**Doctoral thesis submitted to
the Faculty of Behavioural and Cultural Studies
Heidelberg University
in partial fulfillment of the requirements of the degree of
Doctor of Philosophy (Dr. phil.)
in Psychology**

Title of the publication-based thesis

*Predictors of Personality Development in Mid and Late Adulthood.
The Role of Life satisfaction, Cognition and Health
– an Investigation of Differentiating Effects of Aging.
Findings from the "Interdisciplinary Longitudinal Study on Adult
Development and Aging (ILSE)"*

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year of submission
2017

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List of publications for the publication-based dissertation

I. Publication

Tauber, B., Wahl, H.-W., & Schröder, J. (2016). Personality and life satisfaction over 12 years: Contrasting mid- and late life. *GeroPsych: The Journal of Gerontopsychology and Geriatric Psychiatry*, *29*, 37-48. doi:10.1024/1662-9647/a000141

II. Publication

Wettstein*, M., **Tauber*, B.**, Wahl, H.-W., & Frankenberg, C. (2017). 12-Year associations of health with personality in the second half of life – Being versus feeling healthy. *GeroPsych: The Journal of Gerontopsychology and Geriatric Psychiatry, 30*, 5-17. doi:10.1024/1662-9647/a000162

III. Publication

Wettstein, M., **Tauber, B.**, Kuźma, E., & Wahl, H.-W. (2017). The interplay between personality and cognitive ability across 12 years in middle and late adulthood: Evidence for reciprocal associations. *Psychology and Aging*. Advance online publication. doi:http://dx.doi.org/10.1037/pag0000166

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Abstract

Objective: Identifying the sources of personality development across the adult life span is a key issue of current personality research. The present dissertation investigates the long-term, mutual inter-relationships of personality traits with life satisfaction (*publication 1*), constructs of health (*publication 2*) and different cognitive abilities (*publication 3*). Guiding questions where: (1) Can personality and its development be predicted by these different domains? (2) Are these predictions sensitive to aging, namely the change from middle adulthood to old age?

Method: Analyzes were based on data from the "Interdisciplinary Longitudinal Study on Adult Development and Aging (ILSE)", a prospective German cohort study of mid adulthood (Age $_{baseline}$ = 44y) and old age (Age $_{baseline}$ = 63y), longitudinally spanning across 12 years. Participants were recruited stratified by cohort (N $_{mid\ adulthood}$ = 502, N $_{old\ age}$ = 500), sex ($\male$ = 52%, $\female$ = 48%) and region of residence (Region of Heidelberg = 50%, Region of Leipzig = 50%). After 12 years the overall response rate was 76.7%. Personality traits were measured by the 60-item NEO-FFI inventory. Life satisfaction was assessed by a single-item measurement and health variables by an individual's self-rating and an extensive physician-rating. Cognitive abilities (processing speed, crystalline intelligence, fluid intelligence) were measured by a comprehensive test-battery of various well-established cognitive tests of different cognitive domains (e.g. processing speed was measured by the Digit Symbol Test, a subtest of the WAIS-R). Furthermore, gender, education (years of education) and depression (SDS, self-rated depression scale) were used as control variables. In *publication 1* and *2* multi-group cross-lagged panel analyses were used and in *publication 3* multi-group dual latent change regression models were conducted.

Results: The results of *publication 1* suggest that there is only limited evidence of life

satisfaction predicting the personality traits extraversion and neuroticism in later life. The path coefficients were small and only significant in the old cohort. Integrating health into the models weakened the inter-relationships. The results of *publication 2* show that physician-rated health is an important predictor for the personality traits neuroticism, extraversion (uncontrolled) and agreeableness at later life. Self-rated health demonstrated to be more of an outcome measure of earlier personality in adulthood. There were no considerable cohort differences regarding the cross-lagged predictor paths. The results of *publication 3* illustrate the important role of cognitive abilities as a predictor for 12-year personality changes in the personality traits neuroticism, extraversion and openness. Cohort differences, again, were limited.

Conclusions: All in all, health (*publication 2*) and cognitive abilities (*publication 3*) are demonstrated to be important driving forces for following personality development in adulthood for all of the Big-Five personality traits, except conscientiousness. Physician-rated health was a particularly important predictor for later life neuroticism and agreeableness, while cognitive abilities proved to be important predictors for following personality changes in neuroticism, extraversion and openness. Life satisfaction (*publication 1*) is demonstrated to be more of an outcome than a predictor of later personality. Moreover, there were (almost) no effects of aging on the cross-relationships, highlighting the non-transient importance of the predictor domains across life span. Lastly, a differential perspective is highly recommended for future research, as the results appeared to depend highly on the personality trait and predictor considered.

Keywords: ILSE, longitudinal, personality, life satisfaction, self-rated health, physician-rated health, cognitive abilities, adulthood, midlife, old age

Chapter 1: General Introduction

> *"Personality development is a lifelong phenomenon. It is influenced by a*
> *multitude of factors that directly, indirectly and in transaction with each other*
> *shape who we are and who we become."*
>
> (Cited from Specht et al., 2014, p. 226)

The present publication based doctoral thesis addresses, in the spirit of the preceded citation from the work by Specht and colleagues, the field of personality development across adulthood. It aims at contributing to the growing body of research trying to explain *how* and *why* individuals' personalities change across their respective lifespans. It features three recent articles that (1