

Whereas experimental work suggests varying associations between views on aging and cognitive abilities due to individual and contextual factors (e.g., Hess, 2006), it is less clear how individual resources moderate their longitudinal relationship. There are certainly a number of relevant moderators at the individual and contextual level (Diehl et al., 2014; Wurm et al., 2017). However, this thesis focuses on two individual variables that seem particularly crucial, *age group* and *gender*.

Although many empirical studies in the field use gender or age as control variables, there have only been a few systematic attempts to investigate possible differential relationships between men and women or younger and older adults. Gender constitutes a highly salient and important social category deemed meaningful in the context of aging, too. For example, regarding views on aging, a 'double standard of aging' has been discussed, meaning that women are more affected by the negative consequences of aging than men (Sontag, 1972). In addition, belonging to a certain life phase or age group is likely an influential moderator, too. Previous evidence suggests that formation and developmental relevance of ATOA is confined to developmental windows. That is, ATOA seems to be most open to changes in midlife rather than old age (Miche et al., 2014), but gains importance for health-predictive variables with increasing age (e.g., Levy, 2009). The vulnerability of cognitive aging also varies as a function of age. Cognitive changes are more likely to occur and manifest in old age compared to midlife (Ronnlund, Nyberg, Backman, & Nilsson, 2005). Thus, dynamics of cognitive loss become more normative but also more pronounced and severe in old age. Given that characteristics and dynamics of trajectories for both views on aging and cognition show different features in midlife versus old age, an investigation of age differential associations contributes to a life-span perspective.

Overall, in an attempt to integrate diverse theoretical and empirical findings on short- and long-term links between views on aging and cognitive abilities, the conceptual model in Figure 1.1 was introduced to help bridge a connection between both areas. Recent improvements in the field have broadened the understanding of the relation between views on aging and developmental outcomes at large and also specific to cognitive aging. Overall, there is convincing theoretical and emerging empirical ground to assume that views on aging and ATOA predict cognitive aging in normal and even pathological range. The literature review in Table 1.1, however, clearly points to the need for empirical evidence regarding an extension to different cognitive facets, using established diagnostic procedures, and longer time intervals.

Considering claims by stereotype embodiment theory (Levy, 2009) and other work, views on aging seem to be distal resources influencing the availability of other more proximal factors. They stimulate or dampen well-studied resources contributing to cognitive health in old age, such as engaging in leisure activities, leading a healthy lifestyle, and having less physiological stress (e.g., Baumgart et al., 2015). Yet, these long-term *pathways* remain mainly assumptions, since only a few studies so far have empirically tested the underlying mechanisms of views on aging; that is, most of them focused on physical health (Wurm et al., 2017) and only a few concentrated on memory function and cognitive impairment over time (Stephan et al., 2016; Stephan et al., 2017).

The focus of previous research has been on views on aging as a predictor of cognitive abilities, which is also reflected in the noticeably fewer conceptual and empirical contributions on potential reverse effects. While bearing some sort of face validity, explanatory attempts are still lacking to systematize what *kind of experiences* of cognitive failure (subjective versus objective) feeds back into views on aging, by which *mechanisms or processes*, and under which *conditions*.

Taken together, this demonstrates the need for further theoretical and empirical efforts, particularly in terms of reverse effects from cognitive abilities to views on aging and change thereof, operating pathways between views on aging and cognitive aging, as well as individual and contextual variables that may moderate relations.

Research Gaps and Contribution of the Present Dissertation

Gaining a better understanding of how views on aging and cognitive development are connected in old age is not only relevant for basic research in life-span developmental psychology, but holds important implications for intervention research and public health practices. Thus, this dissertation aims at contributing to the growing body of research linking views on aging and cognitive development in old age. Taking the exemplary case of ATOA as a major indicator of views on aging in all three dissertation papers, the overarching question of this work is how individual

differences in ATOA are related to differential cognitive aging trajectories across long observational periods in old age. Summing up the conclusions derived from the literature review presented in Table 1.1 as well as the implications of the conceptual model in Figure 1.1, research gaps around four topics are addressed in the present dissertation:

a) ATOA as a long-term predictor of cognitive development,

b) direction of effects between ATOA and cognitive abilities,

c) underlying mechanisms linking ATOA to cognitive development, and

d) individual factors that moderate a possible relationship.

Table 1.2 summarizes the research questions addressed within this dissertation. Regarding the first research gap, the three individual papers target the role of ATOA as a novel predictor of cognitive aging by taking on different perspectives of cognitive outcomes. First, as stated above, it remains unclear whether and how ATOA is longitudinally related to change in *normal* cognitive aging, with particular emphasis on cognitive abilities outside of memory. Therefore, Paper 1 investigates effects of ATOA on fluid and crystallized abilities over 12 years, assuming differential relations for both cognitive domains given their differences in life-span dynamics, age vulnerability, as well as responsiveness to and dependency on individual investment. Again focusing on change in fluid cognition, Paper 3 extends analyses to a 20-year time interval.

Second, drawing on the latest research connecting views on aging with important biomarkers of AD and dementia-related outcomes, the role of ATOA as a risk factor for *pathological* cognitive aging, i.e., AD and MCI, is further examined in Paper 2. As an important extension to the few existing empirical studies relying on rather simple cognitive screening tests (but not on multimethodological clinical assessments), expert-based diagnoses of cognitive impairment are employed.

Third**,** cognitive outcomes are complemented by a *subjective* approach to measure decline in function in Paper 3. Although it has extensively been studied in the context of normal and pathological cognitive aging (Jessen et al., 2014), to the best of knowledge so far no work has addressed longitudinal associations between subjective cognitive complaints and trajectories of ATOA.

Table 1.2

Summary of the Research Questions Addressed in the Dissertation

Research Questions	**Paper**
a) ATOA as a predictor of cognitive aging in old age	
• Is negative ATOA a long-term risk factor for accelerated cognitive decline?	**1, 3**
• Are predictive effect of ATOA stronger for age-vulnerable fluid abilities compared to more stable crystallized abilities?	**1**
• Are effects long lasting, extending over decades?	**3**
• Is negative ATOA also a risk factor for cognitive pathology, i.e., MCI/AD?	**2**
• Are such predictive effects robust after controlling for other relevant risk factors of cognitive decline like education, genetic and health variables?	**1-3**
b) Directionality of the association between ATOA and cognitive abilities	
• Do (changes in) cognitive abilities shape ATOA over time?	**1-3**
• Are longitudinal associations between ATOA and cognitive factors uni- or bidirectional?	**1, 3**
• Are subjective cognitive complaints longitudinally related to change in ATOA?	**3**
• Is there a closer link between subjective rather than objective cognitive abilities and change in ATOA?	**3**
c) Mechanisms linking ATOA to cognitive development	
• Does leisure activity engagement (behavioral pathway) and control beliefs (psychological pathway) mediate the relationship between negative ATOA and a greater risk of developing MCI/AD?	**2**
d) Individual factors as moderators of the link between ATAO and cognitive abilities	
• Do effects of ATOA on cognitive decline differ between men and women?	**1**
• How does ATOA change in midlife vs. old age and do individuals differ in their change trajectories?	**3**
• Does ATOA gain developmental relevance with increasing age, being a stronger predictor of cognitive decline in old age rather than midlife?	**1, 3**
• Do objective and subjective changes in cognitive functioning shape trajectories of ATOA in middle-aged and older adults?	**3**

The second research gap relates to the direction of effects, since cognitive aging might also play a major role in shaping views on aging and act as a trigger. As negative age stereotypes operate, change in cognitive abilities may drive the occurrence of negative individual age views. To date, however, the little empirical work on reciprocal relationships has yielded mixed findings. Studying the directionality of the association between cognition and subjective aging seems closely tied to issues of plasticity and between-person variability in change of ATOA across mid- and later life. Although discussed in all studies, bidirectional effects play a major role in Paper 3 comprising a very long period of 20 years and contrasting effects in midlife and old age. Moreover, next to objective cognitive abilities, Paper 3 also considers subjective cognitive complaints as a shaping factor of change in ATOA over time.

As shown above, knowledge of operating pathways in the context of views on aging is still scarce, particularly when linked to cognitive outcomes. Thus, given the third identified research gap and to shed more light on underlying pathways, two indicators relating to Levy's three-fold pathway model of stereotype embodiment are examined in their mediating relevance linking ATOA to future diagnoses of MCI and AD in Paper 2: leisure activity engagement (behavioral pathways) and control beliefs (psychological pathways).

Given the fourth research gap, it seems necessary to further explore the moderating roles of gender and age group. In the context of attitude formation, midlife may be seen as a critical life phase in which ATOA gains importance; that is, ATOA shows large variability in midlife but less in late adulthood. In addition, experiencing cognitive decline varies in normativity in middle (off-time) and older age (on-time) and also might differ in personal valence for men and women. Hence, Paper 1 explicitly targets gender differences in the link between ATOA and normal cognitive decline, while Paper 3 examines long-term dynamics of subjective and objective cognitive decline and ATOA in two different age groups, a midlife and an old age sample.

Introducing the Interdisciplinary Longitudinal Study of Adult Development

The present dissertation uses data from the population-based Interdisciplinary Longitudinal Study of Adult Development (ILSE; Sattler et al., 2017). This longitudinal German cohort study aims at investigating risk and protective factors for satisfied and healthy aging. Since starting in 1993, two birth cohorts (born 1930-32 and 1950-52) consisting of 500 participants each have been followed and examined in Heidelberg and Leipzig. Measurements took place in 1993/1994 (T1), 1997/1998 (T2), 2005/2006 (T3), and 2014/2016 (T4). Thus, four waves of completed data collection provide unique insights into a long observational period over 20 years with rich interdisciplinary data that includes psychological aspects such as cognitive abilities, subjective aging (e.g., ATOA scale), and lifestyle habits, as well as a thorough medical assessment. The ILSE study is therefore very well suited for helping to resolve current research issues and investigating long-term change dynamics between ATOA and cognitive development in the second half of life. For example, the comprehensive medical and neuropsychological examination of participants and availability of expert-based diagnoses of cognitive status enables the identification of participants with a non-normative, disease-related process of cognitive aging. In addition, the availability of three and four waves of data collection allow for application of state-of-the-art statistical modeling to study not only between-person differences but also differences in within-person rates of change or interrelations among within-person changes.

Papers 1 and 2 draw on data from the first three measurement waves and the older cohort only, while Paper 3 covers both cohorts across the total time span of 20 years, thus following one age group from their 40s to their 60s, and the other from their 60s to their 80s.

Paper 1 focused on longitudinal domain- and gender-specific effects of ATOA on cognitive functioning in old age. Using latent change score modeling techniques, it was investigated whether the impact of ATOA on rate of cognitive change across 12 years differs for a) age-vulnerable fluid compared to crystallized abilities and b) men and women.

In a cognitively healthy subsample, Paper 2 then addressed whether more negative baseline ATOA was related to an increased risk of expert-diagnosed MCI/AD over 12 years by means of logistic regression. To test the robustness of the association sociodemographic, health, and genetic covariates were added to the model. Moreover, leisure activities and control beliefs were examined as possible mediators linking ATOA to MCI/AD.

Making use of both birth cohorts and 20 years of observation, Paper 3 targeted issues of bidirectionality between subjective aging and cognitive abilities. A multigroup multiple latent growth curve model delineated change associations of ATOA, objective cognitive performance, and subjective cognitive complaints contrasting mid- and later life.

The three individual studies are presented in Chapter 2-4; Chapter 5 then pulls together separate study findings to an integrated discussion.

Chapter 2 – 1st Publication

The Role of Attitude Toward Own Aging for Fluid and Crystallized Functioning: 12-Year Evidence From the ILSE Study

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Abstract

Objectives. Aging attitudes have been shown to affect a variety of important developmental outcomes in old age, including memory. Extending previous research, the present study examined long-term effects of attitudes toward own aging (ATOA), relying on a broader range of cognitive abilities in later life.

Method. Data came from the Interdisciplinary Longitudinal Study of Adult Development (ILSE), with three measurement waves (1993/94, 1997/98, 2005/06) covering a 12-year interval. Drawing on the older of two available birth cohorts (1930-32; n = 500), we analyzed the relationship between ATOA and change in fluid versus crystallized abilities based on overall and gender-specific latent change score models, while controlling for education and objective health.

Results. As expected, ATOA predicted change in fluid functioning—but not in crystallized performance—over 12 years. Gender-specific analyses revealed a stronger association between ATOA and decline in fluid abilities for men, even after controlling for health and education.

Discussion. This study adds to the understanding of long-term implications of aging attitudes for cognitive decline trajectories and shows that negative aging attitudes are a risk factor for age-vulnerable cognitive abilities, particularly among men. Further research is needed to better understand the underlying mechanisms of observed relationships.

Keywords: aging, attitude toward own aging, cognition, fluid and crystallized abilities, Interdisciplinary Longitudinal Study of Adult Development (ILSE)

Introduction

Although positive cohort effects have been observed (Hülür, Ram, & Gerstorf, 2015), many older adults continue to perceive their aging process—especially in the cognitive domain—as uncontrollable and unavoidable, thereby ascribing chronological age considerable causal power able to "produce" disease, impairment, and loss (Lineweaver & Hertzog, 1998). A major reason for such age expectations is common negative age stereotypes, according to which old age is a period of pronounced senility, forgetfulness, and mental confusion (e.g., Kite et al., 2005).

Though aging undoubtedly is associated with normative changes in many realms of cognitive functioning (Glisky, 2007; Schaie, 1996), the cognitive enrichment literature suggests a large degree of plasticity beyond the effect of calendar age (Hertzog et al., 2008). Hence, a core idea of current life-span developmental psychology, that is, to conceptualize individuals as producers of their own development (Baltes et al., 2006), increasingly also enters the area of cognitive trajectories associated with later life. In this context, the impact of negative attitudes toward aging may play a crucial role, as one may assume that the more people think aging implicates an inevitable cognitive decline, the less they believe in personal control and possibilities to influence their cognitive aging actively.

Attitude Toward Own Aging and Cognitive Functioning: Empirical and Conceptual Issues

Subjective aging and the importance of the concept of attitude toward own aging. To describe and explore the ways in which individuals experience their aging process, researchers have used a number of different conceptualizations that can be subsumed under the term subjective aging (for a review, see Diehl et al., 2014). Among the most prominent measures of subjective aging is the construct of attitude toward own aging (ATOA; Lawton, 1975). ATOA reflects a mixture of societally and culturally shared beliefs about the aging process including age stereotypes, as well as individual experiences and expectations related with one's own aging (Diehl et

al., 2014; Hess, 2006; Levy, 2009). Based on Levy's stereotype embodiment theory (2009), a fundamental assumption is that ATOA starts to develop in childhood, becomes increasingly self-relevant as people age, and due to this process ATOA tends to increasingly influence behavior. Being an attitude and age stereotype related construct, it is assumed that ATOA predominantly operates on an implicit level of processing. Consequently, it may play a powerful role in affecting functioning, because its preconscious character may prevent conscious self-regulation and counteracting (Bargh & Chartrand, 1999; Levy, 2009).

Extensively applied in subjective aging research, ATOA has been linked with a number of important developmental outcomes in old age, such as subjective (Moor et al., 2006) and objective health (Westerhof et al., 2014), healthy lifestyle and preventive behaviors (Levy & Myers, 2004), and even mortality (e.g., Levy, Slade, Kunkel, et al., 2002; Sargent-Cox et al., 2014). These longitudinal studies give reason to assume that ATOA is involved in shaping health variables in later life. Although experiencing declining health may also function as an important precursor of one's ATOA, studies addressing the direction of causality suggest that the impact of ATOA on health is stronger than the reverse; that is, ATOA seems to be less a result of health changes but rather drives changes in health (Sargent-Cox, Anstey, & Luszcz, 2012).

Subjective aging and cognitive function. Interestingly, when it comes to cognitive functioning, researchers have typically used experimental study designs (with concepts other than ATOA) to address the role of subjective aging. For example, the experimental induction of negative age stereotypes via both implicit and explicit priming substantially impaired memory performance with small-to-medium effect sizes (Horton, Baker, Pearce, & Deakin, 2008; Lamont et al., 2015). Recent longitudinal data suggest that these findings are not limited to experimental research designs. Levy and colleagues (2012) assessed old-age stereotypes of 395 individuals aged 22 to 77 years at baseline and found that these predicted memory performance 38 years later. Using participants' felt age as a marker for views of aging, Stephan et al. (2016) recently replicated the findings

of Levy et al. in that younger subjective age predicted less decline in immediate and delayed memory function over 4 years in adults aged 50 years and above. Moreover, controlling for demographic, metabolic, and vascular factors, they found depressive symptoms—but not physical activity—to mediate the link between subjective age and declining memory significantly.

Extending cognitive outcomes to episodic memory as well as to executive abilities, Stephan and colleagues (2014) showed that a younger subjective age was linked to better cognitive performance 10 years later. To our knowledge, this is the only study examining subjective aging in relation to cognitive abilities beyond memory function over time. Unfortunately, due to missing cognitive baseline assessments, it was not possible to analyze any changes in cognitive trajectories over time. Additional support for the assumption that the effect of subjective aging may not be limited to memory tasks comes from the meta-analytic work by Lamont et al. (2015) that considered experimental studies with cognitive measures like crosswords, a computer-based driving test, math calculations, and subtests drawn from the Wechsler adult intelligence scale (e.g., verbal ability, working memory, and processing speed) as dependent variables; people consistently performed worse when confronted with negative age stereotypes and effect sizes were even larger for non-memory (mean d = .68) as compared to memory tasks (mean d = .21).

Summing up, there is emerging experimental and longitudinal evidence that subjective aging-related concepts (old age stereotypes, felt age) are not only associated with memory but also with performance on other cognitive tasks. However, it remains an open question, whether these cognitive performance outcomes are also linked to the concept of ATOA. Thus, more research is needed to address *if* and *how* ATOA is longitudinally related to change in cognitive aging, with particular emphasis on cognitive abilities besides memory, such as fluid and crystallized skills.

In contrast to the rather rich empirical literature on developmental linkages of subjective aging, theoretical framework on mechanisms connecting subjective aging with *long-term* outcomes in old age is relatively sparse. According to stereotype embodiment theory (Levy, 2009), subjective

aging exerts its influence along three complementary but interacting pathways: *psychological* (age stereotypes generate aging-related expectations which then become self-fulfilling), *behavioral* (individuals with positive ATOA have a healthier and more active lifestyle), and *physiological* (risk for a heightened cardiovascular stress reactivity in individuals with negative ATOA). Transferring these assumed mechanisms to the context of cognitive trajectories in later life, ATOA may therefore affect how people anticipate, experience, interpret, and evaluate cognitive functioning by moderating goal setting and pursuit and influencing strategy use, motivation, and the belief in one's ability to succeed. Positive ATOA may also have important indirect effects because of its impact on lifestyle and behaviors that are associated with cognitive enrichment in later life—namely, exercise and mentally stimulating activities (Hertzog et al., 2008). Moreover, the harmful impact of stress and physiological arousal on cognitive performance—particularly on working memory and processing speed—has been repeatedly shown in cognitive research (Lupien et al., 2007; McEwen & Sapolsky, 1995).

Concluding, ATOA may affect cognitive, motivational, social, and behavioral resources in more or less beneficial ways (e.g., by selecting or avoiding tasks, settings, and daily routines that comprise cognitive challenges). Hence, positive ATOA may act as a distal resource (Bowen, 2010) stimulating other more proximal resources that, in turn, are associated with cognitive enrichment in old age. In this vein, as plasticity of cognitive development varies across domains (Hertzog et al., 2008), the effect of ATOA might not be equal for all cognitive skills. Given the higher age vulnerability of fluid cognitive functions as compared to crystallized cognitive functions, as well as their prominence in terms of negative stereotypes of old age (i.e., being slow and unable to learn), it seems plausible to assume that ATOA is particularly important for the former; to maintain functioning or to buffer downslide processes age-sensitive cognitive domains requires the intensive investment into various resources.

ATOA, cognitive function, and the role of gender. In addition, the consideration of the role of gender seems important. Previous research in the area has mostly treated gender as a covariate. However, we argue that gender deserves a more advanced theoretical status; that is, we assume gender to be a crucial moderating variable for the examination of effects of ATOA on cognitive trajectories. For example, according to the widely cited cultural metaphor of so-called "double standard of aging" (Sontag, 1972), although backed only by mixed empirical evidence (e.g., Kornadt, Voss, & Rothermund, 2013), attitudes towards older women are even more negative than attitudes towards older men, suggesting that aging has more adverse consequences for women. Hence, female aging may be more "stressed" by negatively oriented ATOA. Moreover, the salience of and chronic exposure to pervasive negative age stereotypes may differentially affect women with more positive versus more negative ATOA. That is, individual differences in ATOA may unfold more impact on cognitive aging among women. On the other hand, male-related ideals value achievement and cognitive strength (Eagly, Wood, & Diekman, 2000; Sontag, 1972). Due to this enhanced importance and involvement, men in particular may prioritize competence-related goals; thus, men may be more willing to invest in cognitive domains whereby ATOA may function as an impetus directing resource allocation. This may suggest a stronger link between ATOA and cognitive performance for older men. Hence, a clear theoretically driven prediction concerning the role of ATOA and gender seems difficult and, thus, an empirical question.

Study Aims and Expectations

This study aimed to extend prior research by (a) providing a longitudinal examination of the effect of ATOA on change in fluid and crystallized abilities over 12 years and (b) considering the role of gender as a moderating variable. We expect that individuals with initially more negative ATOA will show greater decline in fluid abilities over 12 years compared to those holding more positive ATOA. Given participants of rather young-old age at the beginning of the study, effects

are expected to become more pronounced over time. In contrast, a weak link between ATOA and crystallized abilities is predicted. We also assume that possible linkages between ATOA and fluid abilities may be different according to gender; however, we refrain from any directed expectation and regard this issue as an empirical one. Moreover, using state-of-the-art statistical analyses (e.g., latent change score modeling; McArdle, 2009) that have rarely been used in the subjective aging literature enables a rigorous examination of interindividual differences in intraindividual change patterns.

Method

Participants and Procedure

Data came from the Interdisciplinary Longitudinal Study of Adult Development (ILSE), an ongoing longitudinal cohort study with three completed measurement occasions in Germany. ILSE, a population-based study stratified by birth cohort, gender, and region, contained 502 middle-aged participants born 1950–1952 and 500 young-old people born 1930–1932. Starting in 1993/94 (T1), follow-up assessments were conducted 4 (1997/98; T2) and 12 years later (2005/06; T3). Being interested in how ATOA affects cognitive development in old age, we used the older of the two ILSE cohorts, who were followed from their early 60s to their mid-70s (T1: M_{age} = 62.5, SD = 1.0; T2: M_{age} = 66.6, SD = 1.1; T3: M_{age} = 74.3, SD = 1.2). 10.2 % of the participants did not participate at T2, and another 21.6 % at T3, reducing the sample sizes to n_{T2} = 449 and n_{T3} = 352. Compared with dropouts, those remaining in the study had better objective health, were better educated, and performed better on all cognitive tasks at baseline (d's = .20 - .53), but did not differ with respect to ATOA or gender composition.

Measures

Attitude toward own aging. We used the ATOA scale, a subscale of the Philadelphia Geriatric Center Morale Scale (Lawton, 1975), which had found wide application in the subjective

aging literature (e.g., Diehl & Wahl, 2015; Miche et al., 2014) and showed acceptable internal consistency in the current sample (Cronbach's α = .68). Five statements measuring the personal evaluation of one's subjective aging process (e.g., "I have as much pep as last year") could either be disagreed or agreed with (0 or 1) whereby higher ATOA scores indicated a more positive attitude toward own aging.

Assessment of fluid abilities. At all measurement occasions, participants performed a cognitive test battery, which included commonly used paper-pencil subtests (e.g., WAIS-R; Tewes, 1991). Fluid intelligence was assessed using three different measures covering aspects of perceptual speed, reasoning, spatial ability, and working memory. The *digit symbol test* (Oswald & Fleischmann, 1995), one of the most used instruments in cognitive aging studies (Hoyer, Stawski, Wasylyshyn, & Verhaeghen, 2004), consisted of nine digit-symbol pairs (e.g., 1/V, 2/X, …, 9/+) and a list of digits. Participants were requested to match symbols with digits (following the given coding table) as quickly as possible. The number of correctly matched symbols within 90 seconds was measured (0–67 points). *Block design* (WAIS-R; Tewes, 1991) required participants to rearrange four or nine colored blocks according to abstract patterns. Both accuracy and time taken to complete nine items were incorporated into the scoring of the test. The total score ranged from 0 to 51, with higher values indicating better performance. In the *digit span backwards* test (Oswald & Fleischmann, 1995), participants were verbally presented with a series of digits (e.g., "7, 8, 6") and were required to repeat the digits in reverse order. The number of digits increased by 1 until the participant consecutively failed two trials of the same length (possible range of 0–8 points).

Assessment of crystallized intelligence. Crystallized intelligence was measured using three indicators from the German WAIS-R (Tewes, 1991). For the *information* task, participants were asked to answer 24 questions on general knowledge topics (e.g., "What is the capital of Turkey?"). Every correct response was scored with 1 point, resulting in a sum score from 0 to 24. In *similarities*, participants were presented with two words and asked how they were alike (e.g., egg – seed).

Answers to the 16 pairs were rated with 0, 1, or 2 points, depending on the quality of the response, and added to a total score ranging from 0 to 32, where higher values indicated a better performance. In the *picture completion* task, participants were shown pictures with an important part missing they had to identify (e.g., frog with only three legs). Correct answers were scored with 1 point and added to a total score between 0 and 17.

Confounding variables. We will also control in our analysis for the role of two variables that have consistently been found to influence cognitive functioning, that is, education and health (Hertzog et al., 2008; Wilson et al., 2009). Education (number of years at school and university) and objective health at baseline were included as predictors of cognitive performance. Objective physical health was assessed via a medical in-depth examination consisting of an anamnesis (e.g., medical history of the participant), a medical check-up (e.g., sensory function, blood pressure), blood test results, and a geriatric assessment. Geriatricians aggregated the information into an overall physical health score ranging from 1 (*very good*) to 6 (*very bad*). The six scores contained clear descriptions (e.g., score 5 for a poor health status, if suffering from a very serious medical condition, which is not immediately life-threatening or if independent living was no longer possible) to allow objective assignment, to ensure clinical significance of the assigned health score, and to guarantee reliability. Furthermore, gender (male = 1, female = 2) was used as a grouping variable to compute differential analyses for women and men.

Data Analysis

All descriptive and preliminary analyses were carried out with SPSS 22.0. By means of latent change score modeling (LCS; e.g., McArdle, 2009; Steyer, Eid, & Schwenkmezger, 1997) and using Mplus 6.12 (Muthén & Muthén, 1998-2011), we examined whether ATOA predicted intra-individual change in cognition. First, a confirmatory factor analysis was conducted that supported our two-factor model for fluid and crystallized abilities at baseline. Second, we added follow-up models for T2 and T3 and examined longitudinal measurement invariance to ensure that the latent

factors were equally measured across the three measurement occasions. Fit indices for the two longitudinal measurement models with time-invariant factor loadings and intercepts (i.e. strong invariance; see Meredith & Horn, 2001) were $\chi^2 = 93.3$, $df = 23$, RMSEA = .078, CFI = .969, SRMR = .035 for fluid abilities, and $\chi^2 = 83.9$, $df = 23$, RMSEA = .073, CFI = .977, SRMR = .073 for crystallized abilities. Third, change in participants' fluid and crystallized abilities over 12 years was assessed. Fourth, as depicted in Figure 2.1, latent baseline change score models for fluid and crystallized abilities were specified capturing latent cognitive change across 4 (T1–T2) and 12 years (T1–T3), respectively. Baseline ATOA, measured by five dichotomous indicators, was included into the model as a predictor of the two cognitive change score variables. In a following step—to examine differential effects of ATOA for cognitive decline trajectories in women and men—we ran a multigroup model based on gender with confirmed strong measurement invariance across groups (i.e., invariant loadings and thresholds). Then, education and health were entered into the overall and into the gender-specific model as covariates and predictors of cognitive aging. Additionally, dual LCS models with fluid abilities and ATOA over time were calculated to analyze interrelations of change and potential bidirectional effects between ATOA and fluid cognition. Using the same data, Miche et al. (2014) found no substantial between-person variation in decline of ATOA over time; we still considered ATOA as a dynamic predictor (T1–T3) to be able to capture potential within-person and bidirectional effects. Owing to scaling properties of ATOA, a diagonally weighted least square estimator with mean and variance adjustment (WLSMV) was used when ATOA was part of the modelling process and maximum likelihood estimation when it was not. Cutoff values higher than .95 for the Comparative Fit Index (CFI); less than .08 for both the Root Mean Squared Error of Approximation (RMSEA) and the Standardized Root Mean Square Residual (SRMR); and a value below 1 for the Weighted Root Mean Square Residual Index (WRMR) were used to indicate acceptable goodness-of-fit (e.g., Schermelleh-Engel, Moosbrugger, & Müller, 2003; Yu, 2002).

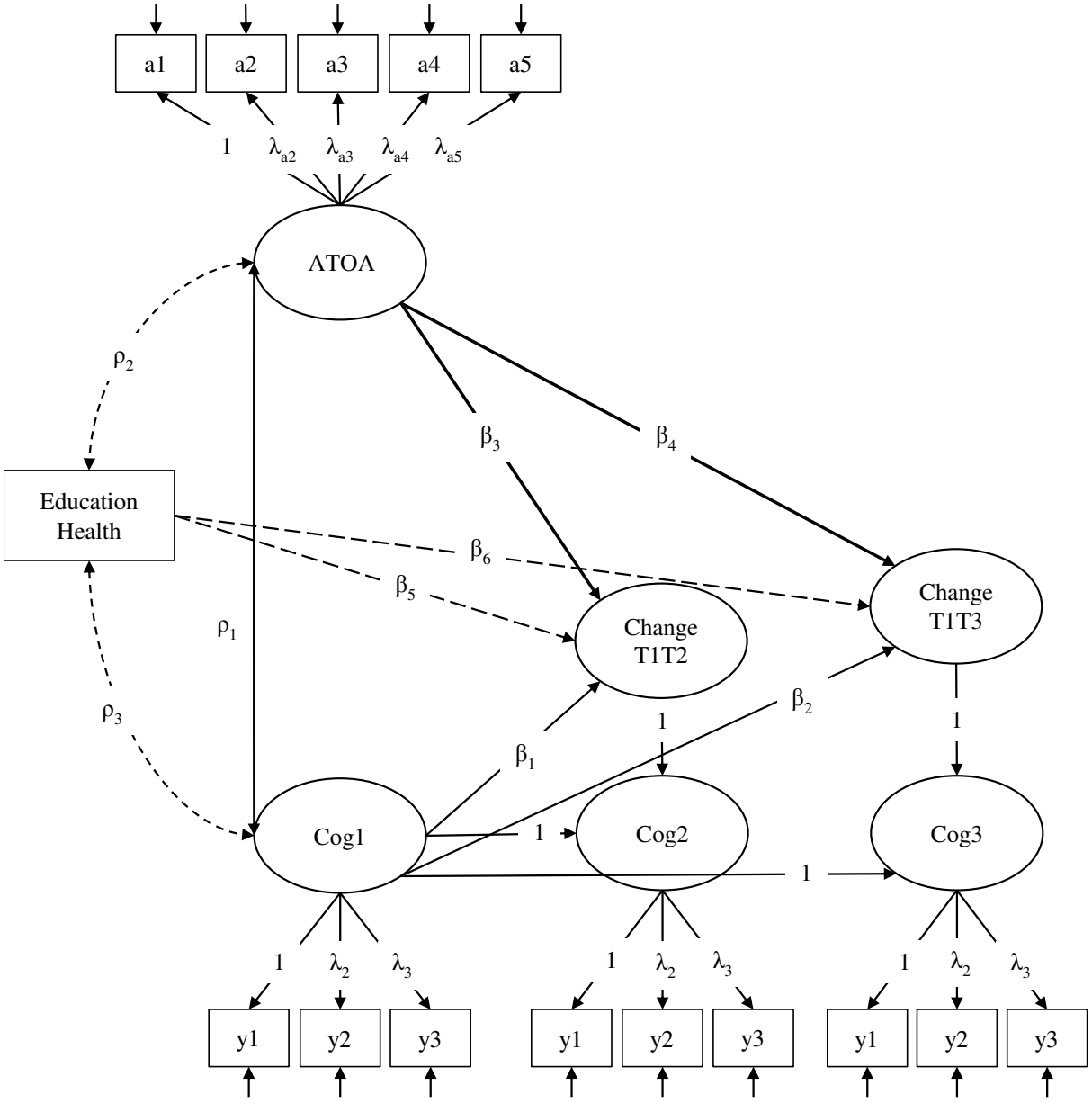

Figure 2.1. Baseline latent change score model of cognitive functioning with correlated error terms, time-invariant factor loadings and intercepts. Two latent variables capture change across 4 (T1-T2) and 12 (T1-T3) years, respectively. Bold arrows represent predictive effects of ATOA on change in cognitive abilities over time. Education and health are added as control variables (dashed arrows).

Results

Descriptive Statistics and Change Analyses

Sample characteristics, cognitive performance at baseline (T1) and 12 years later (T3), and bivariate correlations are presented in Table 2.1. A more positive ATOA at baseline was unrelated to gender or education, but was related to better objective health and better cognitive performance on all fluid and all but one crystallized tests for all measurement occasions. Moreover, superior performance on most cognitive tasks was related to better health and higher education. Being women correlated with higher digit symbol scores and lower scores in block design, information, and picture completion. Although there were similar patterns of association between ATOA and cognition for men and women at baseline, correlations between ATOA and fluid as well as crystallized abilities at T2 and T3 were significant for men only (r_{fluid} = .18-.37; $r_{crystallized}$ = .22-.29). For women, initial ATOA was unrelated to cognitive performance in any test at follow-up (r_{fluid} = .04-.1; $r_{crystallized}$ = –.01 to .1). Compared to women, men had significantly higher education (t = 6.17, p < .001), but no differences emerged with respect to ATOA (t = –.98, p = .33) or health (t = .16, p = .87).

Analyses of cognitive change were based on strong measurement invariance models for fluid and crystallized abilities. Constraining factor means to be equal at all measurement occasions significantly worsened model fit for fluid (χ^2_{diff} = 190.5, df = 2, p < .001), but not for crystallized abilities (χ^2_{diff} = 3.6, df = 2, p = .16), indicating mean level change across 12 years for fluid abilities only. Fixing across-time correlations of factor scores at 1 resulted in significantly poorer model fit for fluid (χ^2_{diff} = 309.7, df = 3, p < .001), and crystallized abilities (χ^2_{diff} = 192.2, df = 3, p < .001). Estimated factor stabilities between T1 and T3 were .90 for fluid and .89 for crystallized abilities, implying some differential cognitive development among participants in both realms.

Table 2.1

Descriptive Statistics and Bivariate Correlations of Study Variables

Variable	*M*	*SD*	Range	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1. ATOA $_{t1}$[a]	1.71	0.3	1-2															
2. Sex (2 = female)	48%	-	1-2	.05														
3. Education	12.89	2.76	8-18	.05	–.27**													
4. Health $_{t1}$	2.47	0.88	1-5	–.30**	–.01	–.06												
Fluid abilities																		
5. Digit symbol$_{t1}$	43.05	11.19	7-67	.13**	.14**	.33**	–.17**											
6. Digit symbol$_{t3}$	39.92	10.91	11-67	.17**	.16**	.26**	–.17**	.80**										
7. Block design$_{t1}$	26.90	8.17	6-47	.18**	–.16**	.41**	–.14**	.49**	.41**									
8. Block design$_{t3}$	24.15	8.10	1-43	.24**	–.15**	.31**	–.17**	.42**	.49**	.68**								
9. Digit span$_{t1}$	4.56	1.17	2-8	.09*	–.05	.32**	–.13**	.39**	.33**	.39**	.30**							
10. Digit span$_{t3}$	4.39	1.23	2-8	.11*	–.01	.30**	–.09	.32**	.34**	.31**	.31**	.38**						
Crystallized abilities																		
11. Information$_{t1}$	15.69	4.70	1-24	.11	–.35**	.52**	–.07	.38**	.31**	.47**	.39**	.29**	.32**					
12. Information$_{t3}$	16.26	4.47	2-24	.09*	–.39**	.55**	–.06	.39**	.44**	.41**	.42**	.27**	.33**	.84**				
13. Similarities$_{t1}$	24.94	5.50	3-32	.12**	–.08	.46**	–.12**	.47**	.40**	.45**	.37**	.32**	.32**	.48**	.58**			
14. Similarities$_{t3}$	24.49	6.02	0-32	.12*	–.05	.43**	–.12*	.44**	.49**	.39**	.42**	.26**	.32**	.60**	.52**	.60**		
15. PicComplet$_{t1}$	11.73	3.86	0-17	.16**	–.26**	.39**	–.12**	.35**	.37**	.39**	.48**	.21**	.30**	.46**	.58**	.47**	.41**	
16. PicComplet$_{t3}$	11.78	4.07	0-17	.18**	–.27**	.31**	–.15**	.39**	.27**	.48**	.39**	.20**	.22**	.52**	.46**	.38**	.52**	.57**

Notes. PicComplet = picture completion. n_{t1} = 489, n_{t3} = 313. [a] Higher values indicate a more positive view toward own aging. $^{*}p < .05$, $^{**}p < .01$.

Baseline Change Score Model for Fluid and Crystallized Abilities

As can be seen in Table 2.2, the model fit was good for the fluid LCS models ($M_f1 - M_f4$) and acceptable for the crystallized LCS model (M_c1). It turned out as expected that analyses concerning latent change over 4 years (change score between T1 and T2) yielded no significant results; therefore, the following reports will be on the 12 year-interval only.

Fluid latent change variables had significant negative means, which indicated substantial decline in fluid abilities over the three measurement points. As hypothesized, changes in fluid abilities were significantly predicted by ATOA ($\beta_{ATOA} = .29$, $p < .05$), in that more positive ATOA at baseline predicted less decline over 12 years. The M_f1-LCS model explained 20% of variance in fluid cognitive change. In contrast to fluid abilities—as anticipated—intraindividual change in crystallized function was not significantly predicted by baseline ATOA ($\beta_{ATOA} = .10$, $p = .47$). The fitted model M_c1 accounted for only 5% of variance in cognitive change across 12 years.

Next, we fitted the fluid model as a multigroup model based on gender (M_f2) to examine possible differential effects for women and men. ATOA was a significant predictor of change in fluid functioning for men ($\beta_{ATOA} = .63$, $p < .001$), with the proportion of variance explained in cognitive decline being 52%. For women, however, ATOA did not significantly contribute to latent change in fluid abilities (Table 2.2). The model for women yielded large standard errors for intercept and variance of the latent cognitive change variable, indicating problems to estimate these parameters precisely (see below for further comments on this issue). Additionally, constraining regression weights of ATOA on fluid change to be equal for women and men significantly worsened model fit ($\chi^2_{diff} = 17.4$, $df = 2$, $p < .001$).

The inclusion of education and objective health into the overall model (M_f3) as covariates of baseline fluid functioning and predictors of subsequent change weakened the predictive power of ATOA to the margin of significance ($\beta_{ATOA} = .28$, $p = .08$). Though they were correlated with per-

formance level at baseline (r_{educ} = .54; r_{health} = –.22), neither education nor objective health significantly predicted decline in fluid abilities (β_{educ} = –.04, n.s.; β_{health} = –.02, n.s.). Moreover, adding education and health to the model did not improve R^2 of fluid change over 12 years.

Table 2.2

Baseline Latent Change Score Models for Fluid and Crystallized Abilities

Model	χ^2	*df*	RMSEA	CFI	WRMR	ATOA β (*SE*)	Education β (*SE*)	Health β (*SE*)	R^2
Fluid abilities									
M_f1[a]	111.46	70	.034	.970	.839	**.29*** (.14)	–	–	**.20**$^{+}$ (.12)
M_f2[a]	240.60	149	.05	.934	1.306				
male						**.63***** (.19)	–	–	**.52*** (.21)
female						–.57 (.70)	–	–	.40 (.77)
M_f3[a]	140.30	90	.033	.969	.825	**.28**$^{+}$ (.16)	–.04	–.02	**.20**$^{+}$ (.11)
M_f4[a]	264.66	189	.04	.953	1.166				
male						**.71***** (.22)	**–.20**$^{+}$ (.12)	.10 (.20)	**.57*** (.28)
female						–.70 (.66)	–.49 (.56)	–.47 (.45)	.69 (1.03)
Crystallized abilities									
M_c1[a]	143.8	70	.046	.951	.989	.10 (.13)	–	–	.05 (.05)

Notes. [a] Strong measurement invariance model with time-invariant factor loadings and intercepts.
$^{+}p < .10$, $^{*}p < .05$, $^{***}p < .001$.

The inclusion of education and objective health into the overall model (M_f3) as covariates of baseline fluid functioning and predictors of subsequent change weakened the predictive power of ATOA to the margin of significance (β_{ATOA} = .28, p = .08). Though they were correlated with per-

formance level at baseline (r_{educ} = .54; r_{health} = –.22), neither education nor objective health significantly predicted decline in fluid abilities (β_{educ} = –.04, n.s.; β_{health} = –.02, n.s.). Moreover, adding education and health to the model did not improve R^2 of fluid change over 12 years.

The multigroup analysis based on gender revealed that ATOA was a significant predictor of change in fluid functioning for men (β_{ATOA} = .71, p < .001; M_f4), even after controlling for education and objective health. The proportion of variance explained in cognitive decline over 12 years was 57%. Again, imposing equality constraints across gender on the paths linking ATOA with fluid change led to significantly poorer model fit (χ^2_{diff} = 14.2, df = 2, p < .001). For women, large standard errors recurred for the estimated parameters of ATOA, as well as for education and health. Therefore, despite similar (albeit opposed) β weights for men (β_{ATOA} = .71) and women (β_{ATOA} = –.70), the effect of ATOA on cognitive change reached no significance for women**.** This result might be due to little heterogeneity in fluid cognitive decline among women compared to men, as between-person variance in latent fluid change was not significant for women. Moreover, longitudinal factor stabilities revealed gender differences in differential change across 12 years, in that men showed significantly more interindividual variation in their cognitive aging trajectories (.86 vs. .94, p < .001).

Additionally, extending the model to a dual LCS model for fluid abilities with ATOA as a time-varying predictor revealed a significant decline in ATOA over 12 years, however, with no significant residual variance, that is, no substantial differential change between persons. Thus, although baseline ATOA was a significant predictor of change in fluid abilities, change in ATOA over 4 or 12 years was not. For the reverse direction, neither initial fluid abilities nor fluid change significantly predicted change in ATOA over time. Further, there was no statistical meaningful correlation between latent changes in ATOA and fluid intelligence.

Discussion

Our aim was to extend previous research by examining longitudinal domain- and gender-specific effects of ATOA on cognitive functioning in old age using 12-year ILSE data. Consistent with hypotheses, positive ATOA was associated with less decline in fluid functioning over 12 years, but not with change in crystallized abilities. Accounting for health and education reduced the predictive power of ATOA for declining fluid abilities slightly below the conventional level of significance in the overall sample (but not if only male participants were considered), though education and health were solely related to performance level at baseline and not to rate of cognitive decline. This latter finding is also in line with prior research using longitudinal data and similar methodological approaches (Finkel, Reynolds, McArdle, Gatz, & Pedersen, 2003; Gerstorf, Herlitz, & Smith, 2006; Wilson et al., 2009). Compared with the nonsignificant effects of education and objective health on change in fluid functioning over time, ATOA seemed to be the most important predictor when simultaneously controlling for between-person differences in level of those variables.

Moreover, we examined the role of gender in an exploratory analysis. Interestingly, our results raise doubt that a double standard of aging generally disfavors women (Sontag, 1972); instead, in the cognitive area, we found a stronger link between ATOA and cognitive functioning in men. Even after controlling for health and education[2], ATOA continued to be a rather strong predictor for rate of decline in fluid abilities in men. In contrast, significantly less between-person variance in differential change among women led to poorer model estimations with large standard errors

[2] Please note that we controlled for the possibility that our results merely reflect differences in baseline fluid abilities or education rather than actual gender differences by running additional multigroup models, which yielded neither differences for lower versus higher fluid abilities, nor for lower versus higher education in our sample. We have also examined a possible moderating role of education in the context of gender, but found no empirical support for this.

and, consequently, nonsignificant results. This finding differs from earlier cognitive aging studies using similar modeling approaches that indicated no gender-specific differences in terms of onset, rate, and variance of cognitive decline (Aartsen, Martin, & Zimprich, 2004; Gerstorf et al., 2006). It could be that the pattern of differential decline trajectories found in this study also emerged due to sample characteristics, and similar effects for women would occur when considering longer time intervals, older ages, and wider age ranges. Nevertheless, taking the assumed operating mechanisms linking ATOA with cognitive outcomes into account, ATOA might indeed be more influential for older men's cognitive performance. For example, men in general show less health-related behavior and less consistency of lifestyle (Courtenay, 2000). The observed time interval comprised the critical transition to retirement, where—particularly for men—occupation as a cognitive training component ended while simultaneously unclosing new opportunities that might be shaped by one's aging attitudes. Therefore, it is rather ambiguous whether gender differences can be ascribed to methodological issues or are in fact ATOA-related; this issue clearly needs further empirical investigation.

Our results substantially add to the emerging evidence (Lamont et al., 2015; Stephan et al., 2014) that the long-term effect of ATOA on cognitive functioning is not limited to memory function. However, compared with studies focusing on memory-related outcomes that found substantial linkages even after controlling for a number of other variables (Levy et al., 2012; Stephan et al., 2016), the effects of ATOA in this study were not as strong. We see a number of reasons for this outcome: First, it could be that memory function is more susceptible than fluid intelligence to the long-term effect of ATOA, with memory being one of the most vulnerable facets of cognition (e.g., Glisky, 2007). Second, differences may be explainable due to differences in age range; for example, using a wider age range Levy et al. (2012) found increasing gaps in memory performance between participants with more positive opposed to more negative ATOA as they aged. This accelerated degradation in people with initial negative ATOA was a 3-year difference at the age of

70 and augmented to 9 years at the age of 90. In contrast, we only followed adults until their mid-70s; it is likely that results would have become more pronounced when even older ages would have been incorporated. Third, applying LCS modeling allows to distinguish true change from observed change, as this technique takes into account the amount of measurement errors (Steyer et al., 1997). It is possible that part of the observed cognitive change in previous studies that used mostly traditional regression-based approaches must be attributed to measurement error rather than to true change.

In line with Miche and colleagues (2014), we found a steady decline of ATOA, but no meaningful interindividual variation. Thus, the nonsignificant within-person effects as well as the nonsignificant link from fluid abilities to potential change in ATOA should be interpreted with this in mind. Yet, this can be seen as first indication that ATOA seems to drive change in fluid abilities more strongly than the reverse. So far, to our knowledge only one other study has directly examined the impact of cognitive functioning on ATOA (Kleinspehn-Ammerlahn et al., 2008), further suggesting that ATOA functions more as a predictor than as an outcome of cognitive abilities. However, more research is needed to disentangle these cause-effect relationships and to further address the impact of change in ATOA over time on differential cognitive decline. Specifically, considering middle adulthood as a potentially vulnerable and pioneer phase of life also with regard to ATOA (Miche et al., 2014) seems very promising.

The generalizability of findings is limited to some extent by the selective dropout of participants over time. To ensure that findings did not merely originate from systematic attrition, we used state-of-the-art estimation procedures and further reran analyses with the longitudinal sample, which yielded the same pattern of results. Another limitation concerns the application of ATOA as a unidimensional scale. Research points to the use of domain-specific multidimensional scales to account for the complexity of attitudes and beliefs toward one's aging process. Although it is likely to obtain even stronger links when attitude and outcome domain correspond, it would also

allow for the ambiguity in terms of cognitive age stereotypes that comprise aspects of growth in knowledge and experience, too (Hummert et al., 1994). Along these lines, though we did not find any association between positive ATOA and enrichment in crystallized abilities, a respective link seems theoretically plausible. In particular, the assumed behavioral pathway of ATOA via cultural engagement and intellectually stimulating activities could pay off here. Typical measures of crystallized abilities such as the ones used in this study, however, assess these abilities on a rather basic level, with probably low sensitivity to detect possible late-life enhancement effects of positive ATOA.

Moreover, to contribute to a deeper understanding of how ATOA shapes cognitive aging trajectories, future studies should focus on possible underlying mechanisms. The search for psychological and behavioral pathways may inform interventions and approaches to counteract detrimental consequences of negative age attitudes and effectively slow the process of cognitive decline in young-old age.

In sum, the present study shows that ATOA has long-term implications for age-vulnerable cognitive skills and provides insight that gender might contribute to a better understanding of age attitude phenomena. Furthermore, our findings add positive aging attitudes to a growing list of resources associated with decelerated cognitive decline in old age and prove the importance of psychological variables for cognitive aging beyond chronological age.

Chapter 3 – 2nd Publication

Attitude Toward Own Aging as a Risk Factor for Cognitive Disorder in Old Age: 12-Year Evidence from the ILSE Study

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Abstract

Previous research has demonstrated the harmful impact of subjective aging processes (e.g., negative age self-stereotyping) on *normal* cognitive aging in different domains of cognitive functioning, such as memory, executive function, and fluid abilities. Recently, subjective aging has also been linked to important biomarkers of Alzheimer disease (AD) and dementia-related outcomes, indicating associations with *pathological* cognitive aging. With data from the Interdisciplinary Longitudinal Study of Adult Development (ILSE), the present study extends this research by examining the long-term effect of attitude toward own aging (ATOA) on expert-based clinical diagnosis of mild cognitive impairment (MCI) and AD in old age. 260 initially cognitive healthy participants with a mean age of 62.5 years were followed for 12 years. In the course of the study, 103 participants developed MCI and 14 received diagnosis of AD. Logistic regression models showed that baseline ATOA predicted future clinical diagnoses of MCI and AD 12 years later, while controlling for sociodemographic, genetic, and health variables. Although theoretically suggested, evidence for a mediating role of leisure-activity level and control beliefs was scarce. Our findings add to the emerging literature supporting negative views of aging to be a risk factor for cognitive disorder in old age.

Keywords: attitude toward own aging, subjective aging, mild cognitive impairment, Alzheimer disease, Interdisciplinary Longitudinal Study of Adult Development (ILSE)

Introduction

Alzheimer's dementia (AD) is a degenerative disorder that causes major decline in cognitive and behavioral functioning and has become one of the more feared diseases in old age (Kessler et al., 2012). AD-related pathological changes in the brain evolve many years, probably several decades, before showing a clinical manifestation (Jack et al., 2013; Sperling et al., 2011). Investigating prodromal stages of dementia like mild cognitive impairment (MCI) and its risk factors is an important research goal due to the assumed possibility of being able to impact the course of cognitive decline and to delay or inhibit dementia onset (Cummings et al., 2007; Gauthier et al., 2006). Characterized as a transitional state of cognitive functioning operating between the changes observed in normal versus pathological aging, MCI subsumes a heterogeneous group, with some reverting to normal functioning or remaining in the state of MCI and about one half progressing to dementia within 5 years (Mitchell & Shiri-Feshki, 2009; Petersen et al., 2014). Because of these high conversion rates, but also because of the substantial number showing reversion to normal, the consideration of risk and protective factors related to MCI, as well as AD, is of utmost importance for aging research as well as clinical practice and prevention efforts.

Notably, evidence has accumulated that lifestyle habits, such as physical and cognitive engagement, affect the development of dementia-related disorders (Hertzog et al., 2008; Sattler, Erickson, Toro, & Schröder, 2011; Yaffe et al., 2009). Overall, a consensus of a multifactorial understanding of dementia-related disorders that also relies on behavioral factors has emerged. The growing evidence in this area is critical because the widespread public view that declining cognitive and physical health is primarily due to calendar age may encourage a reduced sense of responsibility and a downplaying of the importance of a healthy lifestyle (Stewart et al., 2016). In this context and in addition to already established behavioral risk factors, we assume that knowing whether and how attitudes and beliefs about aging are involved in dementia-related processes may

give new insights and stimulate innovative perspectives into the prevention of MCI and AD late in life.

A major reason for this assumption is that previous research has already shown that subjective aging processes (such as aging attitudes and negative age self-stereotyping) are related to late-life developmental outcomes, including normal cognitive functioning, health, hospitalization, and mortality (Levy et al., 2012; Westerhof et al., 2014). However, the potential role of subjective aging for pathological cognitive processes has so far received very limited attention (Levy et al., 2016; Stephan et al., 2017). Thus, this study examines whether attitude toward own aging (ATOA), a well-established and health-predictive construct in the subjective aging literature (Westerhof et al., 2014; Wurm et al., 2017), is associated with expert-diagnosed pathological cognitive decline across a rather long observational interval of 12 years. The concept of ATOA refers to one's personal evaluation of becoming older and captures key aspects of subjective aging in terms of age stereotype–driven individual expectations and experiences linked to the aging process (for a review, see Diehl et al., 2014). According to stereotype embodiment theory (Levy, 2009), negative age stereotypes are internalized from early childhood on, are continuously reinforced throughout the lifespan, become increasingly self-relevant as individuals grow older, and shape subjective aging experiences as captured by ATOA (Kornadt et al., 2017; Wurm et al., 2017). Closely tied to one's self-concept (Kornadt & Rothermund, 2012), ATOA is assumed to serve as a disposition-like lens through which experiences of aging are understood (Bellingtier & Neupert, 2018). Further, ATOA as well as related constructs have been found to predict cognitive functioning in old age.

Subjective Aging Processes and Cognitive Functioning in Old Age

Regarding cognitive functioning in old age, previous studies have demonstrated the harmful long-term impact of subjective aging on *normal* cognitive aging in different cognitive areas, such as memory (Levy et al., 2012; Stephan et al., 2016), executive functioning (Stephan et al., 2014),

and fluid cognitive abilities (Siebert, Wahl, & Schröder, 2018). In these studies, a more negative subjective aging experience—assessed via individual age stereotypes, subjective age, or the ATOA construct—was consistently associated with worse test performance and accelerated deterioration in cognitive functioning over time. For example, we found that more negative ATOA at baseline remained a risk factor for decline in age-vulnerable fluid cognitive skills over 12 years, even after controlling for health and education (Siebert, Wahl, & Schröder, 2018).

Though these findings are promising, the area is plagued by the difficulty to draw causal-like inferences. Aging individuals monitor their individual change process as well as hold expectations about differential change according to the life period they are in (Haslam et al., 2012; Levy & Leifheit-Limson, 2009). Expecting some degree of cognitive decline is among the most common views on late-life development in different age groups (Heckhausen, Dixon, & Baltes, 1989). In a previous study, we found neither baseline fluid cognition nor change in cognition to predict change in ATOA over 12 years (Siebert, Wahl, & Schröder, 2018). This finding matches well with the results of other work examining the impact of cognitive functioning on ATOA in a 6-year interval (Kleinspehn-Ammerlahn et al., 2008). Thus, in the context of normal cognitive performance outcomes, there is some indication that ATOA seems to induce change in cognitive abilities, although a current paper by Seidler and Wolff (2017) indicates a bidirectional association between self-perception of aging and processing speed across 3 years.

This understanding of ATOA's being a predictor has also been applied in previous research on views on aging and outcomes related to cognitive disorders. In particular, age stereotypes and subjective aging have been linked to brain changes and important biomarkers of AD, indicating an association between subjective aging and *pathological* cognitive aging in two recently published longitudinal studies. First, Levy and colleagues (2016), examining 52 older participants (M_{age} = 68) from the Baltimore Longitudinal Study of Aging who underwent yearly MRI assess-

ments up to 10 years, showed differential structural brain changes depending on initial age stereotypes. While adjusting for important variables such as age, gender, education, health variables, and cognitive performance at baseline, participants holding more negative age stereotypes demonstrated a rate of volume decline of the hippocampus—a pivotal brain region for maintenance of memory function (West, 1993)—that was 3 times greater compared to individuals with more positive age stereotypes. Levy and colleagues (2016) also assessed in their work the accumulation of amyloid plaques and neurofibrillary tangles, both contributing to synaptic dysfunction and degeneration of neurons (Selkoe, 1991), in 74 participants via brain autopsies. Again, controlling for the same set of covariates as in the first study, participants with more negative age stereotypes in earlier life had a significantly greater accumulation of amyloid plaques and neurofibrillary tangles. Second, Stephan and colleagues (2017) found that subjective age was related to cognitive status 4 years later in 5,748 individuals aged 65 and above from the HRS. Feeling older increased the risk of both dementia and cognitive impairment without dementia, per a cognitive telephone screening assessment. However, no expert-based clinical diagnosis was available in this study.

This latest research connecting views on aging with dementia related outcomes provides first evidence that the observed association of subjective aging and cognitive functioning is not limited to the realm of *normal* cognitive aging but extends to important biological and structural brain changes indicating *pathological* cognitive aging. However, given the current situation of only two recent studies directly speaking to cognitive pathology, more research is needed to better understand whether subjective aging (such as ATOA) and diagnosed cognitive impairment are longitudinally related. Moreover, to our knowledge, there is no study linking ATOA to an expert-based clinical diagnosis of MCI and AD.

As an important background to address this issue at the behavioral level, considerations at the neuropathological level also seem in place. Challenges in the study of risk factors of cognitive disorders arise from the fact that neuropathological changes such as the accumulation of beta-

amyloid fibrils and plaques appear to begin prior to old age. More precisely, hypothetical models on the temporal course of AD-related pathology assume an early deposition of beta amyloid decades before symptom onset, followed by tau-related neurodegeneration and observable hippocampal volume loss that precedes subtle cognitive impairment and a clinical manifestation (Jack et al., 2013; Sperling et al., 2011). Further, evidence has suggested that in the preclinical phase of dementia-related processes, when no symptoms are yet observable, efficient scaffolding processes of the brain operate to deal with the pathological brain changes (Park & Reuter-Lorenz, 2009; Stern, 2012). Moreover, studies have witnessed substantial heterogeneity in the clinical manifestation of dementia and MCI in individuals with similar degrees of brain pathology, presumably related to the concept of cognitive reserve (Stern, 2009, 2012), hence, pronounced interindividual differences concerning the brain's ability to compensate for pathological changes.

As we argue earlier, ATOA may serve as a promising candidate and under-researched risk factor for MCI and AD. However, as Wilson and Bennett (2017) reason, distinguishing a risk factor from a prodromal manifestation of AD is difficult due to the temporal lag between onset of the pathological cascade of AD and the emergence of clinical symptoms. Although well aware that longitudinal studies cannot completely resolve this issue, we posit that they are helpful in providing further insight on the complex interplay of dementia-related processes and potentially important constructs such as ATOA. In addition, research is needed to empirically address different explanations for the association of ATOA and cognitive disorder. Following the distinction suggested by Levy (2009), pathways may operate on the levels of behavior, psychological constructs, and physiological mechanisms.

Pathways Linking ATOA to Pathological Cognitive Decline

Although there is ample evidence of the long-term effects of subjective aging on developmental outcomes, knowledge on operating mechanisms is still scarce (for a recent review, see Wurm et al., 2017). Based on Levy's (2009) stereotype embodiment framework and existing empirical

evidence, several pathways may be of particular importance for the connection between ATOA and dementia-related disorders, such as physiological processes and behavioral lifestyle factors. The *physiological* pathway emphasizes the key role of stress and its long-term consequences on cognitive functioning by a two-stage process (Levy et al., 2016). First, there is evidence that negative age stereotypes foster stress as a heightened physiological stress response (e.g., enhanced skin conduction and blood pressure) in the face of challenging tasks (Levy et al., 2000). Further, negative ATOA has been shown to function as a vulnerability factor related to negatively reacting to stressful events (Bellingtier & Neupert, 2018). Second, accumulated stress and secretion of stress hormones can damage the brain. That is, physiological and cardiovascular parameters such as high blood pressure and cholesterol levels in midlife are assumed to be related to MCI and dementia (e.g., McEwen & Gianaros, 2011).

Moreover, *behavioral* actions might matter, too. Positive aging attitudes contribute to a healthier, more engaged lifestyle with several beneficial lifestyle habits, which in turn have the potential to postpone dementia onset. That is, older adults' positive subjective aging experiences were related to higher physical activity (Emile et al., 2014; Wurm et al., 2010), more health-conscious behavior (Kim, 2009; Levy & Myers, 2004), and engagement in leisure activities at large (Hicks & Siedlecki, 2017). Going further, late-life leisure activities, such as cognitive and physical activity, have been found to prevent and/or postpone pathological cognitive decline in old age (Karp et al., 2006; Sattler et al., 2011; Sattler, Toro, Schönknecht, & Schröder, 2012). A rich body of work on the effectiveness and neurobiological connections of such leisure engagement has accumulated, based on various conceptualizations of activity and outcome measures (for comprehensive overviews, see Bamidis et al., 2014; Cheng, 2016; Hotting & Roder, 2013). Overall, physical activity has been shown to reduce the risk of chronic diseases associated with cognitive decline, including cardiovascular diseases, stroke, hypertension, inflammation, diabetes mellitus, and the metabolic syndrome (Cotman, Berchtold, & Christie, 2007; Haskell et al., 2007). Besides, physical

activity relates to increases in cerebral blood flow (e.g., Pereira et al., 2007) and to neurotrophin-induced plasticity, especially in the hippocampus (e.g., Erickson, Leckie, & Weinstein, 2014). Cognitive activity is assumed to stimulate the brain and to enhance neuroplasticity, efficiency in neural systems, and longevity of neurons (Hertzog et al., 2008; Scarmeas & Stern, 2003), thereby increasing cognitive reserve and the brain's ability to compensate for pathological changes (Stern, 2012). A recent review by Cheng (2016) comprehensively considers the available research and concludes that "while physical activity, especially aerobic exercise, supports neuronal structural integrity and preserves brain mass (hardware or static brain reserve), cognitive activity strengthens the functioning and plasticity of neuronal circuits (software or dynamic cognitive reserve)" (p. 85).

Further, frequency and intensity of engaging in activities likely interact with *psychological* and *motivational* aspects. A study examining the consequences of attributing illness to "old age" showed that this line of thinking was maladaptive in terms of health motivation (Stewart et al., 2016). The extent to which older people blamed "old age" as a cause of their stroke affected self-reported lifestyle changes, frequency of physician visits, and hospitalization over the subsequent 3 years. Underlying attitudes also seem to influence outcome expectancies and provide information about the controllability of assumed aging-associated outcomes (Lachman et al., 2011). As such, perceived control has already been shown to be a significant mediator in terms of aging attitudes and functional health (Levy, Slade, & Kasl, 2002; Wurm et al., 2007). Control beliefs may also play an important in role with regard to cognitive outcomes, given the existing experimental and longitudinal evidence linking control beliefs to cognitive decline (e.g., Caplan & Schooler, 2003). Older adults who experience deteriorating cognitive fitness and attribute these changes to age rather than factors within their control may be less likely to expend personal effort to counteract the decline, doubting that it will pay off.

Overall, previous theoretical and empirical evidence on possible mechanisms suggests that ATOA may affect the risk of MCI and AD via physiological, behavioral, and psychological levels.

Following Levy (2009) as well as a recent review of Wurm and colleagues (2017), a more positive ATOA is associated with experiencing less stress and enhanced control and may foster health at large, a healthier lifestyle, and heightened engagement in various leisure related activities. All of these factors may contribute toward building up a stronger cognitive reserve capacity and better cognitive scaffolding in middle and old age (Hertzog et al., 2008; Park & Reuter-Lorenz, 2009; Stern, 2012). It is interesting that, although of fundamental importance, only a few studies so far have empirically tested underlying mechanisms in the context of subjective aging, with most of them focusing on physical health outcomes (Wurm et al., 2017) and little work concentrating on memory function and cognitive impairment over time (Stephan et al., 2016, 2017). In this paper, due to missing biological indicator assessment, only the first two of Levy's (2009) tripartite pathway approach are addressed.

Study Aims and Hypotheses

Extending previous research that linked subjective aging to biomarkers of AD and cognitive impairment over time (Levy et al., 2016; Stephan et al., 2017), this study aimed to examine the long-term (12 years) association of ATOA regarding expert-diagnosed MCI and AD in old age. We expected that more negative ATOA would be associated with a higher risk of developing MCI and AD in an initially healthy subsample, after controlling for relevant sociodemographic, genetic, and health variables. A second objective was to test whether a possible relationship between ATOA and cognitive status would be mediated by a subset of pathway indicators, that is, behavioral and psychological, which are available in the Interdisciplinary Longitudinal Study of Adult Development (ILSE). Concretely, we assumed that leisure-activity engagement (i.e., cognitive, physical, and social activities indicating a behavioral pathway) and internal and external control beliefs (indicating a psychological pathway) would mediate a potential linkage between ATOA and MCI/AD.

Method

Participants and Procedure

Data came from the population-based ILSE study (Sattler et al., 2017), an ongoing longitudinal cohort study with three completed measurement occasions in Germany. ILSE is stratified by birth cohort, gender, and region, initially comprising 502 middle-aged participants born in 1950-1952 and 500 young-old people born in 1930-1932. Participants were randomly selected and recruited via city registers in two metropolitan regions in former West (Heidelberg area) and East (Leipzig area) Germany. Starting in 1993/1994 (T1), follow-up assessments were conducted 4 years later (1997/1998; T2) and 12 years later (2005/2006; T3).

The study was based on 315 initially cognitively healthy participants from the older cohort, who completed the third examination wave and were followed from their early 60s to their mid-70s (T1: M_{age} = 62.5, SD = 0.9; T3: M_{age} = 74.3, SD = 1.2). Of the participants in the original sample, 23.8% dropped out between T1 and T3 due to reasons of death (n = 60), relocation (n = 13), health issues (n = 19), or other (n = 27), reducing the sample size to N_{T3} = 381. From this remaining T1-T3 sample, we excluded participants with diagnoses of cognitive impairment at baseline, such as MCI and mild cognitive disorders (n = 66). There were no AD participants at T1. Further, as assumed by previous research that indicated associations between subjective aging and mental health (e.g., Bryant et al., 2012; Dutt et al., 2018), we found significant mean differences in baseline ATOA between cognitively healthy participants with and without mental disorder at T3. Thus, in a next step, study participants meeting criteria of other psychiatric disorder (such as major depression, anxiety disorders, and substance abuse) according to the German version of the *Diagnostic and Statistical Manual of Mental Disorder*s (DSM-III-R; Wittchen et al., 1991) or vascular dementia were also excluded from the analyses. The final sample then consisted of 260 participants, of whom 103 were diagnosed with MCI, 14 were diagnosed with AD, and 143 were healthy controls at T3. Because prevalence of AD was too low to conduct differential analyses, participants

with AD and MCI were clustered. Being aware that these are qualitatively different diagnostic groups, we additionally examined interrelations without the rather low number of AD cases. Compared to dropouts, individuals in the final sample had better objective and subjective health and reported more positive attitudes toward own aging (*d*'s = .24 - .46) but did not differ with respect to education or gender.

The study was approved by the ethics committee of the Medical Faculty of the University of Heidelberg. After a complete description of the study was given to the participants, written informed consent was obtained.

Measures

Attitude toward own aging. We used the Attitude Toward Own Aging (ATOA) subscale of the Philadelphia Geriatric Center Morale Scale (Lawton, 1975), which is widely applied in the age attitudes and age stereotype literature (e.g., Diehl & Wahl, 2015; Miche et al., 2014) and had acceptable internal consistency in the current sample (Cronbach's $\alpha = .66$). Five items that could either be disagreed or agreed with (rated as 0 or 1, respectively) measure the subjective evaluation of one's aging process (e.g., "I have as much pep as last year"), with higher scores indicating a more positive attitude toward own aging.

Neuropsychological assessment and diagnostic categories. At each examination wave, participants were carefully screened for physical and mental health by two specialists in geriatric psychiatry. In addition, to assess cognitive status, professional psychologists administered the same neuropsychological test battery that included tasks on memory (immediate word list recall and delayed word list recognition; Oswald & Fleischmann, 1995), abstract thinking (similarities subtest of the German WAIS-R; Tewes, 1991), spatial orientation (W. C. Horn, 1983), verbal fluency (W. C. Horn, 1983), and attention (Brickenkamp, 1981). Age-adjusted normal values were

available for all psychometric instruments administered, but normal values adjusted for educational level were missing for the tests addressing verbal fluency and visuospatial functioning. In these instances, the results of the entire cohort were differentiated according to high (secondary school) and low (primary school) educational levels, and each of the resulting distributions was used as a reference. Subjective cognitive complaints were assessed in clinical interviews. Cognitive status was then assessed, considering all available anamnestic, clinical, laboratory, and neuropsychological information. MCI was diagnosed according to the aging-associated cognitive decline criteria as put forward by the International Psychogeriatric Association Working Party (Levy, 1994), including (1) subjective impairment, referring to a report by the participant or an informant that cognitive function has declined, and (2) objective impairment, referring to difficulties in at least one of the following cognitive domains, as indicated by neuropsychological test performance of at least one standard deviation below age and education adjusted normative levels: memory and learning, attention and concentration, abstract thinking, language, and visuospatial functioning. AD and vascular dementia were diagnosed using the NINCDS-ADRDA and the National Institute of Neurological Disorders and Stroke and Association Internationale pour la Recherché et l´Enseignement en Neurosciences (NINDS–AIREN) criteria, respectively (McKhann et al., 1984). All final clinical diagnoses were based on a consensus conference consisting of at least two specialists in geriatric psychiatry who considered and integrated all medical and neuropsychological data.

Assessment of covariates. Variables that have repeatedly been found to be linked to cognitive impairment in old age, i.e., gender (male = 1; female = 2), education, health at baseline, and genetic predisposition (Hertzog et al., 2008), were included as covariates. Education was defined by number of years at school and university. Objective physical health was assessed via an in-depth medical examination consisting of an anamnesis (e.g., medical history of the participant), a medical checkup (i.e., sensory function, blood pressure), blood test results, and a geriatric assessment. Trained physicians aggregated the information into an overall health score ranging from 1 (*very*

good) to 6 (*very bad*). Each of the 6 scores contained clear descriptions (e.g., score 5 for a poor health status, if suffering from a very serious medical condition that is not immediately life-threatening or if independent living was no longer possible) to allow objective assignment, to ensure clinical significance of the assigned health score, and to guarantee reliability of the health ratings. Participants were also asked for a personal evaluation of one's health status. This subjective health rating was measured on a scale ranging from 1 (*very good*) to 6 (*very bad*). For the analyses, subjective and objective health rating scores were reversed so that higher values indicated better health. Furthermore, the apolipoprotein E (apoE) genotype was determined using the LightCycler technology (Aslanidis & Schmitz, 1999). In the overall sample of $n = 288$ participants, for whom apoE was available at T3, allelic frequency (apoE ε2: 10.2 %, apoE ε3: 72,6 %, apoE ε4: 17.2 %) was comparable to a representative study in Germany (Förstl, 2006). For the $n = 205$ included in this study, allelic frequency of participants with at least one apoE ε4 was slightly higher (25% versus 15% reported by Förstl, 2006). For the analyses, apoE genotype was dichotomized into apoE ε4 carriers (i.e., participants with at least one ε4 allele in their genotype, $n = 52$) and apoE ε4 noncarriers ($n = 153$), as this grouping has been commonly used in the literature.

Assessment of mediator variables representing behavioral and psychological pathways. Variables that represented the theoretically expected pathways were used as assessed at T1. To measure leisure activity level (behavioral pathway), participants rated on a 7-point scale from 1 (*never*) to 7 (*every day*) how often they engaged in various social and cognitive activities. Moreover, they indicated how many hours per week they participated in physical activities. Following common conceptualization on the basis of empirical data (e.g., Jopp & Hertzog, 2007), we grouped activity ratings into a sum score of physical (hours per week engaging in sports and physically demanding hobbies), cognitive-developmental (e.g., public lecture, course at college), and social engagement (e.g., meeting friends/family, club meetings), as well as an overall activity mean score.

Control beliefs (psychological pathway) were measured with a scale on internal and external control developed for the Berlin Aging Study (Kunzmann, Little, & Smith, 2002). The six-item subscale on *internal control* captured one's perceived control over desirable and undesirable outcomes and included statements about being able to make things happen, whether one perceived being able to obtain desired things by working hard for them, or whether one perceived that the problems in life are mainly the result of one's own behavior (1 = *not at all* to 5 = *very much*; Cronbach's $\alpha = .70$). Moreover, *external control* was assessed via eight items including statements like seeing no possibility to escape from bad things, having no chance if fate doesn't want it, or believing good things in one's life depend on others (Cronbach's $\alpha = .66$). Although in the lower range, internal consistencies were of still acceptable magnitude.

Data Analysis

All descriptive and preliminary analyses were carried out with SPSS 22.0. Logistic regression analyses were performed using Mplus 6.12 (Muthén & Muthén, 1998-2011) to examine whether ATOA predicted development of MCI/AD over 12 years. To reduce the contribution of measurement error, we used a latent modeling approach to measure ATOA. Thus, ATOA at T1 was measured by five dichotomous indicators representing one latent factor. Cognitive status after 12 years, that is, being cognitively healthy versus having a diagnosis of MCI/AD, served as a binary outcome variable. The model was extended in a second step by ATOA at T2 and T3 to analyze the impact of ATOA over time. With longitudinal measurement invariance of ATOA established (for more details on the procedure, see Miche et al., 2014), ATOA at T2 and T3 was added as predictor to the logistic regression model. Additionally, a latent change score approach (e.g., McArdle, 2009) was applied to assess the contribution of longitudinal change of ATOA between T1 and T2 or T1 and T3, respectively. In Mplus, common-factor latent change score models for ATOA were calculated according to McArdle (2009; see Figure 4b, p. 588) with baseline ATOA as a predictor

and the latent change score between either T1 and T2 or T1 and T3 being assumed to correlate with the outcome in terms of cognitive status at T3.

To assess the risk of MCI/AD associated with negative ATOA, we calculated odds ratios (*ORs*). In a next step, separate mediation analyses were conducted using leisure activities and control beliefs as manifest mediators operating between ATOA and cognitive status 12 years later. Note that Mplus uses the underlying continuous latent response variable approach for logistic regression analyses (e.g., McKelvey & Zavoina, 1975); hence, the models' direct and indirect effects refer to a latent continuous response variable assumed to underlie the dichotomous MCI/AD indicator. Doing so, testing the respective indirect effects yields the method of mediation analysis for binary outcomes as suggested by MacKinnon, Lockwood, Brown, Wang, and Hoffman (2007), using the delta method to compute asymptotic standard errors of the indirect effects (for details on Mplus mediation analysis with binary outcomes, see Muthén & Muthén, 1998-2011).

Education, gender (male = 1; female = 2), objective and subjective health (recoded), and genetic disposition (apoE ε4 carriers vs. noncarriers) were included as manifest variables in the logistic regression models as well as in the latent change score models to account for relevant confounds. Due to reasons of parsimony, nonsignificant predictors were removed from the final regression models. We used Monte Carlo integration (Press, Teukolsky, Vetterling, & Flannery, 2007) to account for the few missing data.

Results

Sample Description and Descriptive Data

Sample characteristics of the total sample and the diagnostic groups are presented in Table 3.1. Compared to participants diagnosed with MCI/AD, healthy controls had significantly higher education, $t_{(256)} = 4.13$ $p < .001$, and reported more positive ATOA at baseline, $t_{(255)} = 2.30$, $p < .05$;

however, no differences regarding gender, apoE allele ε4, and subjective or objective health were observed.

Table 3.1

Baseline Characteristics of the Total Sample and Subsamples Based on Cognitive Status 12 Years Later

	Sample Characteristics			
	Total Sample (n = 260)		Normal (n = 143)	MCI/AD (n = 117)
Variables	*M* / % (*SD*)	Range	*M* / % (*SD*)	*M* / % (*SD*)
$ATOA_{T1}$[a]	1.76 (0.28)	1-2	1.80 (0.27)	1.72 (0.29)
Age_{T1}	62.79 (0.90)	61-64	62.76 (0.90)	62.83 (0.89)
Gender (2 = female)	46.2%	-	49.7	41.9
Education (years)	13.00 (2.67)	8-18	13.59 (2.96)	12.29 (2.06)
$Objective\ health_{T1}$	3.73 (0.78)	1-5	3.78 (0.75)	3.65 (0.82)
$Subjective\ health_{T1}$	4.48 (0.87)	1-6	4.66 (0.78)	4.47 (0.98)
ApoE (ε4 carrier)	25.4	-	24.2	27.1

Note. [a] Higher values indicate a more positive view toward own aging.

As depicted in Table 3.2, a more positive ATOA at baseline was unrelated to gender or education, but was related to better subjective health, better objective health, and being cognitively healthy 12 years later. Moreover, correlations emerged between ATOA and assumed mediating variables. A more positive ATOA at baseline significantly correlated with overall leisure activity (r = .42, p < .01), more physical activity (r = .19, p < .01), more cognitive activities (r = .27, p < .01), more social activities (r = .16, p < .05), and fewer external control beliefs (r = -.14, p < .05). Diagnosis of MCI/AD at follow-up was related to overall leisure activity (r = .23, p < .01), cognitive activity (r = .23, p < .01), and external control beliefs (r = -.15, p < .05) at baseline.

Table 3.2

Bivariate Associations of ATOA, Covariates, and Mediators at Time 1 (T1), and Cognitive Status at Time 3 (T3)

Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. $ATOA_{T1}$ [a]												
2. Cognitive $status_{T3}$ [b]	.17*											
3. Gender (2 = female)	-.03	.08										
4. Education (years)	.08	.24**	-.31**									
5. Objective $health_{T1}$	.26**	.08	-.13*	.08								
6. Subjective $health_{T1}$	.27**	.11†	-.19**	.17**	.49**							
7. ApoE (ε4 carrier)	.03	.03	-.02	.06	-.03	.13†						
Mediators												
8. Overall $activity_{T1}$	.42**	.23**	.06	.27**	.14*	.12†	.08					
9. Cognitive $activity_{T1}$	.27**	.23**	.13**	.35**	.14*	.05	.09	.81**				
10. Physical $activity_{T1}$	.19**	.10	-.08	.12†	.10	.20**	-.05	.67**	.29**			
11. Social $activity_{T1}$	.16*	.12†	.08	.07	.04	.05	.03	.67**	.32**	.29**		
12. Internal CB_{T1}	.11	.05	-.22**	-.09	.11	.10	-.10	-.05	.05	-.01	-.09	
13. External CB_{T1}	-.14*	-.15*	.26**	-.17**	-.01	-.07	.01	-.00	-.02	.00	.02	-.08

Notes. ApoE = apolipoprotein E; CB = control beliefs. [a] Higher values indicate a more positive view toward own aging. [b] Dummy-coded with 1 = MCI/AD, 2 = normal functioning. † $p < .10$, * $p < .05$, ** $p < .01$.

Examination of Hypothesis 1

In accordance with our first hypothesis, logistic regression revealed that baseline ATOA significantly predicted cognitive status at T3 (ß = .209, $p < .05$; $OR = 1.27$), in that more negative ATOA was associated with a higher risk of clinical cognitive impairment, that is, diagnosis of MCI/AD 12 years later (see Table 3.3). This association also held after controlling for gender, education, initial subjective and objective health, and apoE genotype. Being male (ß = .198, $p < .01$; $OR = 2.19$) and having fewer years of education (ß = .334, $p < .01$; $OR = 1.29$) significantly contributed to the likelihood of developing MCI/AD over 12 years. Subjective health, objective health, and apoE ε4, however, were unrelated to future diagnosis of MCI/AD. Yet, because objective health changed the ATOA estimate by more than 10%, it was kept in the model as a relevant confounder (Greenland, 2008). A 1-*SD* increase in ATOA at baseline was associated with a 31% higher risk of being diagnosed with MCI/AD 12 years later. Note that rerunning the analyses with the AD participants excluded revealed the same pattern of results. Moreover, extending the model by ATOA at T2/T3 to analyze the contribution of change yielded no significant effects. Apart from the significant baseline ATOA effect, neither latent change in ATOA nor ATOA at T2/T3 was significantly related to cognitive status at T3.

Table 3.3

Logistic Regression Predicting Cognitive Status (Normal Functioning vs. MCI/AD) at Time 3 From Baseline ATOA and Covariates.

	Logistic Regression Model					
	ATOA only		Full [a]		Final	
Variables	β (*SE*)	*OR* (95%)	β (*SE*)	*OR* (95%)	β (*SE*)	*OR* (95%)
ATOA $_{T1}$ [b]	.209* (.09)	1.27 (1.02-1.58)	.283* (.11)	1.43 (1.01-2.03)	.206* (.10)	1.31 (1.00-1.71)
Gender (2 = female)	-	-	.249** (.09)	2.83 (1.37-5.88)	.198** (.07)	2.19 (1.23-3.90)
Education (years)	-	-	.396** (.08)	1.35 (1.17-1.55)	.334** (.07)	1.29 (1.15-1.43)
Objective health $_{T1}$	-	-	.084 (.09)	1.28 (0.77-2.10)	.031 (.08)	1.08 (0.74-1.58)
Subjective health$_{T1}$	-	-	-.068 (.09)	0.84 (0.53-1.34)	-	-
APOE (ε4 carrier)	-	-	-.03 (.08)	0.87 (0.40-1.87)	-	-

Notes. Dashes indicate that variable was not considered in the analysis. OR = odds ratio; CI = confidence interval; apoE = apolipoprotein E. [a] $n = 196$. [b] Higher values indicate a more positive view toward own aging. $^{*}p < .05$, $^{**}p < .01$.

Examination of Hypothesis 2

Regarding the second hypothesis, we examined the role of possible mediators linking ATOA to future cognitive status by separately adding them to the logistic regression model. We considered only those variables being statistically correlated with baseline ATOA and diagnosis of MCI/AD at T3 (i.e., overall leisure activity, cognitive activity and external control beliefs) and removed the nonsignificant predictors subjective health and apoE information from the analyses. Regarding the overall activity mediation model, we found a significant path from only ATOA to overall activity (ß = .44, $p < .001$) but not from overall activity to future cognitive status; thus, the indirect effect was nonsignificant. Further, for the cognitive activity mediation model (see Figure 3.1), there was a significant regression weight from ATOA to cognitive activity (ß = .31, $p < .001$)

but no effect from cognitive activity to future cognitive health status and thus no indirect effect (b = .04, p = .29). Yet, adding cognitive leisure activity to the model weakened the direct effect of ATOA on cognitive status from .21 (p < .05) to .19 (p = .09). For external control beliefs, as depicted in Figure 3.1, we found significant regression weights from ATOA to external control beliefs (ß = -.17, p < .05), external control beliefs to cognitive status at T3 (ß = -.15, p < .05), and a nonsignificant effect from ATOA to cognitive status (ß = .18, p = .08). Though reducing the predictive power of ATOA on cognitive status from .21 to .18, the indirect effect was nonsignificant (b = .03, p = .12). Because the applied delta method is known to be a rather conservative test for indirect effects, we also used bootstrapping on a latent variable level with 10.000 samples to further analyze mediation results (Hayes & Scharkow, 2013). However, this did not change the pattern of results.

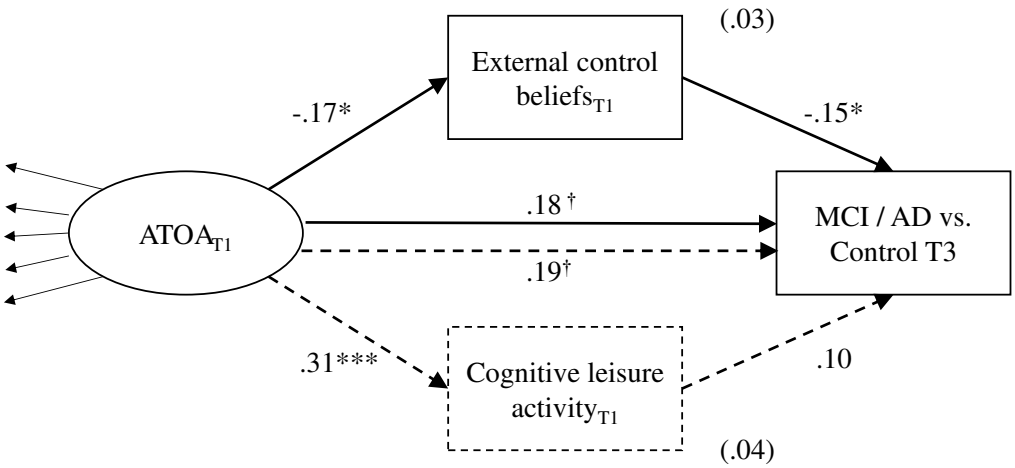

Figure 3.1. Separate mediation models for a) external control beliefs (solid arrows) and b) cognitive leisure activity (dashed arrows) with standardized path coefficients. Unstandardized indirect effects for both mediation models are presented in parentheses.
† p < .10, * p < .05, *** p < .001.

Discussion

Using 12-year ILSE data, we examined the role of ATOA as a potential risk factor for cognitive disorders in old age within a relatively young birth cohort. Extending the two recent findings on dementia biomarkers (Levy et al., 2016) and dementia-related outcomes (Stephan et al., 2017), this study is the first linking subjective aging phenomena with future clinical diagnoses of MCI and dementia. That is, negative ATOA at baseline was associated with a 31% higher risk for MCI/AD diagnosis after 12 years in an initially healthy subsample, even after accounting for gender, education, health, and genetic variables. This finding was consistent with our first hypothesis. Further, the consideration of change in ATOA over time yielded no significant contribution to the prediction of cognitive disorder. This finding is not surprising, because of the limited between-person variability in change of ATOA in our sample, which has been also reported in other work on ATOA in ILSE (Miche et al., 2014; Siebert, Wahl, & Schröder, 2018). The nonsignificant result should, thus, be interpreted with this in mind.

In following adults of a birth cohort born 1930-32 until their mid-70s, we found that this sample mainly consisted of participants with a diagnosis of MCI (n = 103) not being severely impaired or meeting the criteria of AD yet. Due to the low prevalence of AD in our sample (n = 14), reported effects are based on joint analyses of MCI and AD participants without additional differentiation of diagnostic groups. However, when excluding AD cases from the analyses, the same pattern of result emerged, suggesting a substantial longitudinal link even between ATOA and milder forms of cognitive impairment. These findings are in line with the few studies investigating the long-term effects of subjective aging on pathological cognitive outcomes in old age. Focusing on brain changes related to cognitive impairment, Levy et al. (2016) found that people reporting more negative age stereotypes are at greater risk for elevated counts of Alzheimer's biomarkers 20 years later. Likewise, based on a large HRS sample, Stephan et al. (2017) showed that felt age predicted dementia-related outcomes classified by a cognitive screening, even after controlling for several

medical covariates and baseline cognition. Furthermore, they found the same pattern of results for preclinical and clinical dementia outcomes, with an even stronger effect in the dementia group.

As a second objective of the study, we investigated the role of leisure activity and control beliefs as potential mediators linking aging attitudes with future MCI/AD diagnosis. Regarding leisure activity, ATOA was related to all reported types of activity engagement, that is, overall, cognitive, physical, and social activity. Moreover, frequency of overall activity and cognitive activity at baseline correlated with cognitive status at T3, whereas only marginal or no associations emerged between reported social or physical activity and future MCI/AD. These findings are in line with those of previous ILSE work showing cognitive activity (Sattler et al., 2012) and motor coordination (more objective physical indicator) but not self-reported physical activity (Sattler et al., 2011) to be a predictor of cognitive status after 12 years. Yet, the mediation model in our analysis did not confirm an indirect link of negative ATOA on risk of MCI/AD that is mediated by less frequent cognitive activity or overall leisure activity. However, we found some evidence of the contribution of control beliefs. That is, external control beliefs were linked to both ATOA and future cognitive status; people with a more positive ATOA reported less external control beliefs, which, in turn, were associated with a reduced risk of MCI/AD 12 years later. Although the overall indirect effect was not significant, this finding gives some indication of the role of psychological control beliefs associated with aging attitudes.

The lack of significant mediation effects in our sample is partly consistent with other studies. For example, although physical activity has been shown to mediate the relationship between subjective aging and health outcomes (Hicks & Siedlecki, 2017; Kim, 2009), its role is less clear with respect to cognitive aging. In particular, Stephan and colleagues found in their two HRS-based studies that physical inactivity associated with an older subjective age did not explain its relation to worse memory function (Stephan et al., 2016) but did partially explain a higher risk of impaired cognition (Stephan et al., 2017). One reason for the mixed evidence may be that disentangling the

dynamic interplay among subjective aging phenomena, underlying mechanisms such as physical activity, and cognitive outcomes is far more complex than assumed and requires a greater differentiation with regard to valence, content, and multidimensionality of subjective aging experiences and operationalization of indicators of, for example, physical activity (Wurm et al., 2017). However, we also see some practical reasons for the nonsignificant pathways in our study. First, despite the reasonable sample size of 260 participants, it seems that given the rather small effects observed in large samples (e.g., Stephan et al., 2016, 2017), our study may be underpowered. Previous work reporting significant mediation effects often relies on larger sample sizes with over 1,000 participants (e.g., Wurm et al., 2007; Stephan et al., 2016). Second, reliability and validity of the used mediator variables was likely limited. In particular, cognitive leisure activity was assessed by only three items, omitting key aspects of cognitive engagement such as reading books or newspaper, writing, or doing crosswords and measured only at T1, thus, rather distal from the outcome. To better capture differences in people's activity profile, a more differentiated questionnaire, including various aspects as well as information on frequency and intensity of engagement, or even an objective assessment of activity, would be useful. This also seems particularly crucial regarding physical activity. Although there was a relationship between ATOA and physical activity in our data, we were not able to replicate the well-documented association between physical activity and cognitive status. One reason may be that the available indicator of physical activity faces the issues of a self-report measure. Participants indicated how many hours per week they engaged in certain activities such as sports and exhausting hobbies; however, it was without rating intensity of activities or differentiating low, moderate, and high levels of exercise intensity. Moreover, different activities have not been weighted in their relevance for cognitive trajectories. Although, physical activity is one of the most established protective factors of dementia (Cheng, 2016), a recent review by Leshner, Landis, Stroud, and Downey (2017) reporting inconclusive evidence highlights the importance of gathering reliable and valid information of people's past and recent physical

engagement. Thus, there is a need for more longitudinal studies that provide detailed information of people's everyday activity level and a measure of exercise intensity to examine the mediating role of leisure activity engagement in the context of subjective aging and cognitive disorder.

Besides the selected set of available behavioral and psychological mediators considered in this work, other mechanisms are likely to operate as well. Specifically, the experience of psychological and physiological stress should be addressed in further research, given their involvement in both subjective aging (e.g., Levy et al., 2000) and cognitive impairment (e.g., McEwen & Gianaros, 2011). However, these mechanisms have not been assessed in ILSE. In addition to directly aiming to change one's subjective aging experience for the better, identifying operating pathways offers valuable information on how to counteract detrimental consequences of negative age attitudes and inform tailored interventions and preventive efforts for people at risk of future dementia. Moreover, the assessment of individuals' response to experiences associated with becoming older in midlife (e.g., Heckhausen, 2001; Lachman, 2004) may be important because individuals in this age group likely respond to subjective aging evaluations in different ways (Brothers et al., 2017). This would require a more dynamic perspective on how views on aging, cognitive impairment, and risk factors evolve and interact over time. Ecological momentary studies combined with long-term data may also be helpful to trace such dynamics (Bellingtier & Neupert, 2018). For example, one may look at whether and how evaluations of one's own aging process change in middle age when first encountering age-related experiences (e.g., first signs of memory impairment, illness or death of same-aged peers) and how this relates to change in behavior and lifestyle habits (e.g., ignoring biological processes, continuing or even increasing the amount of activity and engagement, shifting to a relief posture). To gain further insight, more longitudinal research on this complex interplay is warranted. Another limitation inherent of longitudinal designs concerns the debatable generalizability of results caused by the selective dropout of participants over time.

Although we considered ATOA at multiple time points, the role of changes in ATOA or in potential mediators over time *before* dementia onset has not been sufficiently addressed in this article, because many of the participants with MCI/AD at T3 already showed signs of cognitive impairment at T2. It may be that not only differences in *how* people approach their aging are of importance but *whether* this individual aging experience changes across time. Aging attitudes show large variability in midlife and become increasingly more negative in later life (Diehl & Wahl, 2015; Miche et al., 2014). These changes in midlife likely depict dynamic and differential adaptation to personal experiences and engagement with "being or becoming older" due to, for example, critical life events like retirement, age-associated decline in cognitive and physical abilities, and death. The same might be true for mediating mechanisms; changes in lifestyle habits and activities associated with one's aging attitudes may be of particular relevance in the context of MCI and dementia. Whereas one person may cease engaging in physical or cognitive activities because of old age, someone else might just keep it up for the same reason—eventually affecting cognitive health in old age. Unfortunately, due to data limitation, changes in activity pattern over time could not been addressed in this paper, because certain activity ratings were assessed only at baseline. Hence, it seems important to also include younger ages in future studies to disentangle the dynamics before a clinical manifestation of dementia.

Moreover, though we carefully excluded participants with cognitive impairment at T1, it is still possible that negative ATOA is more an early sign of underlying brain-related changes rather than cause of cognitive decline. Due to the long asymptomatic phase in AD, underlying pathological changes might have started before the first assessment of ATOA. Thus, a subtle pre-MCI cognitive decline may have influenced the reported subjective aging experience. In this vein, it is interesting that despite differential cognitive decline in our study with some participants being diagnosed with MCI or AD and others not, change in attitudes toward aging over time was not related to cognitive status after 12 years. Regardless of whether this was due to the scale's lacking

sensitivity or a sign of a rather stable, disposition-like concept of ATOA in old age with pronounced differences between individuals (Diehl & Wahl, 2010; Wurm et al., 2017), this finding seems to indicate limited responsiveness of the ATOA scale to cognitive decline in old age.

Taken all together as well as acknowledging a range of limitations, there is evidence that age stereotypes and subjective aging are related to both future AD pathology (Levy et al., 2016) and future clinical expression of MCI and AD (Stephan et al., 2017 and our study). However, given the caveats of these longitudinal studies and lacking thorough empirical evidence on operating mechanisms, it remains unclear how these variables are causally linked and whether subjective aging actually alters the underlying pathophysiological process itself and shapes brain pathology, for example, via stress pathways. Other psychological variables like higher levels of purpose in life have been found to reduce the deleterious effects of AD pathologic changes (i.e., neurofibrillary tangles) on cognitive function and are assumed to relate to concepts of reserve (Boyle et al., 2012; Wilson & Bennett, 2017). Altering the pace of the clinical expression of underlying dementia-related pathology, these results gave rise to the notion "that the negative impact of an important component of AD pathology on cognition may be partly conditional on aspects of psychosocial behavior" (Wilson & Bennett, 2017, p. 7). Clearly, more research with in vivo imaging of biomarker is needed to further investigate these associations between subjective aging, dementia-related pathology and its clinical manifestation, and reserve capacity.

In sum, this study enriches the emerging evidence on subjective aging and its importance for cognitive disorder in old age and extends previous research by showing that negative ATOA is a risk factor for clinically relevant cognitive impairment 12 years later, though the exact mechanisms remain largely unclear. Furthermore, our results substantially add to the finding of subjective aging being an important distal psychological resource with widespread long-term effects on older adults functioning in multiple domains.

Chapter 4 – Paper 3

Change in Attitudes toward Aging:

Cognitive Complaints Matter More Than Objective Performance

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Abstract

Converging longitudinal research suggests that more negative views on aging go along with accelerated cognitive decline. Although conceptually suggested, reciprocal relationships between cognitive functioning and attitudes toward aging have remained less clear empirically. We used the 20-year data from the Interdisciplinary Longitudinal Study of Adult Development (ILSE) to better understand such potential bidirectionality. Drawing on 1002 baseline participants from two age groups, a midlife (M_{age} = 43.7 at baseline) and an old age group (M_{age} = 62.5 at baseline), we examined longitudinal trajectories between attitude toward own aging, performance-based cognitive measures, and subjective cognitive complaints. Findings from multigroup latent growth curve modeling confirmed previous findings that attitude toward own aging predicts cognitive change over 20 years in old age, but also showed that this does not apply to midlife. As the central study finding, cognitive complaints but not cognitive performance were related to change in attitude toward own aging in midlife and old age. Results suggest that differentiating between objective cognitive functioning and subjective cognitive complaints is important when investigating relations between cognitive functioning and attitude toward own aging in different age groups.

Keywords: aging, attitude toward own aging, cognitive complaints, cognitive development, Interdisciplinary Longitudinal Study of Adult Development (ILSE)

Introduction

A number of different, yet related constructs have been suggested to address what is generally labeled as views on aging (Wurm et al., 2017) or subsumed under the umbrella term of subjective aging (Diehl & Wahl, 2015). Major examples include age stereotypes (socially shared beliefs about aging and older people), subjective age (how old one feels), or beliefs and attitudes toward own aging (expectations and evaluations of one's own aging; for an overview see Diehl et al., 2014). Central for all of these constructs is the assumption that people, as they age, adopt and integrate societal and individual beliefs about age and aging. According to the stereotype embodiment theory (Levy, 2009), views on aging are already internalized in childhood, continuously reinforced throughout the lifespan, and become increasingly self-relevant with advancing age. As existing research clearly underlines, views on aging also have the potential to shape developmental outcomes such as well-being and health (Diehl et al., 2014; Kornadt et al., 2017; Westerhof et al., 2014; Wurm et al., 2017).

Apart from the link to well-being and health-related outcomes, much attention has been paid recently to the role of views on aging for cognitive development in later life. This body of work suggests that more negative views on aging are related to accelerated decline in memory (Levy et al., 2012; Robertson et al., 2016), fluid cognitive abilities (Seidler & Wolff, 2017; Siebert, Wahl, & Schröder, 2018), as well as a heightened risk for dementia (Levy et al., 2018; Siebert, Wahl, Degen, & Schröder, 2018), and greater accumulation of Alzheimer's biomarkers (Levy et al., 2016). Moreover, effects tend to become stronger with increasing age (Levy et al., 2012; Siebert, Wahl, & Schröder, 2018).

Notably, in respective previous longitudinal research, views on aging have more often been targeted as predictors of cognitive trajectories than as outcomes (e.g., Levy et al., 2012; Stephan et al., 2014). However, age-related loss in cognitive functioning may also be seen as a trigger playing a crucial role in the formation process of views on aging. That is, realizing one's own

cognitive abilities as decreasing might activate old age stereotypes leading to a more negative subjective aging experience. The few studies examining such bidirectional effects yielded mixed results; however, with more studies finding no reverse effects (Hughes & Lachman, 2018; Kleinspehn-Ammerlahn et al., 2008; Siebert, Wahl, & Schröder, 2018; Stephan et al., 2016). Thus, the overarching aim of the current study is to better understand potential bidirectionality between views on aging and cognitive functioning. Doing so, we concentrate on an established and widely used indicator of subjective aging, more precisely attitude toward own aging (Lawton, 1975; Miche et al., 2014; Westerhof et al., 2014). We also consider two age groups (midlife, old age) assessed over a long period of 20 years and include objective measures of cognitive functioning as well as subjective cognitive complaints.

Attitude Toward Own Aging and Cognitive Performance: In-Depth Consideration of the Issue of Bidirectionality

Attitude toward own aging (ATOA) has been found to predict better cognitive functioning and lower risk of dementia (Levy et al., 2018; Siebert, Wahl, Degen, et al., 2018; Siebert, Wahl, & Schröder, 2018). These findings are important because they enrich the understanding of established risk factors of age-related cognitive loss such as education, health, and physical activity. For example, ATOA seems relevant in that it stimulates or dampens resources and risk factors like engaging in leisure activities, a healthy lifestyle, and physiological stress (e.g., Levy, 2009; Levy et al., 2016; Siebert, Wahl, Degen, et al., 2018; Wurm et al., 2017).

However, conceptual reasoning also suggests that change in cognitive functioning as people age has an important formative role for ATOA. Old age stereotypes portray older adults as forgetful, less competent, and cognitively inferior compared to younger individuals (Hummert et al., 1994; Kite et al., 2005). These negative societal age stereotypes are reinforced as older adults frequently complain about memory loss and cognitive failure (e.g., Lachman, 1991), infusing expectancies and experiences of aging individuals (Haslam et al., 2012; Levy & Leifheit-Limson,

2009). To anticipate some decline in cognitive functioning is among the most common views on late-life development for younger and older adults (Heckhausen et al., 1989). Yet, as adults care a lot about intact cognitive functioning, it may come as no surprise that cognitive decline has been considered as one of the most feared aspects of growing old (Kessler et al., 2012). Although cognitive failures in younger years are commonly attributed to external sources independent of age (e.g., stress, distraction), moments of forgetfulness, cognitive slowing, or impaired learning are often perceived as *age-relevant* in older age (Erber et al., 1997). Thus, the salience of and search for age-associated cues, the interpretation of these experiences as well as anticipated consequences and scopes of action change with age and might be colored by one's subjective aging. As people age, they refer to their cognitive functioning as a key indicator of aging and constantly monitor how well they are aging by comparing themselves with their peers as well as evaluating their own cognitive change process. Indeed, there is some empirical support that social comparisons seem to contribute to changes in views on aging. That is, participants who rated their functional health and memory more favorable compared to age peers felt relatively younger over time (Hughes & Lachman, 2018). Hence, everyday cognitive performance may contribute to change in ATOA (Levy, 2009; see also Diehl & Wahl, 2010).

Contrary to the rather rich empirical work on short- and long-term consequences of ATOA, and although conceptual reasoning suggests that cognitive functioning may shape ATOA, such a predictive role of cognitive performance has previously found only limited attention. The few studies investigating reverse effects yielded mixed findings. For instance, experimental work indicates that participating in cognitive testing can at least momentarily affect subjective age (Hughes, Geraci, & De Forrest, 2013). In one study examining correlates of change in subjective age, however, neither current executive function nor episodic memory was related to change in subjective age in the preceding 10 years when controlling for functional health status (Hughes &

Lachman, 2018). Moreover, another study targeting adults aged 60 and above found neither baseline fluid cognition nor change in fluid cognition predicting subsequent change in ATOA over 12 years (Siebert, Wahl, & Schröder, 2018). These null findings are in line with other work examining the impact of cognitive functioning on ATOA in a 6-year interval (Kleinspehn-Ammerlahn et al., 2008) and on subjective age over 4 years (Stephan et al., 2016). Contrary, Seidler and Wolff (2017) found a bidirectional association between self-perception of aging and processing speed across 3 years. Hence, more longitudinal research is in place to illuminate the conditions under which cognitive functioning may affect ATOA.

Considering subjective cognitive complaints. Eventually, actual (decline in) cognitive test performance may be less crucial for ATOA compared to what people *think* how their cognitive skills develop. It could be the case that change in ATOA is more strongly related to the personal experience of declining cognitive abilities—and less to objective measures of cognition. This line of reasoning is supported by findings showing that subjective health has greater value for well-being than objective health indicators (e.g., Braun, Schmukle, & Kunzmann, 2017). Thus, we argue that considering subjective cognitive complaints about cognitive functioning is a novel and valuable extension to understand linkages between ATOA and cognitive factors, which has been rather neglected by previous work on views on aging.

Studying the personal interpretation of cognitive aging has a long research tradition using indicators that, for example, assess complaints about cognition (subjective cognitive complaints; e.g., Burmester et al., 2016) or specific to memory (e.g., memory complaints or subjective memory; Mitchell et al., 2014; Verhaeghen et al., 2000). Just as views of aging become more negative, cognitive complaints increase with advancing age (Ponds, van Boxtel, & Jolles, 2000). A lot of work addressed the question of whether cognitive complaints can be considered a valid indicator of actual deficits in cognition and have potential value in predicting further cognitive decline or dementia (Burmester et al., 2016; Jessen et al., 2010; Mitchell et al., 2014). Subjective

memory complaints even build a key criterion in some definitions for diagnoses of mild cognitive impairment, a transitional cognitive state between normal aging and early dementia (Petersen et al., 2014). Interestingly, despite a plethora of previous studies, there seems to be no clear consensus on the relationship of subjective cognitive complaints and current impairment or risk of future cognitive decline. Recent reviews found very small but significant associations between cognitive complaints and objective cognitive functioning—cross-sectionally (Burmester et al., 2016) and longitudinally (Mendonca et al., 2016; Mitchell et al., 2014). However, large heterogeneity between study results discloses the need to specify the characteristics under which cognitive complaints can be reliably linked to objective cognition.

Cognitive complaints comprise negative judgements of one's cognitive performance (Mascherek, Zimprich, Rupprecht, & Lang, 2011) and have been conceptualized as the result of a complex and reciprocal interaction between self-referent beliefs stemming from self-schemas, internalized implicit theories, and other bases for self-construal that may be decoupled from accurate monitoring of one's own cognitive functioning (Pearman et al., 2014). Accordingly, cognitive complaints seem to be more closely related to psychological factors such as depression, anxiety, and personality than to cognitive abilities (e.g., Hülür, Hertzog, et al., 2015; Tobiansky et al., 1995; Verhaeghen et al., 2000). Converging evidence also suggests a link to views on aging (Hülür, Hertzog, et al., 2015; Pearman et al., 2014). As has been argued, ATOA may shape the perception and interpretation of aging-related cues. Internalized implicit theories about aging and memory may strongly influence cognitive complaints in aging adults due to heightened sensitivity and biased observation of their own cognitive development (e.g., Pearman et al., 2014; Segel-Karpas & Palgi, 2017), which may result in an even more negative ATOA. Apart from that, worry about declining cognitive abilities may activate age stereotypes and foster negative subjective aging experiences. Whenever older people experience cognitive failures in their everyday life this may work as a repeated trigger activating negative age stereotypes and worsening one's ATOA.

Respective empirical work is to our knowledge not available for ATOA at present, but there is some work using another indicator of views on aging, more precisely the single-item measure of subjective age. These studies suggest a moderately sized correlation between memory complaints and subjective age (Hülür, Hertzog, et al., 2015; Pearman et al., 2014; Segel-Karpas & Palgi, 2017; Stephan, Caudroit, & Chalabaev, 2011). For example, in cross-sectional analyses younger subjective age was associated with higher perceived memory self-efficacy in adults aged 60 and above (Stephan et al., 2011) and fewer memory complaints in old-old participants while controlling for level of neuroticism and depression (Pearman et al., 2014). Using data from the HRS and latent growth curve modeling, Hülür and colleagues (2015) examined longitudinal links between trajectories of cognitive complaints, memory performance, and psychological correlates in participants aged 50 and above. They found subjective age to be substantially associated with level and slope of cognitive complaints over 6 years. However, as subjective age was not assessed at all waves, it was not possible to examine concurrent changes of cognitive complaints and subjective age over the course of the study. Also drawing on the HRS sample, Segel-Karpas and Palgi (2017) found that baseline subjective age moderated the effect of episodic memory decline on cognitive complaints controlling for sociodemographics, self-rated health, activities of daily living, and depressive symptoms. Those who felt younger experienced milder changes in their cognitive complaints in response to objective changes in memory test performance over 4 years. Again, reverse effects could not be tested due to missing follow-up assessment of subjective age.

Summing up, previous studies show associations between subjective age and cognitive complaints. However, to the best of our knowledge so far no work has simultaneously addressed longitudinal linkages between trajectories of objective cognitive performance, cognitive complaints, and ATOA.

The role of midlife vs. old age. We further aim to explore linkages between cognitive ability, cognitive complaints, and ATOA in two different life phases, namely midlife and old age, which

are characterized by different conditions, peculiarities, and change dynamics. Midlife has been defined as an "in-between" life phase, still possessing many competencies of one's previous life, but also coming with first clear signs of aging such as emerging illnesses, beginning cognitive loss, and recognizing life as a limited entity (Lachman, 2004). In the context of age-related attitude formation, midlife may be seen as a critical life phase in which ATOA gains importance. Indeed, ATOA shows large variability in midlife and becomes increasingly more negative in later life (Diehl & Wahl, 2015; Miche et al., 2014). Two previous studies failed to find between-person variation in the decline of ATOA of young-old adults (Kotter-Grühn et al., 2009; Miche et al., 2014) while showing pronounced interindividual differences in change in a middle-aged group (Miche et al., 2014). These changes in ATOA in midlife may reflect varying personal experiences in the domain of cognitive aging such as declining memory, slowing in processing speed, and learning (Diehl & Wahl, 2010). Interindividual differences in nature and timing of cognitive decline have been observed (Schaie, 2005a), which in turn may shape ATOA leading to large variability and change of views on aging transitioning from midlife to early old age. Also, cognitive changes are more likely to occur and manifest in old age compared to midlife (Ronnlund et al., 2005) and can be considered more normative with increasing age. Therefore, the role of experiences of cognitive decline as a shaping factor for ATOA may be stronger in midlife as compared to old age; in midlife even rather small changes in cognitive functioning may lead to marked age attributions and worse ATOA due to their novelty, "off-time" character, and their 'signaling that life is changing effect'. Importantly and in stark contrast to old age, individuals in midlife are mostly still involved in job-related activities, which hold many opportunities to assess own cognitive functionality and apply subjective performance criteria.

Research Goals and Hypotheses

The current study examined the longitudinal interplay between ATOA, cognitive functioning, and cognitive complaints using three waves of data from the Interdisciplinary Longitudinal Study of Adult Development (ILSE) that covers 20 years. We aimed to extend previous research by focusing on two research goals. First, we strived to replicate and extend previous research targeting the relation between ATOA and long-term change in cognitive functioning by relying on a significantly longer observational period of 20 years than previous research (12 years; Siebert, Wahl, & Schröder, 2018) as well as investigating linkages separately in midlife and old age. We expect to see a substantial relation between ATOA and change in objective cognitive performance predominantly in old age due to increasing self-relevance of ATOA and more pronounced loss dynamics of cognitive functioning.

Second, also in light of the mixed results relating cognitive performance to ATOA over time, we aimed to provide another examination of the linkage among objective cognitive functioning and change in ATOA. As a new element compared to previous research, we also considered subjective cognitive complaints as a potential factor shaping ATOA. We expect substantial associations between subjective cognitive complaints and longitudinal change in ATOA in both age groups, which should be seen over and above the effect of objective cognitive functioning. Furthermore, decline in cognitive functioning, even a small but noticeable degree of decline, may be evaluated as less normative in midlife as compared to old age and, thus, may trigger change in ATOA. In contrast, older adults have already experienced and eventually adjusted to ongoing cognitive decline; in consequence, decline may be rather decoupled from ATOA in old age. We, therefore, expect the linkage among subjective cognitive complaints and change in ATOA to be stronger in the midlife sample as compared to the old age group.

Method

Sample

Data came from the ILSE study, a population-based longitudinal study in Germany with four completed measurement occasions over a time span of 20 years. Participants were randomly selected and recruited via city registers from two areas, located in East and West Germany, respectively (Leipzig and Heidelberg). The sample was stratified by birth cohort, gender, and region. The midlife cohort (C50) was born in 1950-1952 (N_{T1}= 502) and the old age cohort (C30) was born in 1930-32 (N_{T1} = 500). Assessment started in 1993/1994 (T1), follow-ups were conducted four (1997/1998, T2), 12 (2005/2006, T3), and 20 (2014/2016, T4) years after the first measurement occasion. Due to a very limited cognitive test battery applied at the second measurement occasion, this study only includes data of T1, T3, and T4.

The midlife age group was followed from their early 40s to their early 60s (T1: M_{age} = 43.7, SD = 0.92; T3: M_{age} = 55.0, SD = 0.96; T4: M_{age} = 63.5, SD = 1.18), whereas the old age group was followed from their early 60s to their early 80s (T1: M_{age} = 62.5, T3: M_{age} = 73.9, SD = 0.90; T4: M_{age} = 82.8.3, SD = 1.16). Of the old age group, 37% did not participate at T3 and another 51% of the remaining participants dropped out at T4, reducing the sample sizes to n_{T3} = 316, and n_{T4} = 152. Compared to dropouts, those participating in the fourth measurement occasion had better objective health (d = .52), were better educated (d = .19), showed better cognitive performance (d = .37), and had more positive ATOA (d = .37) at baseline, but they did not differ with respect to reported cognitive complaints (see measures section below) or gender composition. In the midlife group, 34% of the participants did not participate at T3 and another 11% of the remaining sample at T4, thus the respective sample sizes were n_{T3} = 331, and n_{T4} = 293. In this age group, participants who remained in the sample up to the fourth measurement occasion were better educated (d = .28), had better objective health (d = .23), and showed better cognitive performances (d = .54) at baseline,

whereas we found no differences with regard to ATOA, subjective cognitive complaints, or gender. The study was approved by the ethics committee of the Medical Faculty of the University of Heidelberg. After complete description of the study to the participants, written informed consent was obtained.

Measures

Attitudes toward own aging. We used the established and widely used Attitude Toward Own Aging subscale of the Philadelphia Geriatric Center Morale Scale (Lawton, 1975; see also Miche et al., 2014), which was assessed at all measurement occasions. Five statements measuring the subjective evaluation of one's aging process (e.g., *I have as much pep as I had last year*) could be either agreed or disagreed with (1 and 0). Higher scores indicate a more positive attitude toward own aging. Internal consistencies in the current sample for both age groups were acceptable with Cronbach's α = .68/.68/.67 (C30) and α = .61/.71/.70 (C50) across measurement occasions.

Cognitive complaints. Cognitive complaints were measured by four items of the Nuremberg Self-Assessment List (Oswald & Fleischmann, 1995), an established and psychometrically proven assessment tool in German-speaking countries as part of a broad cognitive assessment battery, i.e., the Nuremberg Gerontopsychological Inventory (Oswald & Fleischmann, 1985). Item phrasing is as follows: (1) *Recently, I have mixed up names, phone numbers, or the date more often*; (2) *I have forgotten birthdays of close relatives or acquaintances more often recently*; (3) *Recently, I have had more difficulties to follow others' chain of thoughts*; (4) *I have forgotten numbers and names more often recently*. The items were chosen to represent multiple aspects of cognition and to match the assessment of cognitive abilities (see Braun et al., 2017). Each item was rated on a 4-point Likert scale ranging from 1 ("*does apply*") to 4 ("*does not apply*") and recoded to ease interpretation. Therefore, high values indicate strong cognitive complaints while small values indicate few

cognitive complaints. Internal consistencies in the current sample for both age groups were acceptable with Cronbach's α = .74/.80/.75 (C30) and α = .71/.78/.75 (C50) across measurement occasions.

Cognitive abilities. Cognitive abilities were measured using three cognitive tests that were available at all measurement occasions. In the *digit symbol test* (Oswald & Fleischmann, 1995), participants were given 90 seconds to translate as many single digits into corresponding symbols as possible (e.g., 1/V, 2/X, …, 9/+). The number of correctly matched symbols served as the test score (0-67 points). In the *digit span test* (Oswald & Fleischmann, 1995), participants had to verbally repeat a series of single digits in the same order as it was given by the interviewer (part 1) or in reversed order (part 2). The sum of the maximum number of correctly repeated digits in both parts served as the test score (possible range of 0-17 points). Both tests are thought to assess working memory and processing speed. In *block design* (a subtest of the German Version of the revised Wechsler Adult Intelligence Scale; Tewes, 1991), participants were required to rearrange four or nine blocks to match two-colored patterns. Both accuracy and time taken to complete nine items were incorporated into the scoring of the test. A total of 51 points could be achieved. This measure is thought to primarily indicate perceptual reasoning. For the analyses, all scores were z-transformed using the mean and variance at the first measurement point of the midlife cohort.

Covariates. Education (number of years at school and university), gender (male = 1, female = 2), and objective health served as control variables as they are meaningfully related to cognition and ATOA (Siebert, Wahl, & Schröder, 2018; Wilson et al., 2009). At each measurement occasion, objective physical health was assessed via an in-depth medical examination. Experienced geriatricians aggregated information from multiple sources (e.g., medical check-up and interview, history of diseases, laboratory tests, geriatric assessment) into an overall physical health score ranging from 1 (*very good*) to 6 (*very bad*). The six scores were clearly labeled (e.g., "5" if

suffering from a very serious medical condition, which is not immediately life threatening) to allow objective assignment, to ensure clinical significance of the assigned health score, and to guarantee reliability. Furthermore, birth cohort (1930-32 vs. 1950-52) was used as a grouping variable to conduct differential analyses for the midlife and the old age group.

Data Analyses

We specified a multigroup latent growth curve model (Duncan & Duncan, 2004) with three parallel processes: cognitive abilities and cognitive complaints as latent factors and ATOA as a manifest indicator (Figure 4.1). To ensure equal measurement of the latent factors across age groups and across waves (Meredith & Horn, 2001), we examined metric measurement invariance in a series of nested models. First, factor loadings were set invariant across age groups and, second, over time. Cognitive abilities were indicated by the three cognitive tests. Cognitive complaints were specified as a four-indicator factor represented by four items.

Figures 4.1 and 4.2 illustrate the prediction-relevant multigroup (midlife vs. old age) latent growth curve model. The model is an extension of the one specified by Braun and colleagues (2017), which included only two waves of ILSE data. Growth curves with latent intercepts and latent linear slopes based on three measurement occasions each were specified for ATOA, cognitive abilities, and cognitive complaints. Because the growth curve of cognitive complaints revealed a curvilinear, quadratic function in the midlife group, we further introduced a quadratic slope component for this construct ensuring a suitable model fit. To investigate the longitudinal associations of cognitive abilities and complaints with ATOA, covariances and directed regression effects between the main constructs were added to the model. More precisely, we specified a) cross-domain covariances of intercepts (Figure 4.2), b) cross-domain covariances of slopes (Figure 4.2), and c) cross-domain level-change association as directed path coefficients to test effects of each variable on growth trajectories of the other variables (e.g., intercept of ATOA predicting slope in cognitive abilities and vice versa; Figure 4.1). In a following step, we controlled for the effect of gender,

education, and time-varying health by regressing ATOA, cognitive ability, and cognitive complaints at each assessment on these covariates. Gender and education were time-invariant control variables, whereas objective health at T1, T3, and T4 was modeled as a dynamic covariate.

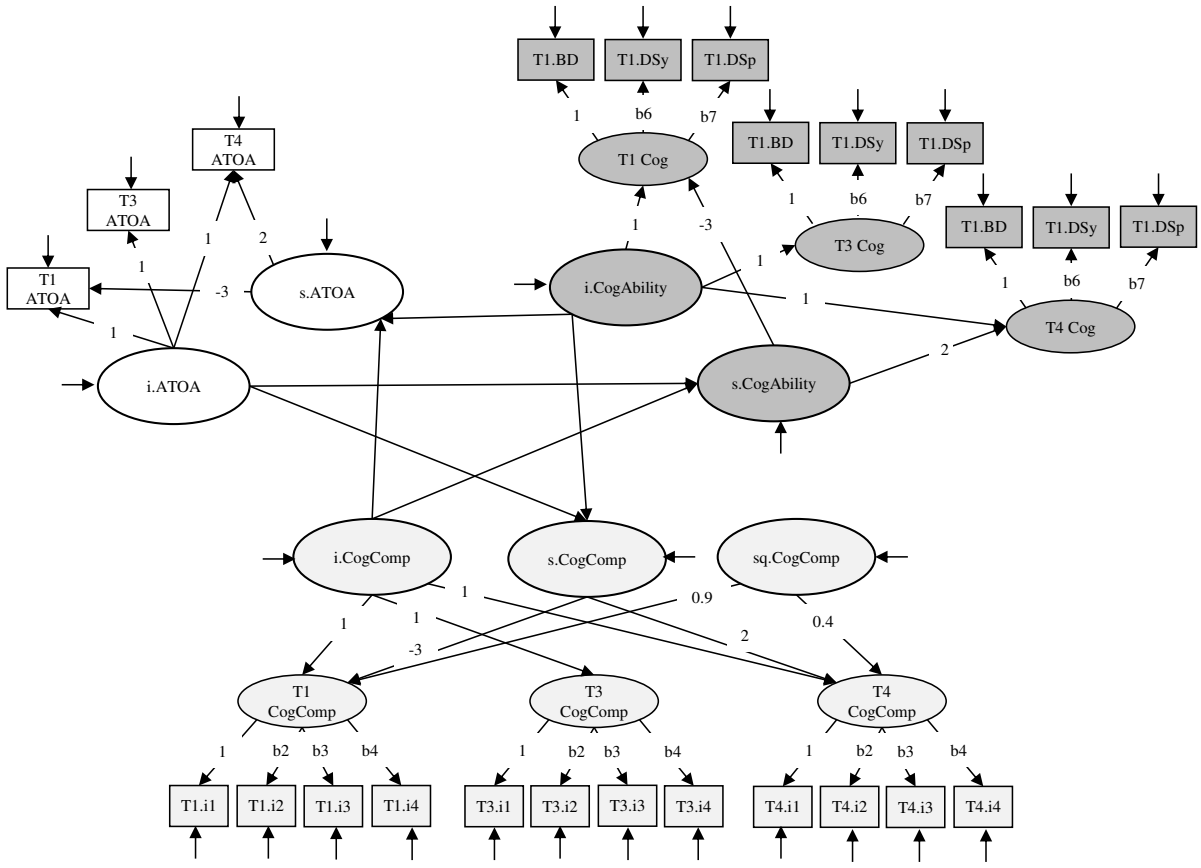

Figure 4.1. Multigroup latent growth curve model with three parallel processes across 20 years: a) attitude toward own aging (ATOA; intercept and linear slope), b) cognitive ability measured by three indicators (intercept and linear slope), and c) cognitive complaints indicated by four items (intercept, linear slope, and quadratic slope). Factor loadings were set equal across age groups and time for cognitive complaints and cognitive ability, respectively. Charted are prediction-relevant cross-domain regression effects between intercept and slope factors. To reduce complexity of the Figure, within- and cross-domain covariances are pictured in Figure 2. Model controlled for gender, education, and time-varying health. i. = intercept, s. = linear slope, sq. = quadratic slope, BD = block design, DSy = digit symbol, DSp = digit span.

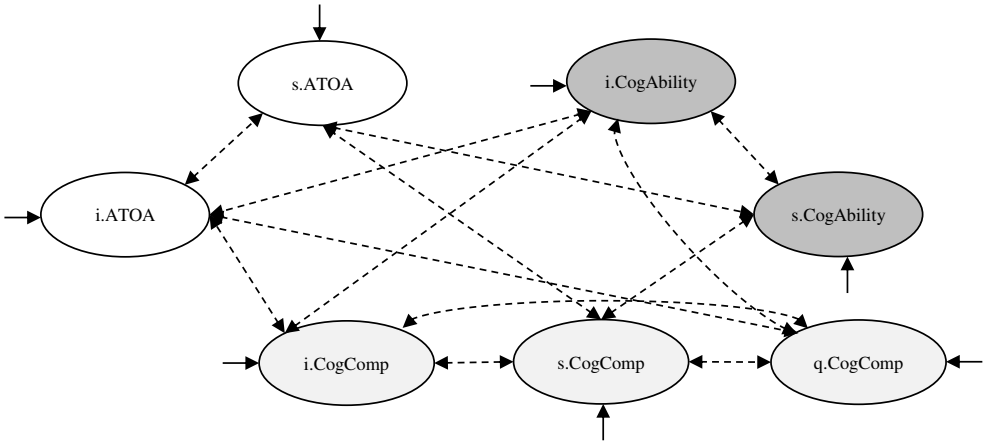

Figure 4.2. Covariances between the latent factors of the multigroup latent growth curve model depicted in Figure 4.1.

All analyses were conducted using lavaan (Rosseel, 2012), a package for structural equation modeling in R. Scripts including our model specifications are provided on the Open Science Framework at https://osf.io/9325m/. Parameter estimations were based on the Full Information Maximum Likelihood (FIML) procedure (Little & Rubin, 2002). Model fit was evaluated using the chi-square test, CFI, RMSEA, and SRMR. CFI above .90, RMSEA below .06, and SRMR below .08 are considered to indicate good model fit (Bentler & Bonett, 1980; Hu & Bentler, 1999). Differences between age groups were analyzed by applying parameter constraints to the unstandardized *b*s or covariances and were tested using chi-square difference scores. For testing measurement equivalence, we additionally used differences in CFI, which have the advantage of being independent of sample size. ΔCFI larger than .01 indicates significant decreases in model fit (Cheung & Rensvold, 2002). Cohen's *d* is reported as a measure of effect size for mean differences (Cohen, 1988) in units of the standard deviation at T1 for both age groups, respectively.

Results

Testing Measurement Invariance

As shown in Table 4.1, the loadings of cognitive abilities and cognitive complaints were invariant across age groups and time, indicating metric measurement invariance. More specifically, for both factors, the two critical comparisons between Model 1 (unconstrained model) versus the more restricted Model 2 (factor loadings constrained to be equal across age groups) and between Model 2 versus the even more restricted Model 3 (factor loadings constrained to be equal across age groups and time) yielded nonsignificant delta chi-square values, with one exception. According to the chi-square test, model fit slightly declined when the loadings of cognitive complaints were constrained to be equal across age groups. However, the CFI decreased only slightly (ΔCFI = .004), which was well below the recommended cut-off value of ΔCFI < .01. Therefore, we consider the measurement models of both cognitive measures to be invariant across age groups and time.

Table 4.1

Tests of Measurement Invariance across Age Groups and Time for Cognitive Ability and Cognitive Complaints

Construct	χ^2	*df*	CFI	RMSEA	SRMR	ΔCFI	$\Delta\chi^2$	Δdf	*p*
Cognitive ability[a]									
M_1	33.44	30	.999	.015	.022				
M_2	43.45	36	.998	.020	.036	.001	10.01	6	.124
M_3	45.12	40	.998	.016	.036	.000	1.67	4	.796
Cognitive complaints[b]									
M_1	49.79	30	.989	.036	.039				
M_2	64.34	36	.985	.040	.046	.004	14.56	6	.024
M_3	65.88	39	.985	.037	.046	.000	1.54	3	.673

Notes. χ^2 = chi-square, df = degrees of freedom, $\Delta\chi^2$ = chi-square difference, Δdf = degrees of freedom difference, M_1 = unconstrained model, M_2 = model that constrained the factor loadings to be equal across age groups, M_3 = model that constrained the factor loadings to be equal across age groups and time.
[a]N_{C50} = 502; N_{C30} = 500. [b]N_{C50} = 501; N_{C30} = 495.

Mean Changes in ATOA, Cognitive Complaints, and Cognitive Ability over 20 Years

If not stated differently, the following results were based on the latent growth curve model pictured in Figure 4.1, meaning that all three constructs were included simultaneously. The model fit was acceptable with $\chi^2(480) = 933.28$, $p < .001$; CFI = .92; RMSEA = .04, SRMR = .08.

Mean intercept and change of the main constructs, as well as age group differences in these measures, are presented in Table 4.2. ATOA was significantly more negative in the older age group corresponding to a medium effect size ($d = .47$, $p < .001$). Notably, both age groups showed a significant mean decline in ATOA and substantial variance of change in ATOA indicating inter-individual differences in initial levels and slope in midlife and old age. The old age group reported significantly more cognitive complaints than the younger group ($d = -.33$, $p < .001$). Although we found a linear decrease in complaints in midlife, there was a significant increase in old age; however, the difference in slope mean between age groups did not reach significance ($d = -.16$, $p = .999$). In addition to the linear slope, there was a significant quadratic change only in midlife. Estimated variances of level and change in cognitive complaints were significantly different from zero in both age groups. Moreover, mean cognitive ability was significantly lower in old age compared to midlife with a large effect size ($d = -.88$, $p < .001$). In both age groups mean cognitive abilities significantly declined over time, however, with substantial variance of change in cognitive abilities only in the older age group. Thus, substantial between-person differences in cognitive change were limited to old age.

Table 4.2

Estimated Mean Changes in Attitude Toward Own Aging, Cognitive Ability, and Cognitive Complaints over 20 Years in Midlife and Old Age

	Midlife				Old Age				Comparison	
	Est.	SE	*p*	*d*	Est.	SE	*p*	*d*	$\Delta\chi^2(1)$	*p*
ATOA										
Intercept										
Mean	-0.13	0.04	.003	-.19	-0.60	0.05	<.001	-.73	47.8	<.001
Variance	0.49	0.06	<.001		0.67	0.08	<.001		3.33	.068
Slope										
Mean	-0.07	0.02	<.001	-.10	-0.16	0.02	<.001	-.20	0.00	.998
Variance	0.02	0.01	.036		0.04	0.01	.007		1.22	.269
Cognitive ability										
Intercept										
Mean	0.34	0.03	<.001	.68	-0.38	0.03	<.001	-.72	261.12	<.001
Variance	0.25	0.03	<.001		0.28	0.04	<.001		0.40	.527
Slope										
Mean	-0.07	0.01	<.001	-.14	-0.12	0.01	<.001	-.23	0.00	.999
Variance	0.00	0.00	.247		0.01	0.00	<.001		11.04	<.001
Cognitive complaints										
Intercept										
Mean	-0.05	0.04	.196	-.08	0.26	0.04	<.001	.34	26.43	<.001
Variance	0.42	0.04	<.001		0.57	0.06	<.001		4.48	.034
Linear slope										
Mean	-0.04	0.02	.018	-.06	0.07	0.02	.001	.09	0.00	.999
Variance	0.02	0.00	<.001		0.03	0.01	<.001		1.43	.231
Quadratic slope										
Mean	-0.37	0.06	<.001	-.57	0.14	0.08	.069	.19	26.96	<.001
Variance	0.71	0.10	<.001		0.37	0.11	.001		5.03	.025

Note. Model fit statistics (N_{C50} = 502; N_{C30} = 500): $\chi^2(480) = 933.28$, $p < .001$; CFI = .92; RMSEA = .04, SRMR = .08.

Longitudinal Associations between Cognitive Ability, Cognitive Complaints, and Attitude Toward Own Aging

Table 4.3 presents covariances and regression estimates of the multigroup latent growth curve model connecting ATOA with cognitive complaints and cognitive abilities. First, we report cross-domain covariances of levels and of slopes (Figure 4.2) and regression effects between level and change (Figure 4.1). Second, we address findings of the latent growth curve model controlling for education, gender, and objective health.

Level of ATOA was associated with level of both measures of cognition in midlife and old age. Participants with more positive ATOA also showed higher cognitive ability ($\beta_{C30} = .41$, $p < .001$; $\beta_{C50} = .25$, $p = .001$) and reported less cognitive complaints ($\beta_{C30} = -.35$, $p < .001$; $\beta_{C50} = -.33$, $p < .001$). For cognitive ability, this association was stronger in midlife compared to old age ($\chi^2(1) = 4.13$, $p = .042$). Lower levels of cognitive complaints were associated with higher levels of cognitive ability but only in old age ($\beta_{C30} = -.17$, $p = .032$).

As expected, level of ATOA had a significant effect on change in cognitive ability over 20 years in old age ($\beta_{C30} = .24$, $p = .035$), indicating that participants initially reporting more negative ATOA showed a steeper decline in their cognitive ability. There was no such effect from ATOA on change in cognitive ability in midlife.

Furthermore, initial levels of cognitive ability or cognitive complaints had no significant effect on the change trajectory of ATOA in neither age group. With regard to cross-domain covariances of slopes, linear change in ATOA was only associated with linear change in cognitive complaints in the midlife group. Participants with fewer decreases in cognitive complaints across 20 years in midlife showed steeper decline in ATOA ($\beta_{C50} = -.34$, $p = .001$). This association was nonsignificant in old age, neither was there a significant slope association between ATOA and cognitive ability in either age group. Both level-change associations between cognitive complaints and cognitive ability were nonsignificant in midlife and old age. Linear change in cognitive ability was

negatively associated with change in cognitive complaints among old age (β_{C30} = -.33, p = .007) but not in midlife.

Table 4.3

Latent Growth Curve Model Examining Associations between Attitude Toward own Aging, Cognitive Ability, and Cognitive Complaints

	Midlife				Old Age				Comparison	
	b	SE	*p*	β	*b*	SE	*p*	β	$\Delta\chi^2(1)$	*p*
Covariances										
i.ATOA with										
s.ATOA	0.04	0.02	.013	**.39**	0.05	0.02	.010	**.33**	0.31	.577
i.Cog ability	0.09	0.03	.001	**.25**	0.18	0.04	<.001	**.41**	4.13	.042
i.Cog complaints	-0.15	0.03	<.001	**-.33**	-0.22	0.05	<.001	**-.35**	1.28	.258
i.Cog complaints with										
s.Cog complaints	-0.03	0.01	<.001	**-.34**	-0.00	0.01	.996	-.00	3.22	.073
sq.Cog complaints	-0.37	0.05	<.001	**-.68**	-0.28	0.07	<.001	**-.61**[a]	4.32	.038[a]
i.Cog ability	-0.01	0.02	.825	-.02	-0.07	0.03	.032	**-.17**[a]	2.61	.106
i.Cog ability with										
s.Cog ability	0.01	0.00	.101	.36[a]	-0.00	0.00	.872	-.02	1.12	.289
s.ATOA with										
s.Cog ability	0.00	0.00	.893	.04	-0.00	0.00	.504	-.09	0.43	.513
s.Cog complaints	-0.01	0.00	.001	**-.34**	-0.01	0.00	.208	-.15	0.17	.683
s.Cog complaints with										
s.Cog ability	-0.00	0.00	.123	-.26	-0.00	0.00	.007	**-.33**	3.58	.058
sq.Cog complaints	0.06	0.01	<.001	**.56**	0.01	0.02	.577	.11	4.32	.038
Regression coefficients										
s.ATOA										
i.Cog ability	0.03	0.03	.315	.11	0.01	0.04	.832	.02	0.18	.670
i.Cog complaints	-0.04	0.02	.115	-.18	-0.04	0.03	.089	-.17[a]	0.03	.862
s.Cog ability										
i.ATOA	0.01	0.01	.080	.34	0.02	0.01	.035	**.24**	0.35	.553
i.Cog complaints	0.01	0.01	.216	.24	0	0.01	.834	.02	0.39	.532
s.Cog complaints										
i.ATOA	-0.01	0.02	.688	-.04	-0.02	0.03	.513	-.09	0.11	.743
i.Cog ability	0.03	0.03	.270	.11[a]	-0.03	0.05	.611	-.08	0.92	.336

Notes. i. = intercept, s. = linear slope, sq. = quadratic slope. Model fit statistics (N_{C50} = 502; N_{C30} = 500): $\chi^2(480) = 933.28$, p < .001; CFI = .92; RMSEA = .04, SRMR = .08. [a] Significance of parameter changed after controlling for gender, education, and time-varying health.

Inclusion of covariates. In a follow-up step, analyses were controlled for effects of gender, education, and time-varying health. Results of the growth curve model remained mostly unchanged, with some exceptions. Interestingly, after controlling for gender, education, and concurrent health two additional level-slope regression effects emerged. The intercept of cognitive complaints predicted slope in ATOA in old age at the threshold of significance (β_{C30} = -.21, p = .054), suggesting that participants with initially fewer cognitive complaints showed relatively less unfavorable change in ATOA. Moreover, level of cognitive ability had a significant regression effect on change in cognitive complaints in midlife (β_{C50} = .22, p = .027). Thus, participants with higher cognitive abilities reported a stronger increase in cognitive complaints over time. Regarding cross-domain covariances of intercepts, level of cognitive complaints did no longer covary significantly with level of cognitive ability in old age (β_{C30} = -.11, p = .188). All remaining results did not differ substantially from findings reported in Table 4.3.

Discussion

This study investigated long-term change associations between cognitive ability, cognitive complaints, and ATOA in the second half of life. We applied parallel process latent growth curve modeling and used data from the ILSE study covering two age groups of adults in midlife and old age over 20 years. Findings suggest interlinkages between change trajectories of ATOA and cognitive factors, however, depending on the considered direction, whether cognitive ability was assessed objectively versus subjectively, and the developmental period.

With respect to our first research goal, intercept of ATOA predicted change in objective cognitive function across the long period of 20 years in the old age group only. Participants with more negative ATOA revealed steeper cognitive decline over time controlling for gender, education, and health. This is consistent with previous ILSE research based on an observational interval of 12 years (Siebert, Wahl, & Schröder, 2018). Moreover, ATOA predicted cognitive change over

20 years in the old age group (participants in their early 60 at baseline) but not in midlife (participants in their early 40 at baseline), which accords well with the literature showing that views on aging gain developmental relevance with increasing age (Levy, 2009; Levy et al., 2012). Summing up on our first research goal, findings replicated and further strengthened the predictive role of ATOA for objective cognitive long-term change in old age.

Regarding our second research goal on reverse effects, higher level of ATOA was associated with lower level of cognitive complaints and with higher level of cognitive performance in both age groups. However, objective cognitive performance did not predict change in ATOA. That is, change in ATOA was unrelated to level and change in cognitive abilities in midlife and old age. This finding is in line with most other studies finding no long-term predictive effect of cognition on different measures of views on aging indicating that views on aging rather drive change in cognitive abilities than the reverse (Hughes & Lachman, 2018; Kleinspehn-Ammerlahn et al., 2008; Stephan et al., 2016). However complementing previous evidence (Hülür, Hertzog, et al., 2015; Segel-Karpas & Palgi, 2017), we found subjective cognitive complaints meaningfully associated with change in ATOA in both age groups. In midlife, a significant change correlation indicated that participants with more negative change in ATOA also showed more pronounced increases in cognitive complaints. In old age, higher level of cognitive complaints predicted more negative change in ATOA across 20 years.

Comparing a midlife and an old age group, we only found limited support for age-specific effects. In line with our hypothesis, subjective cognitive complaints and views on aging are already related in midlife. Participants with steeper decline in ATOA showed less favorable changes in cognitive complaints between their early 40s and mid-60s. Yet, there is also some indication in our study that complaints shape ATOA in old age. Participants who reported lower levels of cognitive complaints showed more favorable patterns of change in ATOA across 20 years after con-

trolling for the effects of gender, education, health, and cognitive decline. This only partly contradicts theorizing that adults might have adjusted to experiences of cognitive decline with increasing age, weakening the link between cognitive development and ATOA in old age. Our data indicate that cognitive decline rather begins to occur in young-old age and these changes correspond to changes in cognitive complaints. Participants in the old age group may thus encounter first serious age-related changes in the cognitive domain to which they have not yet become accustomed. Moreover, the fact that the link between complaints and change in ATOA in old age only emerged after controlling for covariates points to an effect specific to cognition apart from the general health status.

Taken together, we observed substantial but differential linkages of cognitive complaints to longitudinal change in ATOA in both age groups. Importantly when interpreting these age differences, cohort and historical effects need to be taken into account that might influence the way people grow older during different historical times. More research is warranted to further investigate the mutual relationship, their direction, and configuration in different age groups.

At a conceptual level, there are several arguments speaking to a formative involvement of subjective cognitive complaints in ATOA. Laboratory-based cognitive tests might have limited validity when compared to the subjective reports of cognitive complaints (Langlois & Belleville, 2014). Reports of cognitive complaints can offer valuable additional insight, may be well suited to capture what matters for aging individuals, namely everyday cognitive functioning and subtle changes thereof, and have been shown to predict future cognitive impairment (Jessen et al., 2014; Jessen et al., 2010). Some scholars have suggested that discrepancies between laboratory and everyday cognition reflect several factors, including contributions of noncognitive traits (e.g., personality, motivation) and that cognitive tests often demand maximal levels of performance (Hess, 2014; Salthouse, 2012). Thus, also considering measures of everyday cognition, which likely form a basis for subjective aging experiences, may be an interesting target for future research.

In a similar vein, previous research indicates a strong relationship between a person's general, implicit theories about memory aging and personal complaints about their own memory suggesting that personal memory beliefs are, in part, grounded in implicit theories (Lineweaver & Hertzog, 1998). Implicit theories that people hold about aging and cognition may similarly inform reports about ATOA and cognitive complaints. In addition, ATOA and cognitive complaints may tap into similar sources of personal evaluations. For example, both ratings involve processes of social comparisons. Older adults have been shown to rely on social comparison when constructing their views on aging (Hughes & Lachman, 2018; Stephan, Chalabaev, Kotter-Grühn, & Jaconelli, 2013). Relatedly, it has been argued that individuals not only rely on temporal comparisons (i.e., contrasting current with former cognitive abilities) for ratings of cognitive complaints but also use social comparisons with peer groups of older adults (Mascherek & Zimprich, 2011). Moreover, tendencies of complaining about cognitive decline may trigger negative views on aging in other people, provoking stereotype-influenced responses toward that person (Hess, 2006). Being repeatedly treated like an older person may then feed back into one's awareness of aging and heightened monitoring of own aging-related performances reinforcing negative self-views. Salience and experience of cognitive decline might also more directly activate and reinforce old age stereotypes leading to more negative subjective aging. This reasoning would be in line with our finding that level of cognitive complaints predicted change in aging attitudes in old age.

Summing up on our second research goal regarding the formation of ATOA, findings provided important differentiations in terms of subjective cognitive complaints as an experientially framed outcome of cognitive functioning. That is, changes in ATOA seem to be more closely attached to cognitive complaints as compared to objective cognitive abilities, highlighting the importance of subjective awareness of declining abilities—independent of actually measurable cognitive loss.

There was considerable between-person variability in 20-year change in ATOA not only in midlife but also in old age, which is in contrast to other studies on the formation of ATOA in old

age providing shorter follow-up periods of 6 years (Kleinspehn-Ammerlahn et al., 2008) or 12 years (Miche et al., 2014). Moreover, we found between-person variation in cognitive complaints in both age groups, whereas for cognitive abilities meaningful decline with interindividual variability emerged only in the older age group. Participants in the midlife group, who were followed until their early sixties, were simply too young to exhibit 'enough' cognitive change. Interestingly, these same participants reported differential trajectories of subjective complaints backing previous reflections that cognitive complaints are more closely tied to factors other than objective performance, for example, personality traits, depressive symptoms, anxiety, and subjective age (Hülür, Hertzog, et al., 2015; Pearman et al., 2014). One study suggested that the extent of cognitive change was interpreted differently according to one's views on aging (Segel-Karpas & Palgi, 2017). That is, there was no relation between cognitive complaints and subsequent memory change in participants feeling much younger than their actual age, while complaints did predict memory change in those feeling relatively older. Though we did not test such moderating effects, this interpretation would be in line with the pattern of correlated change in our midlife group.

One important direction for future research is to further explore the interplay and mechanisms that explain reciprocal links between views on aging and cognitive factors. Emerging conceptual and empirical work addresses the underlying behavioral, physiological, and psychological pathways by which views on aging turn into cognitive and health outcomes (Levy, 2009; Siebert, Wahl, Degen, et al., 2018; Wurm et al., 2017), though the complex interplay is not yet fully understood. Future studies are also desirable in order to understand how subjective cognitive complaints and changes in ATOA are related. It might be worthwhile to investigate potential third variables that may create a predisposition towards negative evaluations of one's functioning and the aging process like negative affect, personality variables, or socioeconomic factors.

Our findings indicate that subjective, rather than objective, cognitive factors play a role in influencing a person's ATOA and extend the list of existing modifiers already comprising social

resources, objective and subjective health, and depressive symptoms (Jung & Jopp, 2018; Levy, 2008; Miche et al., 2014; Sargent-Cox, Anstey, & Luszcz, 2012a). Important questions that arise in the study of developmental timeframes and influences of ATOA are *what exactly constitute triggers for updates in estimates of aging attitudes?* More so, *is it a continuous process rather than one happening in jumps*? (Staudinger, 2015). Despite growing evidence, these questions remain open. To enhance our understanding approaches are needed that combine observations from micro-level and intraindividual processes (i.e., generated in daily assessment studies) with long-term development at a macro-level.

Study Limitations and Future Research

To our knowledge, the present study is unique in longitudinally examining trajectories of views on aging with cognitive complaints and objective performance during midlife and old age. Strengths of the study include the long observational period of 20 years, inclusion of two age groups, and the repeated assessment of well-established, reliable indicators of each construct. Nevertheless, the following limitations deserve consideration. First, generalizability of study findings is limited to some extent given the challenges involved in longitudinal studies. Over the extensive observational period, we retained a strong response rate of participants overall; however, reduction in sample size was particularly evident in the older age group at the 20-year measurement occasion. Furthermore, dropout of study participants was somewhat selective in both age groups.

Second, the regression from level of cognitive complaints on slope in ATOA in old age had a *p*-value of .054 and was only at the threshold of significance. Clearly, replication in independent samples is needed to strengthen this finding.

Third, both ATOA and cognitive complaints were assessed via self-report measures; hence, subject to same method-related biases like social desirability that may occur using self-reports and may account for some of the shared variance. For a rather implicit self-referred measure of attitudes such as ATOA, it seems, however, elusive to find more objective measurement approaches.

Fourth, with the ATOA scale, we used a rather global unidimensional evaluation of one's aging process without being able to disentangle its specific components related to cognitive, physical, social, or financial factors. However, as domains might differ in their importance and personal relevance depending on a person's age (Kornadt & Rothermund, 2015), it would be beneficial measuring views on aging in multiple different domains to enable direct analyses of the link between cognitive decline and changes in views on aging in the cognitive domain. A helpful scale would be the measure of awareness of age-related change (AARC; Diehl & Wahl, 2010) that separately considers age-related losses and gains across five domains.

Despite these limitations, our study contributes to the literature on antecedents and developmental consequences of ATOA by examining long-term change associations with subjective cognitive complaints and objective cognitive abilities in the second half of life. Our results suggest that cognitive complaints rather than objective cognitive decline serve as important correlate and precursor of changes in ATOA. Thus, a focus on objective cognitive performance is too narrow and should be complemented by subjective reports of daily functioning. In addition, understanding the developmental timelines of such interlinkages profits from a lifespan perspective. Whereas developmental cognitive consequences of ATOA become apparent in old age, the linkages between ATOA and cognitive complaints are already crucial in midlife, as well as in terms of early prevention efforts. Besides intervention programs to explicitly improve views on aging (Kotter-Grühn, 2015), another indirect but beneficial way may involve early cognitive training approaches that also target cognitive complaints.

Chapter 5 – General Discussion

Against the background of the high relevance of identifying favorable conditions and individual resources to promote cognitive health in an aging society, the aim of this dissertation was to examine the role of attitude toward own aging (ATOA) for cognitive development across the second half of life. Building on recent conceptual and empirical advances in the field relating views of aging and cognitive performance (see again Table 1.1 and Figure 1.1), the present work strived to contribute to research gaps in four major thematic areas. The main objective was (a) whether negative ATOA constitutes a long-term risk factor for normal and pathological cognitive aging. Furthermore, open questions related to the issues of (b) bidirectionality, (c) underlying pathways, and (d) individual characteristics as potential moderators of the link between ATOA and cognitive abilities in later life were investigated. Respective findings were channeled into three published/submitted papers that drew on 12- and 20-year data spaces of the ILSE study with adult samples in midlife and old age.

The sections below summarize and discuss empirical findings of the papers organized by these research topics. Finally, strengths and limitations of the present research are discussed, followed by outlining future research directions as well as practical implications.

Main Findings

ATOA as Long-Term Risk Factor for Cognitive Decline in Later Life

As hypothesized, more negative ATOA predicted an accelerated normative decline in cognitive abilities in young-old adults over an observational period of 12 years (Paper 1). Follow-up analyses conducted in Paper 3 showed that the predictive effect of ATOA on normal cognitive aging trajectories even extended up to 20 years. Thus, older adults with more negative aging attitudes as compared to those with more positively toned ATOA showed a steeper decline in cognitive functioning over up to 20 years. These findings are in line with established as well as more

recently published work confirming long-term relations between different measures of views on aging and a range of cognitive outcomes, including memory (Levy et al., 2012; Robertson et al., 2016; Stephan et al., 2016), verbal fluency (Robertson et al., 2016), and processing speed (Seidler & Wolff, 2017).

The replication potential of the present findings is important in the light of this previous research demonstrating that ATOA is a largely underestimated risk factor for cognitive decline. Moreover, results also extend the current scientific knowledge in the area in several ways. First, the parallel multi-indicator assessment of cognitive functioning covering fundamentally different components such as fluid (high age-related sensitivity) and crystallized (high age-related stability) abilities enabled domain-specific examinations. As was expected given their differences in life-span dynamics, age vulnerability, and dependency on individual investment, initial ATOA was indeed strongly related to decline in age-vulnerable fluid abilities, while no long-term association with performance on crystallized cognitive tests was found. The multi-component assessment of cognitive abilities of this work adds a new dimension to previous studies mainly focusing on memory performance as the sole outcome, hence, without differentiating more from less age-vulnerable cognitive functions.

Second, taking advantage of up to four repeated assessments over rather long observational intervals, the present analyses show that the harmful effect of negative ATOA, or, to put it the other way round, the protective effect of positively toned ATOA is long lasting and likely unfolds over decades.

Third, another novelty is that the concept of ATOA, which has been previously proven predictive of health indicators (Westerhof et al., 2014), is also of high relevance in the context of cognitive aging. Seen in conjunction with the literature reviewed in Table 1.1, the now available evidence suggests that the repeatedly observed effects from age views on cognitive aging are not limited to certain measures (such as subjective age). Instead, this rather reflects a global pattern

emerging independent of the views on aging measures. In other words, the connection between views on aging and cognitive aging can increasingly rely on convergent findings based on a multi-method approach of assessing views on aging, which also implies establishing a new modifiable risk factor of cognitive aging in the literature.

Importantly, as Paper 2 indicates, substantial links between ATOA and cognitive functioning are not limited to normal cognitive decline. More negative ATOA also increased the risk of future diagnosis of MCI and AD by 31% within a 12-year follow-up, while controlling for sociodemographic, health, and genetic factors. This result strengthens recent evidence that was able to relate views on aging to AD biomarkers (Levy et al., 2016) and dementia screening tests (Levy et al., 2018; Stephan, Sutin, Luchetti, et al., 2018). Noteworthy, our study used expert-based diagnostic procedures to identify cognitive pathology of study participants. The current state of evidence overall indicates that negative age views are associated with a greater risk of cognitive pathology and dementia, though there may be not sufficient evidence to firmly establish views on aging as a risk factor yet. Emerging findings linking views on aging also with biological indicators (Levy et al., 2016; Stephan et al., 2015; Stephan, Sutin, et al., 2019b) suggest that individual age views may serve as an early marker to detect dementia proneness.

In addition, this dissertation provides first empirical evidence on the association between ATOA and *subjective* measures of cognitive decline over time. In contrast to the largely converging findings related to objective cognitive outcomes as summarized above, however, long-term linkages with subjective cognitive complaints remained less clear in our research. That is, findings compiled in Paper 3 revealed substantial associations between ATOA and subjective cognitive complaints over time, which point to shared developmental dynamics of both variables; however, no prediction effect from ATOA on change in cognitive complaints was observed (see next section for further discussion).

Taken together, findings suggest that ATOA is an important risk factor for future cognitive decline and cognitive pathology in old age. This effect emerged after controlling for sociodemographic, various health, as well as genetically relevant indicators and thus seems to be robust over up to two decades of observation.

Associations between ATOA and Cognitive Abilities: Testing Bidirectionality

Conceptual reasoning suggests that ATOA and views on aging in general are not only a driving force of cognitive development but also an outcome of cognitive change (see Table 1.1 and Figure 1.1). In fact, as societal age stereotypes operate, cognitive problems should serve as a major predictor of views linked to one's aging. However, the issue of bidirectionality of effects has only played a minor role in the previous empirical research and has yielded mixed results. The relation between cognitive functioning and ATOA was examined in all three dissertation papers but with particular statistical effort in Paper 3.

Studying the nature of the association between ATOA and cognitive abilities involves two different perspectives. First, are interindividual differences in cognitive function related to interindividual differences in ATOA, i.e., taking a between-person perspective (*Who has more negative attitudes?*). And, second, are cognitive abilities and change thereof related to changes in ATOA, hence, examined from a within-person perspective (*What leads to changes in attitudes?*). Addressing the first aspect, cross-sectional relations show that individuals with higher cognitive abilities generally have more favorable views on aging such as more positive ATOA (Paper 1 and 3) or younger subjective age (Hughes & Lachman, 2018). As recent research suggests, this is even true in a life-span perspective connecting early life cognitive functioning with subjective age in old age: Findings by Stephan and colleagues (Stephan, Sutin, Kornadt, Caudroit, & Terracciano, 2018) using 50-year data from the Wisconsin Longitudinal Study reveal that higher adolescent IQ was related to younger subjective age 50 years apart. With regard to the second question, however, converging evidence indicates that neither objective cognitive abilities nor respective change can

explain intraindividual *changes* in views on aging in mid- and later life. Our results showed that middle-aged and old-aged participants with higher cognitive abilities also reported more positive ATOA cross-sectionally, but objective cognitive abilities did not predict subsequent change in ATOA, neither over 12 years (Paper 1) nor over 20 years (Paper 3). Also in the context of dementia-related disorders one may assume that more negative ATOA follows the symptoms of pathological cognitive decline processes. Yet, results from Paper 2 deviate from this assumption. Despite heterogeneous cognitive decline between study participants with some progressing to MCI or AD and others not, change in ATOA over time was unrelated to cognitive status after 12 years. This is in line with findings in Paper 3, which did not confirm a meaningful association between objective cognitive decline and changes in ATOA across 20 years. Thus, according to our findings, the common argument that change (loss) in cognitive function, normal or pathological, drives the occurrence of negative age views may not be as true as assumed in both everyday reasoning and the existing scientific literature.

Given the prevalent conceptual argument that cognitive abilities foster change in ATOA, our findings may be seen as somewhat surprising. Notably, however, these null findings parallel most empirical work in the cognitive domain (Hughes & Lachman, 2018; Kleinspehn-Ammerlahn et al., 2008; Stephan et al., 2016) and those studying associations with other key developmental outcomes. For example, longitudinal studies did not find health (Sargent-Cox, Anstey, & Luszcz, 2012b; Spuling, Miche, Wurm, & Wahl, 2013) and depressive symptoms (Dutt et al., 2018; Spuling et al., 2013) to be robust determinants of changes in views on aging, whereas the other causal direction was well supported.

As an important extension to previous research, this work combined trajectories of ATOA with both objective cognitive functioning and *subjective* cognitive complaints. Examining long-term change in the association of ATOA with subjective cognitive complaints, Paper 3 showed that cognitive complaints rather than objective cognitive decline were an important correlate and

precursor of changes in ATOA. The personal experience of cognitive decline was strongly related to changes in ATOA, indicating that the subjective awareness of cognitive loss matters more than objectively measurable decline. Apparently, there are fundamental differences in respective long-term associations of objective (developmental outcome) and subjective (developmental antecedent) cognitive measures with ATOA. A focus on objective cognitive performance thus seems too narrow as subjective reports about subtle changes in everyday cognitive function offer valuable additional insight into the link between cognitive development and views on aging.

A prerequisite for identifying factors related to changes in views on aging is that individuals differ in how their age views change over time. Therefore, the interindividual variability of trajectories of ATOA was investigated. Paper 1 showed that over the 12-year interval no substantial between-person variability in change in ATOA occurred in old age. Thus, ATOA became more negative with advancing age—but with high similarity in trajectories for all participants. When extending the observational period to 20 years (Paper 3) considerable variation in ATOA between the study participants now in their advanced old age emerged. More precisely, participants transitioned from their third to their fourth age, which is characterized by high vulnerability and unpredictability as well as sizeable functional loss and high levels of frailty (Baltes & Smith, 2003) and shifting from a positive to a predominantly "negative view of the future potential to sustain and improve life quality" (p. 125). The long observation period and possible differences in severe multiple loss experiences between participants may account for this pattern.

Overall, the findings of this dissertation indicate a disposition-like concept of ATOA that becomes increasingly negative as people age, reveals pronounced differences between older adults in their third age (Diehl & Wahl, 2010; Wurm et al., 2017) as well as slope variability when extending observational periods to the fourth age, and shows limited responsiveness to objective cognitive decline. Instead of being driven by objective cognitive loss, age views may be grounded in cultural stereotypes and psychological variables like control beliefs, self-efficacy, or personality

tinting the subjective awareness and evaluation of aging-related decline (Diehl et al., 2014; Lineweaver & Hertzog, 1998). The importance of psychological resources to deal with age-related loss was also observed in a recent study on daily variations in subjective age (Bellingtier & Neupert, 2019). Interestingly, whereas daily control beliefs were related to daily subjective age in a sample of older adults, stressors and physical health symptoms were not. The authors concluded that the occurrence of stressors or health problems was not as important as feeling in control and being able to manage them.

Considering the findings discussed above, the initial question of uni- or bidirectionality deserves a more differentiated answer. While views on aging robustly predict cognitive aging outcomes across cognitive domains, different measures of views on aging as well as study length, the reverse direction needs a more detailed examination. The contribution of cognitive factors on change in ATOA seem to vary depending on the analytical approach (between- versus within-person) and the source of cognitive reports (subjective versus objective cognitive decline).

Pathways Underlying the Association between ATOA and Cognitive Decline

Treating long-term pathways between ATOA and cognitive development requires conceptual reasoning that addresses the diversity of possible operating mechanisms. Therefore, it seems promising to connect theoretical work on age views (Levy, 2009; Wurm et al., 2017) with established knowledge on risk factors of cognitive decline. Following Levy's tripartite stereotype embodiment theory (2009), theoretical and empirical findings were compiled to delineate potential psychological, behavioral, and physiological mechanisms with specific importance for cognitive aging (see again Figure 1.1). These considerations led to the empirical testing of two pathways. Paper 2 investigated the role of leisure activity (i.e., physical, cognitive, and social activity; behavioral pathway) and control beliefs (psychological pathway) as potential mediators operating between ATOA and future MCI/AD diagnosis. However, no significant mediation effects emerged. Study limitations like insufficient sample power and challenges related to the measure of leisure activity (e.g.,

single assessment, self-report measure) may account for this finding. Seen in conjunction with the few existing studies testing mechanisms between views on aging and cognitive functioning (e.g., physical activity; Stephan et al., 2016, 2017), empirical evidence on long-term pathways in the context of cognitive aging remains inconclusive. Therefore, a major task for future research is to empirically identify underlying mechanisms. Understanding how negative views on aging accelerate cognitive decline is pivotal to validate and anchor the predictor effect as well as to inform prevention efforts. Promising future steps may be the repeated collection of activity data and their characteristics (e.g., sort, frequency, and intensity) in everyday life via ecological momentary assessments as well as the consideration of objective and physiological parameter like stress reactivity.

Findings from experimental studies also suggest that a more nuanced research approach considering personal and situational factors is needed. In recent work, Hess and colleagues (Hess, Growney, & Lothary, 2019; Hess et al., 2018) showed that personally held or experimentally activated negative aging stereotypes did not necessarily lead to higher cardiovascular responses or worse performance in cognitive challenging situations as found previously (Levy et al., 2000). Instead, the effects of aging attitudes depended on situational factors such as the experimentally manipulated intrinsic motivation to perform well (Hess et al., 2019). Moreover, greater levels of experienced cognitive costs linked to negative aging attitudes negatively affected intrinsic motivation and engagement in cognitively demanding but beneficial activities (Hess et al., 2018).

These findings reveal that some individuals are more susceptible to the negative consequences of views on aging based upon the importance they assign to an aging-related experience or the degree to which they enjoy and value cognitive health in later life (Hess et al., 2019). It is thus important to characterize personal factors beyond aging attitudes that interact with the assumed psychological, behavioral, and physiological mechanisms and to disclose conditions and situations under which negative views on aging are particularly harmful to cognitive aging.

Individual Factors Moderating the Link between ATOA and Cognitive Abilities

Given that key individual characteristics tint and shape a person's age views and cognitive functioning, the role of *age group* and *gender* as moderators of the link between ATOA and cognition was examined. Both variables constitute highly salient and relevant social categories closely tied to different expectations in terms of functionality and age effects. Investigating gender differences in multigroup latent change score models, Paper 1 raised doubt that a 'double standard of aging' generally disfavors women (Sontag, 1972); instead, there was a stronger link between ATOA and cognitive decline in men over 12 years. Although there are substantive reasons for this (less health-related behavior and the male ideal of cognitive power; see discussion of Paper 1), it is rather ambiguous whether gender differences describe the actual relation between ATOA and cognitive decline or whether findings were caused by sampling issues and limited between-person change in cognitive decline among women. To further illuminate the moderating role of gender, more studies should explicitly focus on gender-specific effects rather than statistically controlling for such effects. Replication of findings is warranted in samples with greater age ranges and younger birth cohorts given that social roles and educational as well as occupational access for men and women have become increasingly aligned over the past century. This research may also profit from measures that differentiate aging experiences in multiple domains in order to map possible gender-specific biases.

Moreover, previous evidence suggests that the formation and developmental relevance of ATOA is linked to developmental windows or life phases (Miche et al., 2014). Making use of both ILSE birth cohorts, Paper 3 therefore also aimed at investigating change patterns of ATOA and cognitive development in midlife vs. old age by means of multigroup latent growth curve modeling. In line with the literature (Levy, 2009; Levy et al., 2012) that views on aging gain *developmental relevance* with increasing age, negative ATOA was a risk factor for cognitive decline in the older (60 years at baseline) but not in the younger cohort (40 years at baseline). In fact, even

within the old age cohort effects became stronger with increasing age. As Paper 1 revealed, ATOA predicted cognitive decline only after extending the observational interval from 4 to 12 years that is, when participants reached their mid-70s.

In contrast, there was less evidence for age differences with regard to the *formation* and *developmental antecedents* of ATOA. First, Paper 3 demonstrated a mean decline in ATOA over 20 years in midlife and old age as well as meaningful interindividual variability in decline in both age groups. The latter result notably expands existing knowledge derived from studies with age heterogeneous sample, yet shorter follow-up (Kleinspehn-Ammerlahn et al., 2008), or previous ILSE research (Miche et al., 2014) finding no substantial heterogeneity in older adults. Our data suggest that when very long timeframes spanning over decades and the pivotal transition to the fourth age are taken into consideration, ATOA declines not uniformly but differentially among individuals. The explanation likely lies in a multitude of loss experiences which may occur in quite different constellations at the between-individual level, such as personal experiences of severe age-related losses like pressing morbidity, death of spouse, increasing functional limitations and dependency, or need for care (Baltes et al., 2006; Baltes & Smith, 2003). Yet, since between-individual slope differences only occur across long observation periods in old age, we argue that this finding does not conflict with the basic assumptions of ATOA's trait-like character with pronounced differences between individuals rather than within individuals (e.g., Diehl & Wahl, 2010). Second, in terms of developmental antecedents of ATOA, cognitive complaints were longitudinally related to change in ATOA in both age groups (Paper 3). However, finding a latent change correlation in midlife and a prediction effect in old age, there is some indication that the association might differ among age groups. More research including samples with wider age rages is needed to better understand the nature of the long-term association between views on aging and cognitive complaints in different developmental stages of life.

Taken together, evidence supports the relevance of considering individual factors like gender and age group when studying the link between views on aging and cognitive development. Both views on aging and cognitive abilities as well as their longitudinal association showed specific characteristics depending on the life phase (midlife versus old age), which underlines the importance of a life-span approach.

Strengths and Limitations

This section serves as an integrated discussion of strengths and limitations of the present dissertation. Instead of revisiting weaknesses of the individual papers that are mentioned in the respective chapters, more general and overarching aspects regarding conceptual and methodological issues will be addressed.

As can be seen from the many recently published studies in the field (see again Table 1.1), the dissertation touches upon a hot topic connecting two major traditions of psychological aging research: views on aging and cognitive aging. Understanding their developmental co-dynamic bears practical implications for an aging society. Findings help to inform healthy aging by a) identification of a novel modifiable risk factor for normal and pathological cognitive decline in later life and by b) providing further insight into designing effective interventions to improve age views.

A major strength of the present dissertation lies in its longitudinal approach with a unique observation up to 20 years due to the use of data from the ILSE study, a German population-based study with rich interdisciplinary examinations (Sattler et al., 2017). Covering two birth cohorts and a follow-up span of two decades, studies included individuals over the entire second half of life, i.e., from middle adulthood (early 40s) to old-old age (mid 80s). This allows gaining new insights into long-term change dynamics between age views and cognitive decline as well as comparing strength and direction of associations in different age groups. Another advantage is the high quality and number of measures assessed in ILSE. This includes a broad range of cognitive abilities

based on reliable and well-established cognitive tests such as the Wechsler Intelligence Scale (Tewes, 1991) and a thorough gero-medical examination that provides an expert-based diagnosis of cognitive status and overall physical health.

Moreover, availability of multiple measurement points and large sample sizes allow for taking advantage of state-of-the-art statistical modeling approaches that have only found rare application in related research endeavors before, such as dual latent change score models (Paper 1), logistic regressions with mediation analyses (Paper 2), and latent growth curves with parallel process modelling (Paper 3). In most cases, latent indicators were used to reduce contribution of measurement error and measurement invariance was specified to ensure equal measurement of latent indicators across time and groups (Meredith & Horn, 2001).

Concluding, the present thesis built on the remarkable potential of the ILSE study in terms of study length, cohort design, and data protocol richness that was combined with a theoretical-conceptual framework linking age views and cognitive aging from a life-span perspective. This enabled investigating the role of ATOA for different facets of cognitive aging in normal and pathological ranges, as well as their reverse relationship; in addition, two critical life phases transitioning from midlife to young-old age and from young-old to old-old age were available. However, there are also important limitations of the dissertation that need to be addressed and that may offer new avenues for future research.

Similar to other longitudinal studies, the ILSE sample is plagued by positive selection bias and systematic study dropout (Van Beijsterveldt et al., 2002). Participants who had higher cognitive abilities, were healthier, better educated, and reported more positive ATOA at baseline were more likely to remain in the study over 12 and 20 years. Sample selectivity limits generalizability of findings and likely reduces between-person variability in study variables. This may limit statistical power to detect small effects leading to a potential underestimation of true effects (Button et al., 2013). Still, dropout rates in ILSE are lower than one would expect from other long-term studies

(Sattler et al., 2017). 789 out of 1002 initial participants completed the third wave after 12 years (78.7%). At the fourth measurement wave, 570 participants were re-examined resulting in a high longitudinal response rate of 56.9% after 20 years (Hildesheim et al., under review). In order to at least partially counteract systematic dropout, advanced state-of-the-art procedures were applied to handle missing data in all analyses. Robust weighted least squares (WLSMV), Monte Carlo integration, and full information maximum likelihood (FIML) were used to provide more consistent and efficient estimates of population parameters (Hoyle, 2012).

Given the cross-sequential study design operationalized in ILSE, age is confounded with cohort and time period (Schaie, 2006), making it difficult to disentangle age, cohort, and period effects in the data. ILSE participants from the two cohorts grew up in different historical times. This is especially relevant given that the old age sample was born in the early 1930s, thus, before World War II and came of age during and shortly after the war. In contrast, the midlife sample was born in the early 1950s growing up during the years of the "Wirtschaftswunder" ("economic miracle") with increasing prosperity and stability. Thus, both cohorts were exposed to different historical forces during the formative years in their development, such as educational attainment, identity development, and entry into the labor force. This might have affected their cognitive development as well as their ATOA, and thus might have an influence on the mutual relation between the variables.

Moreover, using a German longitudinal study limits the cross-cultural generalizability of study findings. As shown in Table 1.1, previous longitudinal studies linking age views and cognitive functioning mainly involved American, Irish, and German samples. Hence, effects may not be representative for non-Western cultures since research indicates that content of age stereotypes can differ between cultures (Löckenhoff et al., 2009). In particular, given existing evidence that views on aging in the cognitive domain are even less favorable in Asian countries (Cha & Seo,

2009; Voss, Kornadt, Hess, Fung, & Rothermund, 2018), it would be intriguing to examine linkages between ATOA and cognitive functioning in these cultures.

Regarding the measures used in this dissertation, mostly well-established instruments were applied. All three papers rely on ATOA as a measure views on aging (Lawton, 1975). As stated in the Introduction, on the one hand, ATOA seems well suited for the current research purpose. On the other hand, being a global and unidimensional scale, the ATOA instrument has its shortcomings in terms of fully accounting for the heterogeneity of aging-related beliefs and evaluations (Kornadt & Rothermund, 2015). In addition to cognitive decline, aging individuals experience changes in multiple domains like physical health, work, finance, social roles, and interpersonal relations. Thus, ATOA likely captures a multitude of different aging experiences that are individually weighted. Moreover, importance and relevance of these domains can vary between persons and change according to a person's age (Kornadt & Rothermund, 2015). As such, a number of studies support the so-called stereotype-matching effect (Levy & Leifheit-Limson, 2009) showing stronger links between views on aging and developmental outcome when both measures refer to the same domain (Wurm et al., 2017). A promising and important step for future research is therefore to further qualify this dissertation's findings using scales like AARC (Diehl & Wahl, 2010) that capture the awareness of becoming older as a multidimensional experience. Assessing views on aging specific to cognitive functioning might lead to a better and more differentiated prediction of cognitive decline and, thereby, easing the search for operating pathways. Discrimination between gain- and loss-oriented as well as domain-specific aging experiences may also allow for a more fine-tuned assessment of changes in views on aging in the cognitive domain. For example, the lack of responsiveness of ATOA to ongoing cognitive changes in both normal and pathological ranges may owe to its limited sensitivity to alterations in single domains. It therefore remains open

to future research to examine whether cognitive decline does aggravate age views specific to cognitive functioning, and if so, whether associations vary by individual factors like gender or age group.

In addition, the third variable problem also applies to the present research. While we controlled for a range of covariates, other variables (e.g., personality, SES, depressive symptoms) that were not considered may also contribute to the relationship between both constructs. For example, personality traits—reflecting dispositional patterns of perception, evaluation, and behavior (Baltes et al., 2006)—show substantial associations with views on aging (Kornadt, Siebert, & Wahl, under review; Miche et al., 2014; Rupprecht, Dutt, Wahl, & Diehl, 2019) and cognitive aging (Wettstein et al., in press). Individuals with higher neuroticism may be particularly prone to the harmful effects of negative ATOA due to a heightened sensitivity toward experiences of (cognitive) loss and an maladaptive physiological stress responses (Bibbey, Carroll, Roseboom, Phillips, & de Rooij, 2013; Schneider, 2004). Moreover, openness comes along with active striving for gain-related goals in the aging process (Rupprecht et al., 2019). Hence, openness may buffer against the negative consequences of ATOA on cognitive decline. More research is needed to elucidate the interplay and possible interaction between personality, views on aging, and normal as well as pathological cognitive decline over time.

Another limitation that arises when studying cognitive aging in longitudinal data sets concerns the issue of practice or retest effects (Salthouse, 2010). An unexpected, slight increase in cognitive performance observed in the younger cohort between wave 1 and wave 2 that were only 4 years apart indeed supports this assumption. However, subsequent examination waves were about 8 years apart, respectively, reducing the risk of lasting practice effects.

Implications and Outlook

Drawing from the present findings, three major lines of action are in place: empirical, conceptual, and practical. One key *research* implication arising from this thesis is the need for the application of new study designs and more differentiated measures in order to enhance understanding of the developmental dynamic between views on aging and cognitive aging. In addition to the existing experimental, cross-sectional, and longitudinal work, it seems worthwhile to complement these perspectives by the study of micro-processes. For example, measurement burst designs on daily activities and health behaviors offer the possibility to track back what people with more positive views on aging are actually doing and experiencing throughout their days. This can provide new insights into pathways operating between more positive age views and prolonged cognitive health in later life. Moreover, daily assessments can show whether and how cognitive performance as well as perceived cognitive failures and complaints relate to fluctuations in views on aging even on a daily basis.

Indeed, recent findings based on daily diary designs show substantial associations between subjective age and control beliefs (Bellingtier & Neupert, 2019) and stress reactivity (Bellingtier & Neupert, 2018). One study found that older workers' tendency to attribute personal and social events to age depended on daily variations in subjective age and age identification and that blaming age was coupled with higher negative affect and less cognitive engagement (Armenta, Scheibe, Stroebe, Postmes, & Van Yperen, 2018). Further integrating such micro perspectives on daily fluctuations into long-term development at a macro level can provide valuable information about the formation and malleability of age views, the kind of information that triggers change in age views (or not), and whether age views change rather steadily or more suddenly after a special and meaningful experience (Staudinger, 2015).

Another novel and interesting approach is to examine neurobiological correlates and genetic underpinnings of views on aging in the context of cognitive functioning. There is some empirical

indication that younger subjective age is cross-sectionally associated with larger regional grey matter volume and younger predicted brain age (Kwak, Kim, Chey, & Youm, 2018). Notably, differences in grey matter volume were found in brain regions related to metacognition, self-awareness, and cognitive decline (Kwak et al., 2018). Studying genetic underpinnings of subjective age, Stephan and colleagues (Stephan, Sutin, Kornadt, & Terracciano, 2019) found subjective age to be related to polygenic scores of education, well-being, and negative affect but unrelated to polygenic scores of cognition and dementia. Thus, this study provides no indication that the relation between younger felt age and better cognitive abilities is a result of a possibly lower genetic propensity to cognitive decline in people feeling younger than their age. Overall, to further illuminate the role of views on aging in this cause-effect chain—are they symptom, early sign, moderator, or cause of cognitive decline?—more work also considering genetic and neurobiological correlates of views on aging is warranted.

In this thesis, assumptions were derived based on work relying on various operationalizations of views on aging beyond the ATOA subscale. Although these concepts are assumed to be strongly related (e.g., Diehl et al., 2014) and there is some empirical support for an overlap of construct (Brothers et al., 2017), a thorough empirical evaluation is still pending. It is therefore necessary that future studies compare established uni- and multidimensional concepts in terms of their formation across the lifespan, potential changeability and timing thereof, as well as their developmental relevance for specific outcomes. This holds major implications for interventions against negative age views by identifying people at risk of cognitive decline, composing meaningful ingredients of intervention strategies, and finding the appropriate timing for intervening.

With the availability of two developmental windows (midlife and old age), this dissertation underscores that views on aging gain importance with increasing age and are subject to changes already in midlife. To expand scientific knowledge on the life-span relatedness of developmental dynamics between age views and cognition as well as its conditions, it is necessary that future

studies target early age and adolescence as well as old-old age. For instance, evidence suggests that the course is set already at an early stage as higher intelligence in early life was shown to relate to younger felt age in later life, being partly mediated by openness (Stephan, Sutin, Kornadt, et al., 2018). So far, little is known about the conditions of subjective aging experiences in a period of life characterized by high frailty, vulnerability, and multi-morbidity. The ILSE study period ended when participants were about 85 years old and thus entered very old age. As this is the period of life characterized by highest vulnerability (Baltes & Smith, 2003) and steepest cognitive declines (Singer et al., 2003), associations may be different compared to earlier life phases. That is, the predictive effect of views on aging may weaken because morbidity-related and biological processes become the main driving forces of very old adults' cognitive development (Baltes et al., 2006).

Furthermore, dissertation findings stimulate *theorizing* and *conceptual work* regarding views on aging specific to cognitive development but also in more general terms. Missing a thorough framework on how negative views on aging turn into normal and pathological cognitive decline, it has been proposed that views on aging may affect cognitive decline via one's cognitive reserve (Stern, 2002, 2009, 2012). By helping to build up a stronger cognitive reserve, i.e., through beneficial activity and health patterns, individuals with more positive views on aging may be less affected by the negative consequences of age-related neurodegeneration because they have higher reserve thresholds. More conceptual work backed by empirical research is needed to validate this reasoning. Hence, one important contribution to the field would be to further spell out an overall conceptual framework integrating diverse findings on cognitive risk factors and cognitive reserve with evidence on age view and their genetic and neurobiological underpinnings and pathways. Furthermore, and as has been argued elsewhere (Diehl et al., 2014), there is a need to develop an overarching theoretical model that integrates not only cognitive factors but a broad range of de-

velopmental antecedents, consequences, and mechanisms of views on aging from a life-span perspective. In addition to individual factors primarily considered in this work, also contextual and socio-historical factors form both views on aging and functioning as well as their relationship (Diehl et al., 2014; Wurm et al., 2017). Kornadt and Rothermund (2015) argue that development is always a result of the interaction of an individual with the social and historical contexts and findings should be interpreted in consideration thereof.

In addition, this work also holds *practical* value. Taken together with other studies (e.g., Levy, 2016; Stephan et al., 2017; 2018), there is robust evidence that negative views on aging accelerate cognitive decline and pose a threat for dementia in later life. To this end, views on aging deserve to be considered as a meaningful risk factor of cognitive decline alongside the range of the classical risk factors. In a latest book chapter on cognitive aging, Dixon and Lachman (2019) take this overdue step by explicitly adding views on aging to the list of important risk factors of cognitive decline in old age. This underlines the need of exploiting the emerging potentials and improving views on aging in society and individuals as one rewarding avenue to promote cognitive health in old age. Interventions to counteract negative views on aging may pay off in several ways by reducing negative age stereotypes as well as their unjustified prejudices and adverse feelings and by contributing to cognitive functioning. Such interventions on malleable psychological risk factors offer promising low-cost options. Initial attempts to develop and empirically investigate interventions (e.g., AgingPLUS; Brothers & Diehl, 2017) that target views on aging are encouraging. Large trainings studies like the ACTIVE Study (Tennstedt & Unverzagt, 2013) that aim at maintaining cognitive health and functional independence in older adults through targeted intervention could thus profit from adopting new training components on how to foster positive age views. However, to date, studies that systematically address and evaluate intervention programs and their effectiveness as well as sustainability for cognitive outcomes are still missing. One important direction for future research therefore is to evaluate whether and how findings can be transferred into efficient

intervention strategies in order to reduce cognitive decline in old age. Dissertation findings suggest that it would be important to particularly target individuals with lower cognitive abilities and those reporting high levels of cognitive complaints. Moreover, interventions may profit from also explicitly treating subjective cognitive complaints. Focusing already on individuals in midlife may prevent these individuals from developing even more complaints and even more negative age views as they age.

Finally, implications can be derived at different contextual level (see again Figure 1.1, Albarracin & Shavitt, 2018). Next to approaches enhancing positive views on aging in individuals and people at risk, actions at community and country level are essential. Evidence suggests that individual age views are influenced by population aging on the district level (Wolff, Beyer, Wurm, Nowossadeck, & Wiest, 2018). Directly affecting the environment of aging adults, efforts at community level to provide good infrastructure and opportunities for intergenerational contact and social integration may thus help to promote positive views on aging. "Investing in infrastructure and in leisure time facilities for older persons may contribute to the perception of having opportunities for ongoing development in old age among the inhabitants of these regions" (Wolff et al., 2018, p. 54). In a recent study including eight European countries, even small differences in perception of old age at the population level were significantly related to cognitive functioning at the individual level (Smith et al., 2018). A more positive status of old age in the population was linked to higher cognitive functioning of individuals living in that country. This finding discloses the need for policy and public health interventions also at country level to improve cognitive health in older individuals. The school could be a vehicle to transmit differentiated knowledge about aging already at a very early stage. Though a slight positive trend was reported in Germany (Beyer, Wurm, & Wolff, 2017), the even increasing negativity of common age stereotypes in the English language (Levy, 2017; Ng et al., 2015), demands a clear-cut message that positive age views significantly

contribute to health in old age in order to encourage individuals to take active control and responsibility for their own aging process. However, a balanced view when informing about a nuanced and differentiated picture of age-related gains and losses as well as individual opportunities appears crucial.

References

Aartsen, M. J., Martin, M., & Zimprich, D. (2004). Gender differences in level and change in cognitive functioning: Results from the Longitudinal Aging Study Amsterdam. *Gerontology, 50*(1), 35-38. doi: 10.1159/000074387

Abrams, D., Eller, A., & Bryant, J. (2006). An age apart: The effects of intergenerational contact and stereotype threat on performance and intergroup bias. *Psychology and Aging, 21*(4), 691-702. doi: 10.1037/0882-7974.21.4.691

Albarracin, D., & Shavitt, S. (2018). Attitudes and attitude change. *Annual Review of Psychology, 69*, 299-327. doi: 10.1146/annurev-psych-122216-011911

Armenta, B. M., Scheibe, S., Stroebe, K., Postmes, T., & Van Yperen, N. W. (2018). Dynamic, not stable: Daily variations in subjective age bias and age group identification predict daily well-being in older workers. *Psychology and Aging, 33*(4), 559-571. doi: 10.1037/ pag0000263

Aslanidis, C., & Schmitz, G. (1999). High-speed apolipoprotein E genotyping and apolipoprotein B3500 mutation detection using real-time fluorescence PCR and melting curves. *Clinical Chemistry, 45*(7), 1094-1097.

Baltes, P. B. (1987). Theoretical propositions of life-span developmental psychology: On the dynamics between growth and decline. *Developmental Psychology, 23*, 611-626. doi: 10.1037/0012-1649.23.5.611

Baltes, P. B. (1997). On the incomplete architecture of human ontogeny - Selection, optimization, and compensation as foundation of developmental theory. *American Psychologist, 52*, 366-380. doi: 10.1037//0003-066x.52.4.366

Baltes, P. B., & Baltes, M. M. (1990). Psychological perspectives on successful aging: The model of selective optimization with compensation. In P. B. Baltes & M. M. Baltes (Eds.),

Successful aging: Perspectives from the behavioral sciences (pp. 1-34). New York, NY: Cambridge University Press.

Baltes, P. B., Lindenberger, U., & Staudinger, U. M. (2006). Life span theory in developmental psychology. In R. M. Lerner & W. Damon (Eds.), *Handbook of child psychology: Theoretical models of human development* (6 ed., pp. 569-664). New York, NY: Wiley.

Baltes, P. B., & Smith, J. (2003). New frontiers in the future of aging: From successful aging of the young old to the dilemmas of the fourth age. *Gerontology, 49*, 123-135. doi: 10.1159/000067946

Bamidis, P. D., Vivas, A. B., Styliadis, C., Frantzidis, C., Klados, M., Schlee, W., . . . Papageorgiou, S. G. (2014). A review of physical and cognitive interventions in aging. *Neurosci Biobehav Rev, 44*, 206-220. doi: 10.1016/j.neubiorev.2014.03.019

Barber, S. J. (2017). An examination of age-based stereotype threat about cognitive decline: Implications for stereotype-threat research and theory development. *Perspectives on Psychological Science, 12*(1), 62-90. doi: 10.1177/1745691616656345

Bargh, J. A., & Chartrand, T. L. (1999). The unbearable automaticity of being. *American Psychologist, 54*(7), 462-479. doi: 10.1037//0003-066x.54.7.462

Barnes, D. E., Alexopoulos, G. S., Lopez, O. L., Williamson, J. D., & Yaffe, K. (2006). Depressive symptoms, vascular disease, and mild cognitive impairment: Findings from the cardiovascular health study. *Archives of General Psychiatry, 63*(3), 273-280. doi: 10.1001/archpsyc.63.3.273

Bartres-Faz, D., Cattaneo, G., Solana, J., Tormos, J. M., & Pascual-Leone, A. (2018). Meaning in life: Resilience beyond reserve. *Alzheimers Research & Therapy, 10*. doi: 10.1186/s13195-018-0381-z

Baumgart, M., Snyder, H. M., Carrillo, M. C., Fazio, S., Kim, H., & Johns, H. (2015). Summary of the evidence on modifiable risk factors for cognitive decline and dementia: A

population-based perspective. *Alzheimers & Dementia, 11*(6), 718-726. doi: 10.1016/j.jalz.2015.05.016

Bellingtier, J. A., & Neupert, S. D. (2018). Negative aging attitudes predict greater reactivity to daily stressors in older adults. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 73*(7), 1155-1159. doi: 10.1093/geronb/gbw086

Bellingtier, J. A., & Neupert, S. D. (2019). Feeling young and in control: Daily control beliefs are associated with younger subjective ages. *Journals of Gerontology, Series B: Psychological and Social Sciences*, Advanced online publication. doi: 10.1093/geronb/gbz015

Bentler, P. M., & Bonett, D. G. (1980). Significance tests and goodness of fit in the analysis of covariance-structures. *Psychological Bulletin, 88*(3), 588-606. doi: 10.1037/0033-2909.107.2.238

Beyer, A.-K., Wurm, S., & Wolff, J. K. (2017). Älter werden – Gewinn oder Verlust? Individuelle Altersbilder und Altersdiskriminierung. In K. Mahne, J. K. Wolff, J. Simonson & C. Tesch-Römer (Eds.), *Altern im Wandel: Zwei Jahrzehnte Deutscher Alterssurvey (DEAS)* (pp. 329-343). Wiesbaden: Springer Fachmedien.

Bibbey, A., Carroll, D., Roseboom, T. J., Phillips, A. C., & de Rooij, S. R. (2013). Personality and physiological reactions to acute psychological stress. *International Journal of Psychophysiology, 90*(1), 28-36. doi: 10.1016/j.ijpsycho.2012.10.018

Bickel, H. (2018). Informationsblatt 1: Die Häufigkeit von Demenzerkrankungen: Deutsche Alzheimer Gesellschaft e.V. Selbsthilfe Demenz.

Birren, J. E. (1965). Age changes in speed of behavior: Its central nature and physiological correlates. In A. T. Welford & J. E. Birren (Eds.), *Behavior, aging and the nervous system: Biological determinants of speed and behavior* (pp. 191-216). Springfield, IL: Charles C. Thomas.

Boss, L., Kang, D. H., & Branson, S. (2015). Loneliness and cognitive function in the older adult: A systematic review. *International Psychogeriatrics, 27*(4), 541-553. doi: 10.1017/S1041610214002749

Bowen, C. (2010). *Images of aging are related to the plasticity of adult development.* (Doctoral dissertation), Jacobs University, Bremen.

Boyle, P. A., Buchman, A. S., Wilson, R. S., Yu, L., Schneider, J. A., & Bennett, D. A. (2012). Effect of purpose in life on the relation between Alzheimer disease pathologic changes on cognitive function in advanced age. *Archives of General Psychiatry, 69*(5), 499-505.

Brandtstädter, J. (1998). Action perspectives on human development. In W. Damon & R. M. Lerner (Eds.), *Handbook of child psychology: Theoretical models of human development* (pp. 807-863). Hoboken, NJ: John Wiley & Sons.

Brandtstadter, J., & Renner, G. (1990). Tenacious goal pursuit and flexible goal adjustment: Explication and age-related analysis of assimilative and accommodative atrategies of coping. *Psychology and Aging, 5*(1), 58-67. doi: 10.1037/0882-7974.5.1.58

Brandtstädter, J., & Rothermund, K. (2003). Intentionality and time in human development and aging: Compensation and goal adjustment in changing developmental contexts. In U. M. Staudinger & U. Lindenberger (Eds.), *Understanding human development: Dialogues with lifepan psychology* (pp. 105-124). Boston, MA: Kluwer Academic Publishers.

Braun, T., Schmukle, S. C., & Kunzmann, U. (2017). Stability and change in subjective well-being: The role of performance-based and self-rated cognition. *Psychology and Aging, 32*(2), 105-117. doi: 10.1037/pag0000153

Brewer, M. B., & Lui, L. (1984). Categorization of the elderly by the elderly: Effects of perceiver's category membership. *Personality and Social Psychology Bulletin, 10*, 585-595. doi: 10.1177/0146167284104012

Brickenkamp, R. (1981). *d2 Test of Attention*. Göttingen, Germany: Hogrefe.

Brothers, A., & Diehl, M. (2017). Feasibility and efficacy of the aging plus program: Changing views on aging to increase physical activity. *Journal of Aging and Physical Activity, 25*(3), 402-411. doi: 10.1123/japa.2016-0039

Brothers, A., Miche, M., Wahl, H.-W., & Diehl, M. (2017). Examination of associations among three distinct subjective aging constructs and their relevance for predicting developmental correlates. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 72*(4), 547-560. doi: 10.1093/geronb/gbv085

Brubaker, M. S., & Naveh-Benjamin, M. (2018). The effects of stereotype threat on the associative memory deficit of older adults. *Psychology and Aging, 33*(1), 17-29. doi: 10.1037/ pag0000194

Bryant, C., Bei, B., Gilson, K., Komiti, A., Jackson, H., & Judd, F. (2012). The relationship between attitudes to aging and physical and mental health in older adults. *International Psychogeriatrics, 24*, 1674-1683. doi: 10.1017/S1041610212000774

Burmester, B., Leathem, J., & Merrick, P. (2016). Subjective cognitive complaints and objective cognitive function in aging: A systematic review and meta-analysis of recent cross-sectional findings. *Psychological Review, 26*(4), 376-393. doi: 10.1007/s11065-016-9332-2

Button, K. S., Ioannidis, J. P. A., Mokrysz, C., Nosek, B. A., Flint, J., Robinson, E. S. J., & Munafò, M. R. (2013). Power failure: Why small sample size undermines the reliability of neuroscience. *Nature Reviews Neuroscience, 14*, 365. doi: 10.1038/nrn3475

Caplan, L. J., & Schooler, C. (2003). The roles of fatalism, self-confidence, and intellectual resources in the disablement process in older adults. *Psychology and Aging, 18*(3), 551-561. doi: 10.1037/0882.7974.18.3.551

Carstensen, L. L. (2006). The influence of a sense of time on human development. *Science, 312*, 1913-1915. doi: 10.1126/science.1127488

Cattell, R. B. (1963). Theory of fluid and crystallized intelligence: A critical experiment. *Journal of Educational Psychology, 54*(1), 1-22. doi: 10.1037/H0046743

Cha, M., & Seo, S. (2009). A cross-country exploration: Dietetic students' knowledge, attitudes, and intentions to provide services to the elderly. *Educational Gerontology, 35*(9), 801-817. doi: 10.1080/03601270902717996

Chasteen, A. L., Bhattacharyya, S., Horhota, M., Tam, R., & Hasher, L. (2005). How feelings of stereotype threat influence older adults' memory performance. *Experimental Aging Research, 31*, 235-260. doi: 10.1080/03610730590948177

Cheng, S. T. (2016). Cognitive reserve and the prevention of dementia: The role of physical and cognitive activities. *Current Psychiatry Reports, 18*(9), 85. doi: 10.1007/s11920-016-0721-2

Chertkow, H., Feldman, H. H., Jacova, C., & Massoud, F. (2013). Definitions of dementia and predementia states in Alzheimer's disease and vascular cognitive impairment: consensus from the Canadian conference on diagnosis of dementia. *Alzheimers Research & Therapy, 5*, S2. doi: 10.1186/Alzrt198

Cheung, G. W., & Rensvold, R. B. (2002). Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural Equation Modeling-a Multidisciplinary Journal, 9*(2), 233-255. doi: 10.1207/S15328007sem0902_5

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Earlbaum Associates.

Cotman, C. W., Berchtold, N. C., & Christie, L. A. (2007). Exercise builds brain health: Key roles of growth factor cascades and inflammation. *Trends in Neurosciences, 30*(9), 464-472. doi: 10.1016/j.tins.2007.06.011

Courtenay, W. H. (2000). Behavioral factors associated with disease, injury, and death among men: Evidence and implications for prevention. *The Journal of Men's Studies, 9*(1), 81-142. doi: 10.3149/jms.0901.81

Craik, F. I. M., & Byrd, M. (1982). Aging and cognitive deficits: The role of attentional resources. In F. I. M. Craik & S. Trehub (Eds.), *Aging and cognitive processes* (pp. 191-2011). Boston, MA: Springer.

Cummings, J. L., Doody, R., & Clark, C. (2007). Disease-modifying therapies for Alzheimer disease: challenges to early intervention. *Neurology, 69*(16), 1622-1634. doi: 10.1212/01.wnl.0000295996.54210.69

Cummings, J. L., Morstorf, T., & Zhong, K. (2014). Alzheimer's disease drug-development pipeline: few candidates, frequent failures. *Alzheimers Research & Therapy, 6*(4). doi: 10.1186/Alzrt269

Deary, I. J., Corley, J., Gow, A. J., Harris, S. E., Houlihan, L. M., Marioni, R. E., . . . Starr, J. M. (2009). Age-associated cognitive decline. *British Medical Bulletin, 92*(1), 135-152. doi: 10.1093/bmb/ldp033

Delius, J. A. M., Düzel, S., Gerstorf, D., & Lindenberger, U. (2017). Berlin Aging Studies (BASE and BASE-II). In N. A. Pachana (Ed.), *Encyclopedia of geropsychology* (pp. 386–395). New York, NY: Springer.

Diehl, M., & Wahl, H.-W. (2015). *Research on subjective aging: New developments and future directions.* (Annual Review of Gerontology and Geriatrics, Vol. 35). New York, NY: Springer.

Diehl, M., Wahl, H.-W., Barrett, A. E., Brothers, A., Miche, M., Montepare, J. M., . . . Wurm, S. (2014). Awareness of aging: Theoretical considerations on an emerging concept. *Developmental Review, 34*, 93-113. doi: 10.1016/j.dr.2014.01.001

Diehl, M., & Wahl, H.-W. (2010). Awareness of age-related change: Examination of a (mostly) unexplored concept. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 65B*, 340-350. doi: 10.1093/geronb/gbp110

Diehl, M., & Willis, S. L. (2003). Everyday competence and everyday problem solving in aging adults: Role of the physical and social context. In H.-W. Wahl, R. Scheidt & P. Windley (Eds.), *Annual Review of Gerontology and Geriatrics: Vol. 23. Aging in context: Socio-physical environments* (pp. 130-166). New York, NY: Springer.

Dixon, R. A., & Hultsch, D. F. (1983). Structure and development of metamemory in adulthood. *Journals of Gerontology, 38*(6), 682-688. doi: 10.1093/geronj/38.6.682

Dixon, R. A., & Lachman, M. E. (2019). Risk and protective factors in cognitive aging: advances in assessment, prevention, and promotion of alternative pathways. In G. Samanez-Larkin (Ed.), *The aging brain: functional adaptation across adulthood*. Washington, DC: American Psychological Association.

Dubois, B., Feldman, H. H., Jacova, C., Dekosky, S. T., Barberger-Gateau, P., Cummings, J., . . . Scheltens, P. (2007). Research criteria for the diagnosis of Alzheimer's disease: revising the NINCDS-ADRDA criteria. *Lancet Neurology, 6*(8), 734-746. doi: 10.1016/S1474-4422(07)70178-3

Duncan, T. E., & Duncan, S. C. (2004). An introduction to latent growth curve modeling. *Behavior Therapy, 35*(2), 333-363. doi: 10.1016/S0005-7894(04)80042-X

Dutt, A. J., Gabrian, M., & Wahl, H.-W. (2018). Awareness of age-related change and depressive symptoms in middle and late adulthood: Longitudinal associations and the role of self-regulation and calendar age. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 73*(6), 944-953. doi: 10.1093/geronb/gbw095

Eagly, A. H., Wood, W., & Diekman, A. B. (2000). Social role theory of sex differences and similarities: A current appraisal. In T. Eckes & H. M. Trautner (Eds.), *The developmental social psychology of gender* (pp. 123-174). Mahwah, NJ: Erlbaum.

Emile, M., Chalabaev, A., Stephan, Y., Corrion, K., & d'Arripe-Longueville, F. (2014). Aging stereotypes and active lifestyle: Personal correlates of stereotype internalization and relationships with level of physical activity among older adults. *Psychology of Sport & Exercise, 11*, 198-204. doi: 10.1016/j.psychsport.2013.11.002

Erber, J. T., Szuchman, L. T., & Prager, I. G. (1997). Forgetful but forgiven: How age and life style affect perceptions of memory failure. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 52*(6), P303-307.

Erickson, K. I., Leckie, R. L., & Weinstein, A. M. (2014). Physical activity, fitness, and gray matter volume. *Neurobiology of Aging, 35*, S20-28. doi: 10.1016/j.neurobiolaging.2014.03.034

Ferrucci, L. (2008). The Baltimore Longitudinal Study of Aging (BLSA): A 50-year-long journey and plans for the future. *Journals of Gerontology, Series A: Biological Sciences and Medical Sciences, 63*(12), 1416-1419. doi: 10.1093/gerona/63.12.1416

Finkel, D., Reynolds, C. A., McArdle, J. J., Gatz, M., & Pedersen, N. L. (2003). Latent growth curve analyses of accelerating decline in cognitive abilities in late adulthood. *Developmental Psychology, 39*(3), 535-550. doi: 10.1037/0012-1649.39.3.535

Flynn, J. R. (1984). The mean IQ of Americans: Massive gains 1932 to 1978. *Psychological Bulletin, 95*(1), 29-51. doi: 10.1037//0033-2909.95.1.29

Flynn, J. R. (2007). *What is intelligence? Beyond the Flynn effect*. New York, NY: Cambridge University Press.

Förstl, H. (2006). Kognitive Störungen: Koma, Delir, Demenz. In H. Förstl, M. Hautzinger & G. Roth (Eds.), *Neurobiologie psychischer Störungen* (pp. 221-295). Berlin, Heidelberg: Springer.

Gauthier, S., Reisberg, B., Zaudig, M., Petersen, R. C., Ritchie, K., Broich, K., . . . Winblad, B. (2006). Mild cognitive impairment. *Lancet, 367*(9518), 1262-1270. doi: 10.1016/S0140-6736(06)68542-5

Gerstorf, D., Herlitz, A., & Smith, J. (2006). Stability of sex differences in cognition in advanced old age: The role of education and attrition. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 61*(4), P245-P249. doi: 10.1093/geronb/61.4.P245

Gerstorf, D., Ram, N., Lindenberger, U., & Smith, J. (2013). Age and time-to-death trajectories of change in indicators of cognitive, sensory, physical, health, social, and self-related functions. *Developmental Psychology, 49*(10), 1805-1821. doi: 10.1037/a0031340

Ghisletta, P., Rabbitt, P., Lunn, M., & Lindenberger, U. (2012). Two thirds of the age-based changes in fluid and crystallized intelligence, perceptual speed, and memory in adulthood are shared. *Intelligence, 40*(3), 260-268. doi: 10.1016/j.intell.2012.02.008

Giles, H., Noels, K. A., Williams, A., Ota, H., Lim, T.-S., Sik Hung, N., . . . Somera, L. (2003). Intergenerational communication across cultures: Young people's perceptions of conversations with family elders, non-family elders and aame-age peers. *Journal of Cross-Cultural Gerontology, 18*, 1.

Gimson, A., Schlosser, M., Huntley, J. D., & Marchant, N. L. (2018). Support for midlife anxiety diagnosis as an independent risk factor for dementia: a systematic review. *BMJ Open, 8*(4). doi: 10.1136/bmjopen-2017-019399

Glisky, E. L. (2007). Changes in cognitive function in human aging. In D. R. Riddle (Ed.), *Brain aging: models, methods, and mechanisms* (pp. 2-30). Boca Raton: CRC Press.

Greenland, S. (2008). Invited commentary: Variable selection versus shrinkage in the control of multiple confounders. *Am J Epidemiol, 167*(5), 523-529. doi: 10.1093/aje/kwm355

Greve, W., & Thomsen, T. (2019). *Entwicklungspsychologie. Eine Einführung in die Erklärung menschlicher Entwicklung.* Wiesbaden: Springer Fachmedien.

Gulpers, B., Ramakers, I., Hamel, R., Kohler, S., Oude Voshaar, R. C., & Verhey, F. (2016). Anxiety as a predictor for cognitive decline and dementia: A systematic review and meta-analysis. *American Journal of Geriatric Psychiatry, 24*(10), 823-842. doi: 10.1016/j.jagp. 2016.05.015

Gunzelmann, T. (2008). Ist Altern messbar? In W. Oswald, G. Gatterer & U. Fleischmann (Eds.), *Gerontopsychologie (2. Aufl.)* (pp. 59-78). Wien: Springer.

Hasher, L., & Zacks, R. T. (1988). Working memory, comprehension, and aging: A review and a new view. *Psychology of Learning and Motivation, 22*, 193-225. doi: 10.1016/S0079-7421 (08)60041-9

Haskell, W. L., Lee, I. M., Pate, R. R., Powell, K. E., Blair, S. N., Franklin, B. A., . . . Bauman, A. (2007). Physical activity and public health: Updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Circulation, 116*(9), 1081-1093. doi: 10.1161/CIRCULATIONAHA.107.185649

Haslam, C., Morton, T. A., Haslam, S. A., Varnes, L., Graham, R., & Gamaz, L. (2012). "When the age is in, the wit is out": Age-related self-categorization and deficit expectations reduce performance on clinical tests used in dementia assessment. *Psychology and Aging, 27*(3), 778-784. doi: 10.1037/a0027754

Hausdorff, J. M., Levy, B. R., & Wei, J. Y. (1999). The power of ageism on physical function of older persons: Reversibility of age-related gait changes. *Journal of the American Geriatrics Society, 47*, 1346-1349.

Hayes, A. F., & Scharkow, M. (2013). The relative trustworthiness of inferential tests of the indirect effect in statistical mediation analysis: Does method really matter? *Psychological Science, 24*(10), 1918-1927. doi: 10.1177/0956797613480187

Heckhausen, J. (2001). Adaptation and resilience in midlife. In M. E. Lachman (Ed.), *Handbook of midlife development* (pp. 345-394). Hoboken, NJ: John Wiley & Sons.

Heckhausen, J., & Baltes, P. B. (1991). Perceived controllability of expected psychological change across adulthood and old-age. *Journal of Gerontology, 46*(4), P165-P173. doi: 10.1093/geronj/46.4.P165

Heckhausen, J., Dixon, R. A., & Baltes, P. B. (1989). Gains and losses in development throughout adulthood as perceived by different adult age groups. *Developmental Psychology, 25*, 109-121. doi: 10.1037/0012-1649.25.1.109

Hertzog, C. (1985). An individual-differences perspective: Implications for cognitive research in gerontology. *Research on Aging, 7*(1), 7-45. doi: 10.1177/0164027585007001002

Hertzog, C., Kramer, A. F., Wilson, R. S., & Lindenberger, U. (2008). Enrichment effects on adult cognitive development: Can the functional capacity of older adults be preserved and enhanced? *Psychological Science in the Public Interest, 9*(1), 1-65. doi: 10.1111/j.1539-6053.2009.01034.x

Hess, T. M. (2005). Memory and aging in context. *Psychological Bulletin, 131*(3), 383-406. doi: 10.1037/0033-2909.131.3.383

Hess, T. M. (2006). Attitudes toward aging and their effects on behaviour. In J. E. Birren & K. W. Schaie (Eds.), *Handbook of the psychology of aging* (2 ed., pp. 379-406). San Diego, CA: Academic Press.

Hess, T. M. (2014). Selective engagement of cognitive resources: Motivational influences on older adults' cognitive functioning. *Perspectives on Psychological Science, 9*(4), 388-407. doi: 10.1177/1745691614527465

Hess, T. M., Auman, C., Colcombe, S. J., & Rahhal, T. A. (2003). The impact of stereotype threat on age differences in memory performance. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 58B*, P3-P11. doi: 10.1093/geronb/58.1.P3

Hess, T. M., Growney, C. M., & Lothary, A. F. (2019). Motivation moderates the impact of aging stereotypes on effort expenditure. *Psychology and Aging, 34*(1), 56-67. doi: 10.1037/pag 0000291

Hess, T. M., Growney, C. M., O'Brien, E. L., Neupert, S. D., & Sherwood, A. (2018). The role of cognitive costs, attitudes about aging, and intrinsic motivation in predicting engagement in everyday activities. *Psychology and Aging, 33*(6), 953-964. doi: 10.1037/pag0000289

Hicks, S. A., & Siedlecki, K. L. (2017). Leisure activity engagement and positive affect partially mediate the relationship between positive views on aging and physical health. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 72*(2), 259-267. doi: 10.1093/geronb/gbw049

Higgins, E. T. (1998). Promotion and prevention: Regulatory focus as a motivational principle. *Advances in Experimental Social Psychology, 30*, 1-46. doi: 10.1016/S0065-2601(08) 60381-0

Hildesheim, C., Wahl, H.-W., Schröder, J., Kunzmann, U., Siebert, J. S., & Zenthöfer, A. (2019). *Interdisciplinary Longitudinal Study on Adult Development and Aging*. Manuscript submitted for publication.

Horn, J. L., & Cattell, R. B. (1967). Age differences in fluid and crystallized intelligence. *Acta Psychologica, 26*(2), 107-129. doi: 10.1016/0001-6918(67)90011-X

Horn, W. C. (1983). *Leistungsprüfsystem*. Göttingen, Germany: Hogrefe.

Horton, S., Baker, J., Pearce, G. W., & Deakin, J. M. (2008). On the malleability of performance: Implications for seniors. *Journal of Applied Gerontology, 27*, 446-465. doi: 10.1177/ 0733464808315291

Hotting, K., & Roder, B. (2013). Beneficial effects of physical exercise on neuroplasticity and cognition. *Neurosci Biobehav Rev, 37*(9 Pt B), 2243-2257. doi: 10.1016/j.neubiorev.2013.04.005

Hoyer, W. J., Stawski, R. S., Wasylyshyn, C., & Verhaeghen, P. (2004). Adult age and digit symbol substitution performance: A meta-analysis. *Psychology and Aging, 19*(1), 211-214. doi: 10.1037/0882-7974.19.1.211

Hoyle, R. H. (2012). *Handbook of structural equation modeling*. New York, NY: Guilford Press.

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Structural Equation Modeling-a Multidisciplinary Journal, 6*(1), 1-55. doi: 10.1080/10705519909540118

Hughes, M. L., Geraci, L., & De Forrest, R. L. (2013). Aging 5 years in 5 minutes: The effect of taking a memory test on older adults' subjective age. *Psychological Science, 24*, 2481-2488. doi: 10.1177/0956797613494853

Hughes, M. L., & Lachman, M. E. (2018). Social comparisons of health and cognitive functioning contribute to changes in subjective age. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 73*(5), 816-824. doi: 10.1093/geronb/gbw044

Hultsch, D. F., Hertzog, C., & Dixon, R. A. (1987). Age-differences in metamemory: Resolving the inconsistencies. *Canadian Journal of Psychology / Revue Canadienne De Psychologie, 41*(2), 193-208. doi: 10.1037/H0084153

Hülür, G., Hertzog, C., Pearman, A. M., & Gerstorf, D. (2015). Correlates and moderators of change in subjective memory and memory performance: Findings from the Health and Retirement Study. *Gerontology, 61*(3), 232-240. doi: 10.1159/000369010

Hülür, G., Ram, N., & Gerstorf, D. (2015). Historical improvements in well-being do not hold in late life: birth- and death-year cohorts in the United States and Germany. *Developmental Psychology, 51*(7), 998-1012. doi: 10.1037/a0039349

Hummert, M. L., Garstka, T. A., Shaner, J. L., & Strahm, S. (1994). Stereotypes of the elderly held by young, middle-aged, and elderly adults. *Journal of Gerontology, 49*, P240-P249. doi: 10.1093/geronj/49.5.P240

Jack, C. R., Jr., Knopman, D. S., Jagust, W. J., Petersen, R. C., Weiner, M. W., Aisen, P. S., . . . Trojanowski, J. Q. (2013). Tracking pathophysiological processes in Alzheimer's disease: an updated hypothetical model of dynamic biomarkers. *Lancet Neurology, 12*(2), 207-216. doi: 10.1016/S1474-4422(12)70291-0

Jessen, F., Amariglio, R. E., van Boxtel, M., Breteler, M., Ceccaldi, M., Chetelat, G., . . . Grp, S. I. W. (2014). A conceptual framework for research on subjective cognitive decline in preclinical Alzheimer's disease. *Alzheimers & Dementia, 10*(6), 844-852. doi: 10.1016/j.jalz.2014.01.001

Jessen, F., Wiese, B., Bachmann, C., Eifflaender-Gorfer, S., Haller, F., Kolsch, H., . . . Bickel, H. (2010). Prediction of dementia by subjective memory impairment effects of severity and temporal association with cognitive impairment. *Archives of General Psychiatry, 67*(4), 414-422. doi: 10.1001/archgenpsychiatry.2010.30

Jopp, D., & Hertzog, C. (2007). Activities, self-referent memory beliefs, and cognitive performance: Evidence for direct and mediated relations. *Psychology and Aging, 22*(4), 811-825. doi: 10.1037/0882-7974.22.4.811

Jung, S., & Jopp, D. S. (2018). Adult children's relationship to parent influences their views on aging and attitude toward own aging. *The International Journal of Aging and Human Development*. Advanced online publication. doi: 10.1177/0091415018784703

Jung, S., & Siedlecki, K. L. (2018). Attitude toward own aging: Age invariance and construct validity across middle-aged, young-old, and old-old adults. *Journal of Adult Development, 25*(2), 141-149. doi: 10.1007/s10804-018-9283-3

Kalaria, R. N., Maestre, G. E., Arizaga, R., Friedland, R. P., Galasko, D., Hall, K. T., . . . Antuono, P. (2008). Alzheimer's disease and vascular dementia in developing countries: Prevalence, management, and risk factors. *Lancet Neurology, 7*(9), 812-826. doi: 10.1016/S1474-4422(08)70169-8

Karp, A., Paillard-Borg, S., Wang, H. X., Silverstein, M., Winblad, B., & Fratiglioni, L. (2006). Mental, physical and social components in leisure activities equally contribute to decrease dementia risk. *Dementia and Geriatric Cognitive Disorders, 21*(2), 65-73. doi: 10.1159/000089919

Kastenbaum, R., Derbin, V., Sabatini, P., & Artt, S. (1972). "The ages of ME": Toward personal and interpersonal definitions of functional aging. *Aging and Human Development, 3*, 197-211. doi: 10.2190/TUJR-WTXK-866Q-8QU7

Kessler, E.-M., Bowen, C., Baer, M., Froelich, L., & Wahl, H.-W. (2012). Dementia worry: A psychological examination of an unexplored phenomenon. *European Journal of Ageing*, 1-10. doi: 10.1007/s10433-012-0242-8

Kim, S. H. (2009). Older people's expectations regarding ageing, health-promoting behaviour and health status. *Journal of Advanced Nursing, 65*(1), 84-91. doi: 10.1111/j.1365-2648.2008.04841.x

Kite, M. E., Stockdale, G. D., Whitley, B. E., Jr., & Johnson, B. T. (2005). Attitudes toward younger and older adults: An updated meta-analytic review. *Journal of Social Issues, 61*, 241-266. doi: 10.1111/j.1540-4560.2005.00404.x

Kleinspehn-Ammerlahn, A., Kotter-Grühn, D., & Smith, J. (2008). Self-perceptions of aging: Do subjective age and satisfaction with aging change during old age? *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 63B*, P377-P385. doi: 10.1093/geronb/63.6.P377

Kornadt, A. E., & Rothermund, K. (2011). Contexts of aging: Assessing evaluative age stereotypes in different life domains. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 66*, 547-556. doi: 10.1093/geronb/gbr036

Kornadt, A. E., & Rothermund, K. (2012). Internalization of age stereotypes into the self-concept via future self-views: A general model and domain-specific differences. *Psychology and Aging, 27*, 164-172. doi: 10.1037/a0025110

Kornadt, A. E., & Rothermund, K. (2015). Views on aging: Domain-specific approaches and implications for developmental regulation. In M. Diehl & H.-W. Wahl (Eds.), *Annual Review of Gerontology and Geriatrics: Vol. 35. Research on subjective aging: New developments and future directions* (pp. 121-144). New York, NY: Springer Publishing.

Kornadt, A. E., Siebert, J. S., & Wahl, H.-W. (2019). *The interplay of personality and attitudes toward own aging across two decades of later life.* Manuscript submitted for publication.

Kornadt, A. E., Voss, P., & Rothermund, K. (2013). Multiple standards of aging: Gender-specific age stereotypes in different life domains. *European Journal of Ageing, 10*, 335-344. doi: 10.1007/s10433-013-0281-9

Kornadt, A. E., Voss, P., & Rothermund, K. (2015). Hope for the best, prepare for the worst? Future self-views and preparation for age-related changes. *Psychology and Aging, 30*(4), 967-976. doi: 10.1037/pag0000048

Kornadt, A. E., Voss, P., & Rothermund, K. (2017). Age stereotypes and self-views revisited: Patterns of internalization and projection processes across the life span. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 72*(4), 582-592. doi: 10.1093/geronb/gbv099

Kotter-Grühn, D. (2015). Changing negative views of aging: Implications for intervention and translational research. In M. Diehl & H.-W. Wahl (Eds.), *Annual Review of Gerontology*

and Geriatrics: Vol. 35. Research on subjective aging: New developments and future directions (pp. 167-186). New York, NY: Springer Publishing.

Kotter-Grühn, D., Kleinspehn-Ammerlahn, A., Gerstorf, D., & Smith, J. (2009). Self-perceptions of aging predict mortality and change with approaching death: 16-year longitudinal results from the Berlin Aging Study. *Psychology and Aging, 24*, 654-667. doi: 10.1037/a0016510

Kunzmann, U., Little, T., & Smith, J. (2002). Perceiving control: A double-edged sword in old age. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 57*(6), P484-P491.

Kuzma, E., Sattler, C., Toro, P., Schonknecht, P., & Schröder, J. (2011). Premorbid personality traits and their course in mild cognitive impairment: Results from a prospective population-based study in Germany. *Dementia and Geriatric Cognitive Disorders, 32*(3), 171-177. doi: 10.1159/000332082

Kwak, S., Kim, H., Chey, J., & Youm, Y. (2018). Feeling how old I am: Subjective age is associated with estimated brain age. *Frontiers in Aging Neuroscience, 10*. doi: 10.3389/ Fnagi.2018.00168

Lachman, M. E. (1991). Perceived control over memory aging: Developmental and intervention perspectives. *Journal of Social Issues, 47*(4), 159-175. doi: 10.1111/j.1540-4560.1991. tb01840.x

Lachman, M. E. (2004). Development in midlife. *Annual Review of Psychology, 55*, 305-331. doi: 10.1146/annurev.psych.55.090902.141521

Lachman, M. E., Neupert, S. D., & Agrigoroaei, S. (2011). The relevance of control beliefs for health and aging. In K. W. Schaie & S. L. Willis (Eds.), *Handbook of the psychology of aging* (7th ed., pp. 175-190). New York, NY: Academic Press.

Lamont, R. A., Swift, H. J., & Abrams, D. (2015). A review and meta-analysis of age-based stereotype threat: Negative stereotypes, not facts, do the damage. *Psychology and Aging, 30*, 180-193. doi: 10.1037/A0038586

Langlois, A. S., & Belleville, S. (2014). Subjective cognitive complaint in healthy older adults: identification of major domains and relation to objective performance. *Neuropsychology, Development, and Cognition. Section B, Aging, Neuropsychology and Cognition, 21*(3), 257-282. doi: 10.1080/13825585.2013.795928

Lawton, M. P. (1975). The Philadelphia Geriatric Center Morale Scale: A revision. *Journal of Gerontology, 30*, 85-89. doi: 10.1093/geronj/30.1.85

Leshner, A. I., Landis, S., Stroud, C., & Downey, A. (2017). *Preventing cognitive decline and dementia: A way forward*. Washington, DC: National Academies Press.

Levy, R. (1994). Aging-associated cognitive decline. *International Psychogeriatrics, 6*, 63-68.

Levy, B. R. (1996). Improving memory in old age through implicit self-stereotyping. *Journal of Personality and Social Psychology, 71*, 1092-1107. doi: 10.1037/0022-3514.71.6.1092

Levy, B. R. (2000). Handwriting as a reflection of aging self-stereotypes. *Journal of Geriatric Psychiatry, 33*, 81-94.

Levy, B. R. (2008). Rigidity as a predictor of older persons' aging stereotypes and aging self-perceptions. *Social Behavior and Personality, 36*, 559-570.

Levy, B. R. (2009). Stereotype embodiment. A psychological approach to aging. *Current Directions in Psychological Science, 18*, 332-336. doi: 10.1111/j.1467-8721.2009.01662.x

Levy, B. R. (2017). Age-stereotype paradox: Opportunity for social change. *Gerontologist, 57*, S118-S126. doi: 10.1093/geront/gnx059

Levy, B. R., Ferrucci, L., Zonderman, A. B., Slade, M. D., Troncoso, J., & Resnick, S. M. (2016). A culture-brain link: Negative age stereotypes predict alzheimer's disease biomarkers. *Psychology and Aging, 31*(1), 82-88. doi: 10.1037/pag0000062

Levy, B. R., Hausdorff, J. M., Hencke, R., & Wei, J. Y. (2000). Reducing cardiovascular stress with positive self-stereotypes of aging. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 55B*, P205-P213. doi: 10.1093/geronb/55.4.P205

Levy, B. R., & Leifheit-Limson, E. (2009). The stereotype-matching effect: Greater influence on functioning when age stereotypes correspond to outcomes. *Psychology and Aging, 24*, 230-233. doi: 10.1037/a0014563

Levy, B. R., & Myers, L. M. (2004). Preventive health behaviors influenced by self-perceptions of aging. *Preventive Medicine, 39*, 625-629. doi: 10.1016/j.ypmed.2004.02.029

Levy, B. R., Slade, M. D., & Kasl, S. V. (2002). Longitudinal benefit of positive self-perceptions of aging on functional health. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 57B*, P409-P417. doi: 10.1093/geronb/57.5.P409

Levy, B. R., Slade, M. D., Kunkel, S. R., & Kasl, S. V. (2002). Longevity increased by positive self-perceptions of aging. *Journal of Personality and Social Psychology, 83*, 261-270. doi: 10.1037/0022-3514.83.2.261

Levy, B. R., Slade, M. D., Pietrzak, R. H., & Ferrucci, L. (2018). Positive age beliefs protect against dementia even among elders with high-risk gene. *PLoS ONE, 13*(2). doi: 10.1371/journal.pone.0191004

Levy, B. R., Zonderman, A. B., Slade, M. D., & Ferrucci, L. (2012). Memory shaped by age stereotypes over time. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 67*, 432-436. doi: 10.1093/geronb/gbr120

Light, L. L. (1988). Language and aging: Competence versus performance. In J. E. Birren & V. L. Bengtson (Eds.), *Emergent theories of aging* (pp. 177–213). New York, NY: Springer.

Lindenberger, U. (2001). Lifespan theories of cognitive development. In N. J. Smelser & P. B. Baltes (Eds.), *International encyclopedia of the social and behavioral sciences* (pp. 8848-8854). Amsterdam: Elsevier Science.

Lindenberger, U. (2014). Human cognitive aging: Corriger la fortune? *Science, 346*(6209), 572-578. doi: 10.1126/science.1254403

Lineweaver, T. T., & Hertzog, C. (1998). Adults' efficacy and control beliefs regarding memory and aging: Separating general from personal beliefs. *Aging Neuropsychology and Cognition, 5*(4), 264-296. doi: 10.1076/anec.5.4.264.771

Little, R. J., & Rubin, D. B. (2002). *Statistical analysis with missing data* New York, NY: Wiley.

Löckenhoff, C. E., De Fruyt, F., Terracciano, A., McCrae, R. R., De Bolle, M., Costa, P. T., Jr., . . . Yik, M. (2009). Perceptions of aging across 26 cultures and their culture-level associates. *Psychology and Aging, 24*, 941-954. doi: 10.1037/a0016901

Lupien, S. J., Maheu, F., Tu, M., Fiocco, A., & Schramek, T. E. (2007). The effects of stress and stress hormones on human cognition: Implications for the field of brain and cognition. *Brain and Cognition, 65*(3), 209-237. doi: 10.1016/j.bandc.2007.02.007

MacKinnon, D. P., Lockwood, C. M., Brown, C. H., Wang, W., & Hoffman, J. M. (2007). The intermediate endpoint effect in logistic and probit regression. *Clinical Trials, 4*(5), 499-513. doi: 10.1177/1740774507083434

Mascherek, A., & Zimprich, D. (2011). Correlated change in memory complaints and memory performance across 12 years. *Psychology and Aging, 26*(4), 884-889. doi: 10.1037/a0023156

Mascherek, A., Zimprich, D., Rupprecht, R., & Lang, F. R. (2011). What do cognitive complaints in a sample of memory clinic outpatients reflect? *GeroPsych, 24*, 187-195. doi: 10.1024/1662-9647/a000046

Mayeux, R., & Stern, Y. (2012). Epidemiology of Azheimer disease. *Cold Spring Harbor Perspectives in Medicine, 2*(8). doi: 10.1101/cshperspect.a006239

McArdle, J. J. (2009). Latent variable modeling of differences and changes with longitudinal data. *Annual Review of Psychology, 60*, 577-605. doi: 10.1146/annurev.psych.60.110707.163612

McArdle, J. J., Ferrer-Caja, E., Hamagami, F., & Woodcock, R. W. (2002). Comparative longitudinal structural analyses of the growth and decline of multiple intellectual abilities over the life span. *Developmental Psychology, 38*(1), 115-142. doi: 10.1037//0012-1649.38.1.115

McEwen, B. S., & Gianaros, P. J. (2011). Stress- and allostasis-induced brain plasticity. *Annual Review of Medicine, 62*, 431-445. doi: 10.1146/annurev-med-052209-100430

McEwen, B. S., & Sapolsky, R. M. (1995). Stress and cognitive function. *Current Opinion in Neurobiology, 5*(2), 205-216. doi: 10.1016/0959-4388(95)80028-X

McKelvey, R. D., & Zavoina, W. (1975). A statistical model for the analysis of ordinal level dependent variables. *The Journal of Mathematical Sociology, 4*, 103-120. doi: 10.1080/0022250X.1975.9989847

Mendonca, M. D., Alves, L., & Bugalho, P. (2016). From subjective cognitive complaints to dementia: Who is at risk? A systematic review. *American Journal of Alzheimers Disease and Other Dementias, 31*(2), 105-114. doi: 10.1177/1533317515592331

Meredith, W., & Horn, J. (2001). The role of factorial invariance in modeling growth and change. In L. M. Collins & A. G. Sayer (Eds.), *New methods for the analysis of change*. Washington, DC: American Psychological Association.

Merton, R. K. (1948). The self-fulfilling prophecy. *The Antioch Review, 8*, 193-210. doi: 10.2307/4609267

Miche, M., Elsässer, V., Schilling, O. K., & Wahl, H.-W. (2014). Attitude toward own aging in midlife and early old age over a 12-year period: Examination of measurement equivalence

and developmental trajectories. *Psychology and Aging, 29*, 588-600. doi: 10.1037/a0037259

Mitchell, A. J., Beaumont, H., Ferguson, D., Yadegarfar, M., & Stubbs, B. (2014). Risk of dementia and mild cognitive impairment in older people with subjective memory complaints: Meta-analysis. *Acta Psychiatrica Scandinavica, 130*(6), 439-451. doi: 10.1111/acps.12336

Mitchell, A. J., & Shiri-Feshki, M. (2009). Rate of progression of mild cognitive impairment to dementia: Meta-analysis of 41 robust inception cohort studies. *Acta Psychiatrica Scandinavica, 119*(4), 252-265. doi: 10.1111/j.1600-0447.2008.01326.x

Montepare, J. M. (1996). An assessment of adults' perceptions of their psychological, physical, and social ages. *Journal of Clinical Geropsychology, 2*, 117-128.

Montepare, J. M. (2009). Subjective age: Toward a guiding lifespan framework. *International Journal of Behavioral Development, 33*, 42-46. doi: 10.1177/0165025408095551

Moor, C., Zimprich, D., Schmitt, M., & Kliegel, M. (2006). Personality, aging self-perceptions, and subjective health: A mediation model. *The International Journal of Aging and Human Development, 63*, 241-257. doi: 10.2190/AKRY-UM4K-PB1V-PBHF

Moscovici, S. (1988). Notes towards a description of social representations. *European Journal of Social Psychology, 18*(3), 211-250. doi: 10.1002/ejsp.2420180303

Muthén, L. K., & Muthén, B. O. (1998-2011). *Mplus user's guide* (6th ed.). Los Angeles, CA: Muthén & Muthén.

Nelson, E. A., & Dannefer, D. (1992). Aged heterogeneity: Fact or fiction? The fate of diversity in gerontological research. *The Gerontologist, 32*, 17-23. doi: 10.1093/geront/32.1.17

Ng, R., Allore, H. G., Trentalange, M., Monin, J. K., & Levy, B. R. (2015). Increasing negativity of age stereotypes across 200 years: Evidence from a database of 400 million words. *PLoS ONE, 10*(2). doi: 10.1371/journal.pone.0117086

Nichols, E., Szoeke, C. E. I., Vollset, S. E., Abbasi, N., Abd-Allah, F., Abdela, J., . . . Murray, C. J. L. (2019). Global, regional, and national burden of Alzheimer's disease and other dementias, 1990-2016: A systematic analysis for the Global Burden of Disease Study 2016. *Lancet Neurology, 18*(1), 88-106. doi: 10.1016/S1474-4422(18)30403-4

Noble, J. M., Manly, J. J., Schupf, N., Tang, M. X., Mayeux, R., & Luchsinger, J. A. (2010). Association of C-reactive protein with cognitive impairment. *Archives of Neurology, 67*(1), 87-92.

North, M. S., & Fiske, S. T. (2015). Modern attitudes toward older adults in the aging world: A cross-cultural meta-analysis. *Psychological Bulletin, 141*(5), 993-1021. doi: 10.1037/ a0039469

Oswald, W. D., & Fleischmann, U. M. (1985). Psychometrics in aging and dementia: advances in geropsychological assessments. *Archives of Gerontology and Geriatrics, 4*, 299-304. doi: 10.1016/0167-4943(85)90037-8

Oswald, W. D., & Fleischmann, U. M. (1995). *Nürnberger-Alters-Inventar (NAI). Testinventar & NAI-Testmanual und Textband. (3. überarbeitete und ergänzte Auflage)*. Göttingen, Germany: Hogrefe.

Park, D. C. (2000). The basic mechanisms accounting for age-related decline in cognitive function. In D. C. Park & N. Schwarz (Eds.), *Cognitive aging: A primer* (pp. 3-22). New York, NY: Psychology Press.

Park, D. C., & Festini, S. B. (2017). Theories of memory and aging: A look at the past and a glimpse of the future. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 72*(1), 82-90. doi: 10.1093/geronb/gbw066

Park, D. C., & Reuter-Lorenz, P. (2009). The adaptive brain: Aging and neurocognitive scaffolding. *Annual Review of Psychology, 60*, 173-196. doi: 10.1146/annurev.psych.59. 103006.093656

Pearman, A., Hertzog, C., & Gerstorf, D. (2014). Little evidence for links between memory complaints and memory performance in very old age: Longitudinal analyses from the Berlin Aging Study. *Psychology and Aging, 29*(4), 828-842. doi: 10.1037/a0037141

Pereira, A. C., Huddleston, D. E., Brickman, A. M., Sosunov, A. A., Hen, R., McKhann, G. M., . . . Small, S. A. (2007). An in vivo correlate of exercise-induced neurogenesis in the adult dentate gyrus. *Proceedings of the National Academy of Sciences of the United States of America, 104*(13), 5638-5643. doi: 10.1073/pnas.0611721104

Petersen, R. C. (2004). Mild cognitive impairment as a diagnostic entity. *J Intern Med, 256*(3), 183-194. doi: 10.1111/j.1365-2796.2004.01388.x

Petersen, R. C., Caracciolo, B., Brayne, C., Gauthier, S., Jelic, V., & Fratiglioni, L. (2014). Mild cognitive impairment: A concept in evolution. *J Intern Med, 275*(3), 214-228. doi: 10.1111/joim.12190

Petersen, R. C., Smith, G. E., Waring, S. C., Ivnik, R. J., Tangalos, E. G., & Kokmen, E. (1999). Mild cognitive impairment: Clinical characterization and outcome. *Archives of Neurology, 56*(3), 303-308. doi: 10.1001/archneur.56.3.303

Pietrzak, R. H., Maruff, P., Woodward, M., Fredrickson, J., Fredrickson, A., Krystal, J. H., . . . Darby, D. (2012). Mild worry symptoms predict decline in learning and memory in healthy older adults: A 2-year prospective cohort study. *American Journal of Geriatric Psychiatry, 20*(3), 266-275. doi: 10.1097/JGP.0b013e3182107e24

Ponds, R. W. H. M., van Boxtel, M. P. J., & Jolles, J. (2000). Age-related changes in subjective cognitive functioning. *Educational Gerontology, 26*(1), 67-81. doi: 10.1080/036012700267402

Popham, L. E., & Hess, T. M. (2016). Stereotype threat. In S. K. Whitbourne (Ed.), *The encyclopedia of adulthood and aging* (pp. 1354-1357). London, UK: Wiley-Blackwell.

Press, W. H., Teukolsky, S. A., Vetterling, W. T., & Flannery, B. P. (2007). *Numerical recipes: The art of scientific computing* (3rd ed.). New York, NY: Cambridge University Press.

Rabbitt, P. (1965). An age-decrement in the ability to ignore irrelevant information. *Journals of Gerontology, 20*(2), 233-238. doi: 10.1093/geronj/20.2.233

Reijnders, J., van Heugten, C., & van Boxtel, M. (2013). Cognitive interventions in healthy older adults and people with mild cognitive impairment: A systematic review. *Ageing Research Reviews, 12*(1), 263-275. doi: 10.1016/j.arr.2012.07.003

Reitz, C., & Mayeux, R. (2014). Alzheimer disease: Epidemiology, diagnostic criteria, risk factors and biomarkers. *Biochemical Pharmacology, 88*(4), 640-651. doi: 10.1016/j.bcp.2013.12.024

Robertson, D. A., King-Kallimanis, B. L., & Kenny, R. A. (2016). Negative perceptions of aging predict longitudinal decline in cognitive function. *Psychology and Aging, 31*(1), 71-81. doi: 10.1037/pag0000061

Ronnlund, M., Nyberg, L., Backman, L., & Nilsson, L. G. (2005). Stability, growth, and decline in adult life span development of declarative memory: Cross-sectional and longitudinal data from a population-based study. *Psychology and Aging, 20*(1), 3-18. doi: 10.1037/0882-7974.20.1.3

Rosseel, Y. (2012). Lavaan: An R package for structural equation modeling. *Journal of Statistical Software, 48*(2), 1-36.

Rothermund, K., & Brandtstädter, J. (2003). Age stereotypes and self-views in later life: Evaluating rival assumptions. *International Journal of Behavioral Development, 27*, 549-554. doi: 10.1080/01650250344000208

Rubin, D., & Berntsen, D. (2006). People over forty feel 20% younger than their age: Subjective age across the lifespan. *Psychonomic Bulletin & Review, 13*, 776-780. doi: 10.3758/bf03193996

Rupprecht, F., Dutt, A., Wahl, H.-W., & Diehl, M. (2019). The role of personality in becoming aware of age-related changes. *GeroPsych, 32*, 57-67. doi: 10.1024/1662-9647/a000204

Salthouse, T. A. (1996). The processing-speed theory of adult age differences in cognition. *Psychological Review, 103*(3), 403-428. doi: 10.1037/0033-295x.103.3.403

Salthouse, T. A. (2009). When does age-related cognitive decline begin? *Neurobiology of Aging, 30*(4), 507-514. doi: 10.1016/j.neurobiolaging.2008.09.023

Salthouse, T. A. (2010). Influence of age on practice effects in longitudinal neurocognitive change. *Neuropsychology, 24*(5), 563-572. doi: 10.1037/a0019026

Salthouse, T. A. (2012). Consequences of age-related cognitive declines. *Annual Review of Psychology, 63*, 201-226. doi: 10.1146/annurev-psych-120710-100328

Sargent-Cox, K. A., Anstey, K. J., & Luszcz, M. A. (2012a). Change in health and self-perceptions of aging over 16 years: The role of psychological resources. *Health Psychology, 31*, 423-432. doi: 10.1037/a0027464

Sargent-Cox, K. A., Anstey, K. J., & Luszcz, M. A. (2012b). The relationship between change in self-perceptions of aging and physical functioning in older adults. *Psychology and Aging, 27*, 750-760. doi: 10.1037/a0027578

Sargent-Cox, K. A., Anstey, K. J., & Luszcz, M. A. (2014). Longitudinal change of self-perceptions of aging and mortality. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 69*, 168-173. doi: 10.1093/geronb/gbt005

Sattler, C., Erickson, K. I., Toro, P., & Schröder, J. (2011). Physical fitness as a protective factor for cognitive impairment in a prospective population-based study in Germany. *Journal of Alzheimers Disease, 26*(4), 709-718. doi: 10.3233/Jad-2011-110548

Sattler, C., Toro, P., Schönknecht, P., & Schröder, J. (2012). Cognitive activity, education and socioeconomic status as preventive factors for mild cognitive impairment and Alzheimer's disease. *Psychiatry Research, 196*(1), 90-95. doi: 10.1016/j.psychres.2011.11.012

Sattler, C., Wahl, H.-W., Schröder, J., Kruse, A., Schönknecht, P., Kunzmann, U., . . . Zenthöfer, A. (2017). Interdisciplinary Longitudinal Study on Adult Development and Aging (ILSE). In N. A. Pachana (Ed.), *Encyclopedia of geropsychology* (pp. 1213-1222). New York, NY: Springer.

Scarmeas, N., & Stern, Y. (2003). Cognitive reserve and lifestyle. *Journal of Clinical and Experimental Neuropsychology, 25*(5), 625-633. doi: 10.1076/jcen.25.5.625.14576

Schaie, K. W. (1996). *Intellectual development in adulthood: The Seattle Longitudinal Study*. Cambridge, UK: University Press.

Schaie, K. W. (2005a). *Developmental influences on adult intelligence: The Seattle Longitudinal Study*. New York, NY: Oxford University Press.

Schaie, K. W. (2005b). What can we learn from longitudinal studies of adult development? *Research in Human Development, 2*(3), 133-158. doi: 10.1207/s15427617rhd0203_4

Schaie, K. W. (2006). Commentary: Interdisciplinary longitudinal studies of ageing. In H.-W. Wahl, H. Brenner, H. Mollenkopf, D. Rothenbacher & C. Rott (Eds.), *The many faces of health, competence and well-being in old age* (pp. 223-230): Springer.

Schaie, K. W., & Hofer, S. M. (2001). Longitudinal studies in aging research. In J. E. Birren & K. W. Schaie (Eds.), *Handbook of the psychology of aging* (pp. 53-77). San Diego, CA: Academic Press.

Schermelleh-Engel, K., Moosbrugger, H., & Müller, H. (2003). Evaluating the fit of structural equation models: Tests of significance and descriptive goodness-of-fit measures. *Methods of Psychological Research, 8*(2), 23-74.

Schmader, T., Johns, M., & Forbes, C. (2008). An integrated process model of stereotype threat effects on performance. *Psychological Review, 115*(2), 336-356. doi: 10.1037/0033-295X.115.2.336

Schneider, T. R. (2004). The role of neuroticism on psychological and physiological stress responses. *Journal of Experimental Social Psychology, 40*(6), 795-804. doi: 10.1016/j.jesp.2004.04.005

Segel-Karpas, D., & Palgi, Y. (2017). 'It is nothing more than a senior moment': the moderating role of subjective age in the effect of change in memory on self-rated memory. *Aging & Mental Health*, 1-5. doi: 10.1080/13607863.2017.1399350

Seidler, A. L., & Wolff, J. K. (2017). Bidirectional associations betweeen self-perceptions of aging and processing speed across 3 years. *GeroPsych, 30*(2), 49-59. doi: 10.1024/1662-9647/a000165

Selkoe, D. J. (1991). The molecular pathology of Alzheimer's disease. *Neuron, 6*(4), 487-498.

Shors, T. J., Anderson, M. L., Curlik, D. M., & Nokia, M. S. (2012). Use it or lose it: How neurogenesis keeps the brain fit for learning. *Behavioural Brain Research, 227*(2), 450-458. doi: 10.1016/j.bbr.2011.04.023

Siebert, J. S., Wahl, H.-W., Degen, C., & Schröder, J. (2018). Attitude toward own aging as a risk factor for cognitive disorder in old age: 12-year evidence from the ILSE study. *Psychology and Aging, 33*(3), 461-472. doi: 10.1037/pag0000252

Siebert, J. S., Wahl, H.-W., & Schröder, J. (2018). The role of attitude toward own aging for fluid and crystallized functioning: 12-year evidence from the ILSE study. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 73*(5), 836-845. doi: 10.1093/geronb/gbw050

Singer, T., Verhaeghen, P., Ghisletta, P., Lindenberger, U., & Baltes, P. B. (2003). The fate of cognition in very old age: Six-year longitudinal findings in the Berlin Aging Study (BASE). *Psychology and Aging, 18*(2), 318-331. doi: 10.1037/0882-7974.18.2.318

Smith, E. B., Desai, M. M., Slade, M., & Levy, B. R. (2018). Positive aging views in the general population predict better long-term cognition for elders in eight countries. *Journal of Aging and Health, Advanced online publication*. doi: 10.1177/0898264318784183

Sonnega, A., Faul, J. D., Ofstedal, M. B., Langa, K. M., Phillips, J. W. R., & Weir, D. R. (2014). Cohort profile: the Health and Retirement Study (HRS). *International Journal of Epidemiology, 43*(2), 576-585. doi: 10.1093/ije/dyu067

Sontag, S. (1972). The double standard of aging. *Saturday Review of the Society, 53*, 29-38.

Sperling, R. A., Aisen, P. S., Beckett, L. A., Bennett, D. A., Craft, S., Fagan, A. M., . . . Phelps, C. H. (2011). Toward defining the preclinical stages of Alzheimer's disease: recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. *Alzheimers & Dementia, 7*(3), 280-292. doi: 10.1016/j.jalz.2011.03.003

Spuling, S. M., Miche, M., Wurm, S., & Wahl, H.-W. (2013). Exploring the causal interplay of subjective age and health dimensions in the second half of life. A cross-lagged panel analysis. *Zeitschrift für Gesundheitspsychologie, 21*, 5-15. doi: 10.1026/0943-8149/ a000084

Staudinger, U. M. (2015). Images of aging: Outside and inside perspectives. In M. Diehl & H.-W. Wahl (Eds.), *Annual Review of Gerontology and Geriatrics: Vol. 35. Research on subjective aging: New developments and future directions* (pp. 187-209). New York, NY: Springer Publishing.

Steele, C. M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. *American Psychologist, 52*, 613-629. doi: 10.1037/0003-066X.52.6.613

Stephan, Y., Caudroit, J., & Chalabaev, A. (2011). Subjective health and memory self-efficacy as mediators in the relation between subjective age and life satisfaction among older adults. *Aging & Mental Health, 15*, 428-436. doi: 10.1080/13607863.2010.536138

Stephan, Y., Caudroit, J., Jaconelli, A., & Terracciano, A. (2014). Subjective age and cognitive functioning: A 10-year prospective study. *American Journal of Geriatric Psychiatry, 22*, 1180-1187. doi: 10.1016/j.jagp.2013.03.007

Stephan, Y., Chalabaev, A., Kotter-Grühn, D., & Jaconelli, A. (2013). "Feeling younger, being stronger": An experimental study of subjective age and physical functioning among older adults. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 68*, 1-7. doi: 10.1093/geronb/gbs037

Stephan, Y., Sutin, A. R., Caudroit, J., & Terracciano, A. (2016). Subjective age and changes in memory in older adults. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 71*(4), 675-683. doi: 10.1093/geronb/gbv010

Stephan, Y., Sutin, A. R., Kornadt, A., Caudroit, J., & Terracciano, A. (2018). Higher IQ in adolescence is related to a younger subjective age in later life: Findings from the Wisconsin Longitudinal Study. *Intelligence, 69*, 195-199. doi: 10.1016/j.intell.2018.06.006

Stephan, Y., Sutin, A. R., Kornadt, A., & Terracciano, A. (2019). Polygenic scores for education, health, and personality as predictors of subjective age among older individuals of european ancestry: Evidence from the Health and Retirement Study. *Psychology and Aging, 34*(1), 139-144. doi: 10.1037/pag0000283

Stephan, Y., Sutin, A. R., Luchetti, M., & Terracciano, A. (2017). Feeling older and the development of cognitive impairment and dementia. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 72*(6), 966-973. doi: 10.1093/geronb/gbw085

Stephan, Y., Sutin, A. R., Luchetti, M., & Terracciano, A. (2018). Subjective age and risk of incident dementia: Evidence from the National Health and Aging Trends survey. *Journal of Psychiatric Research, 100*, 1-4. doi: 10.1016/j.jpsychires.2018.02.008

Stephan, Y., Sutin, A. R., & Terracciano, A. (2015). Younger subjective age is associated with lower C-reactive protein among older adults. *Brain, Behavior, and Immunity, 43*, 33-36. doi: 10.1016/j.bbi.2014.07.019

Stephan, Y., Sutin, A. R., & Terracciano, A. (2019a). Subjective age and adiposity: evidence from five samples. *International Journal of Obesity, 43*(4), 938-941. doi: 10.1038/s41366-018-0179-x

Stephan, Y., Sutin, A. R., & Terracciano, A. (2019b). Subjective age and cystatin C among older adults. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 74*(3), 382-388. doi: 10.1093/geronb/gbx124

Stern, Y. (2002). What is cognitive reserve? Theory and research application of the reserve concept. *Journal of the International Neuropsychological Society, 8*(3), 448-460. doi: 10.1017/S1355617702813248

Stern, Y. (2009). Cognitive reserve. *Neuropsychologia, 47*(10), 2015-2028. doi: 10.1016/j.neuropsychologia.2009.03.004

Stern, Y. (2012). Cognitive reserve in ageing and Alzheimer's disease. *Lancet Neurology, 11*(11), 1006-1012. doi: 10.1016/S1474-4422(12)70191-6

Stern, Y., Arenaza-Urquijo, E. M., Bartres-Faz, D., Belleville, S., Cantilon, M., Chetelat, G., . . . Conceptual Frameworks, W. (2018). Whitepaper: Defining and investigating cognitive reserve, brain reserve, and brain maintenance. *Alzheimers & Dementia*. doi: 10.1016/j.jalz.2018.07.219

Stewart, T. L., Chipperfield, J. G., Perry, R. P., & Hamm, J. M. (2016). Attributing heart attack and stroke to "Old Age": Implications for subsequent health outcomes among older adults. *Journal of Health Psychology, 21*(1), 40-49. doi: 10.1177/1359105314521477

Steyer, R., Eid, M., & Schwenkmezger, P. (1997). Modeling true intraindividual change: True change as a latent variable. *Methods of Psychological Research - Online, 2*(21-33).

Tennstedt, S. L., & Unverzagt, F. W. (2013). The ACTIVE study: Study overview and major findings. *Journal of Aging and Health, 25*, 3-20. doi: 10.1177/0898264313518133

Terracciano, A., Stephan, Y., Luchetti, M., Albanese, E., & Sutin, A. R. (2017). Personality traits and risk of cognitive impairment and dementia. *Journal of Psychiatric Research, 89*, 22-27. doi: 10.1016/j.jpsychires.2017.01.011

Teuscher, U. (2009). Subjective age bias: A motivational and information processing approach. *International Journal of Behavioral Development, 33*, 22-31. doi: 10.1177/0165025408099487

Tewes, U. (1991). *Hamburg-Wechsler-Intelligenztest für Erwachsene, Revision 1991 (HAWIE-R)* (2nd ed.). Bern, Switzerland: Huber.

Thomae, H. (1970). Theory of aging and cognitive theory of personality. *Human Development, 13*(1), 1-16.

Tobiansky, R., Blizard, R., Livingston, G., & Mann, A. (1995). The gospel oak study stage IV: The clinical relevance of subjective memory impairment in older people. *Psychological Medicine, 25*(4), 779-786. doi: 10.1017/S0033291700035029

Tsoi, K. K. F., Chan, J. Y. C., Hirai, H.-W., Wong, S. Y. S., & Kwok, T. C. Y. (2015). Cognitive tests to detect dementia: A systematic review and meta-analysis. *Jama Internal Medicine, 175*(9), 1450-1458. doi: 10.1001/jamainternmed.2015.2152

Uotinen, V., Rantanen, T., & Suutama, T. (2005). Perceived age as a predictor of old age mortality: A 13-year prospective study. *Age and Ageing, 34*, 368-372. doi: 10.1093/ageing/afi091

Van Beijsterveldt, C. E., van Boxtel, M. P., Bosma, H., Houx, P. J., Buntinx, F., & Jolles, J. (2002). Predictors of attrition in a longitudinal cognitive aging study: the Maastricht Aging Study (MAAS). *J Clin Epidemiol, 55*(3), 216-223.

Verhaeghen, P., & Cerella, J. (2002). Aging, executive control, and attention: A review of meta-analyses. *Neurosci Biobehav Rev, 26*(7), 849-857. doi: 10.1016/S0149-7634(02)00071-4

Verhaeghen, P., Geraerts, N., & Marcoen, A. (2000). Memory complaints, coping, and well-being in old age: A systemic approach. *The Gerontologist, 40*(5), 540-548. doi: 10.1093/geront/40.5.540

Verhaeghen, P., & Salthouse, T. A. (1997). Meta-analyses of age-cognition relations in adulthood: Estimates of linear and nonlinear age effects and structural models. *Psychological Bulletin, 122*(3), 231-249. doi: 10.1037//0033-2909.122.3.231

Voss, P., Kornadt, A. E., Hess, T. M., Fung, H. H., & Rothermund, K. (2018). A world of difference? Domain-specific views on aging in China, the US, and Germany. *Psychology and Aging, 33*(4), 595-606. doi: 10.1037/pag0000237

Wahl, H.-W., Siebert, J. S., & Tauber, B. (2017). Psychological theories of successful aging. In N. A. Pachana (Ed.), *Encyclopedia of geropsychology* (pp. 1931-1940). New York, NY: Springer.

West, M. J. (1993). Regionally specific loss of neurons in the aging human hippocampus. *Neurobiology of Aging, 14*(4), 287-293. doi: 10.1016/0197-4580(93)90113-P

Westerhof, G. J., Miche, M., Brothers, A., Barrett, A. E., Diehl, M., Montepare, J. M., . . . Wurm, S. (2014). The influence of subjective aging on health and longevity: A meta-analysis of longitudinal data. *Psychology and Aging, 29*, 793-802. doi: 10.1037/a0038016

Wettstein, M., Wahl, H.-W., Siebert, J. S., & Schröder, J. (in press). Still more to learn about late-life cognitive development: how personality and health predict 20-year cognitive trajectories. *Psychology and Aging*.

Willis, S. L., Schaie, K. W., & Martin, M. (2009). Cognitive plasticity. In V. L. Bengston, D. Gans, N. M. Pulney & M. Silverstein (Eds.), *Handbook of theories of aging* (pp. 295-322). New York, NY: Springer Publishing Co.

Wilson, R. S., & Bennett, D. A. (2017). How does psychosocial behavior contribute to cognitive health in old age? *Brain Sciences, 7*(6), 56. doi: 10.3390/brainsci7060056

Wilson, R. S., Hebert, L. E., Scherr, P. A., Barnes, L. L., de Leon, C. F. M., & Evans, D. A. (2009). Educational attainment and cognitive decline in old age. *Neurology, 72*(5), 460-465. doi: 10.1212/01.wnl.0000341782.71418.6c

Wimo, A., Guerchet, M., Ali, G. C., Wu, Y. T., Prina, A. M., Winblad, B., . . . Prince, M. (2017). The worldwide costs of dementia 2015 and comparisons with 2010. *Alzheimers & Dementia, 13*(1), 1-7. doi: 10.1016/j.jalz.2016.07.150

Wisdom, N. M., Mignogna, J., & Collins, R. L. (2012). Variability in Wechsler Adult Intelligence Scale-IV subtest performance across age. *Archives of Clinical Neuropsychology, 27*(4), 389-397. doi: 10.1093/arclin/acs041

Wittchen, H. U., Zaudig, M., Schramm, E., Spengler, P., Mombour, W., Klug, J., & Horn, R. (1991). *Strukturiertes klinisches Interview für DSM-III-R*. Göttingen, Germany: Beltz-Test.

Wohlwill, J. F. (1970). Age variable in psychological research. *Psychological Review, 77*(1), 49-64. doi: 10.1037/H0028600

Wolff, J. K., Beyer, A.-K., Wurm, S., Nowossadeck, S., & Wiest, M. (2018). Regional impact of population aging on changes in individual self-perceptions of aging: Findings from the German Ageing Survey. *The Gerontologist, 58*(1), 47-56. doi: 10.1093/geront/gnx127

Wrosch, C., & Heckhausen, J. (1996). Adaptiveness of social comparisons: Developmental regulation via primary and secondary control. *Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie, 28*(2), 126-147.

Wurm, S., Diehl, M., Kornadt, A. E., Westerhof, G. J., & Wahl, H.-W. (2017). How do views on aging affect health outcomes in adulthood and late life? Explanations for an established connection. *Developmental Review, 46*, 27-43. doi: 10.1016/j.dr.2017.08.002

Wurm, S., Tesch-Römer, C., & Tomasik, M. J. (2007). Longitudinal findings on aging-related cognitions, control beliefs, and health in later life. *Journals of Gerontology, Series B:*

Psychological Sciences and Social Sciences, 62B, P156-P164. doi: 10.1093/geronb/62.3.P156

Wurm, S., Tomasik, M., & Tesch-Römer, C. (2010). On the importance of a positive view on aging for physical exercise among middle-aged and older adults: Cross-sectional and longitudinal findings. *Psychology & Health, 25*, 25-42. doi: 10.1080/08870440802311314

Yaffe, K., Fiocco, A. J., Lindquist, K., Vittinghoff, E., Simonsick, E. M., Newman, A. B., . . . Harris, T. B. (2009). Predictors of maintaining cognitive function in older adults: The Health ABC Study. *Neurology, 72*(23), 2029-2035.

Yaffe, K., Kurella-Tamura, M., Ackerson, L., Hoang, T. D., Anderson, A. H., Duckworth, M., . . . Investigators, C. S. (2014). Higher levels of cystatin C are associated with worse cognitive function in older adults with chronic kidney disease: The chronic renal insufficiency cohort cognitive study. *Journal of the American Geriatrics Society, 62*(9), 1623-1629. doi: 10.1111/jgs.12986

Yu, C. Y. (2002). *Evaluating cutoff criteria of model fit indices for latent variable models with binary and continuous outcomes.* (Doctoral dissertation), University of California, Los Angeles, CA.

Ziegenhorn, A., & Heuser, I. (2005). Die leichte kognititve Störung oder: Ist Vergesslichkeit im Alter nicht normal? *Neurotransmitter, 1*, 60-64.

Tables

Figures

Abbreviations

AARC	Awareness of age-related change
AD	Alzheimer disease
ApoE	Apolipoprotein E
ATOA	Attitude toward own aging
BLSA	Baltimore Longitudinal Study of Aging
CFI	Comparative fit index
C30	ILSE's old age cohort
C50	ILSE's midlife cohort
DEAS	German Aging Survey
DSM-III-R	Diagnostic and Statistical Manual of Mental Disorders
ESS	European Social Survey
FIML	Full information maximum likelihood
HRS	Health and Retirement Study
ILSE	Interdisciplinary Longitudinal Study of Adult Development
LCS	Latent change score model
MCI	Mild cognitive impairment
MIDUS	Midlife in the United States
MRI	Magnetic resonance imaging
NHATS	National Health and Aging Trends Study
NINCDS–ADRDA	National Institute of Neurological and Communicative Diseases and Stroke and the Alzheimer's Disease and Related Disorders Association
NINDS-AIREN	National Institute of Neurological Disorders and Stroke and Association Internationale pour la Recherché et l´Enseignement en Neurosciences
OR	Odds ratio

PGCMS	Philadelphia Geriatric Center Morale Scale
RMSEA	Root mean square error of approximation
SHARE	Survey of Health, Ageing, and Retirement in Europe
SRMR	Standardized root mean square residual
TILDA	Irish Longitudinal Study on Ageing
WAIS-R	Wechsler Adult Intelligence Scale—Revised
WLSMV	Mean- and variance-adjusted robust weighted least squares estimation
WRMR	Weighted root mean square residual index

Personal Contribution for the Publications of this Thesis

1st Publication

Siebert, J. S., Wahl, H.-W., & Schröder, J. (2018). The role of attitude toward own aging for fluid and crystallized functioning: 12-year evidence from the ILSE study. *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 73,* 836-845. doi: 10.1093/geronb/gbw050.

I developed the idea, conducted the latent change score modeling, and wrote the article. H.-W. Wahl supervised the manuscript.

2nd Publication

Siebert, J. S., Wahl, H.-W., Degen, C., & Schröder, J. (2018). Attitude toward own aging as a risk factor for cognitive disorder in old age: 12-year evidence from the ILSE study. *Psychology and Aging, 33,* 461-472. doi: 10.1037/pag0000252

I developed the research question, did the statistical analyses, and wrote the article. C. Degen commented on the methods section, H.-W. Wahl mentored the manuscript preparation.

3rd Publication

Siebert, J. S., Braun, T., & Wahl, H.-W (2019). *Change in attitudes toward aging: Cognitive complaints matter more than objective performance.* Manuscript submitted for publication.

I developed the research question, collected parts of the T4 data, advised on the data analyses performed by T. Braun, and wrote the article. T. Braun contributed to writing the method and results section, H.-W. Wahl supervised the manuscript.

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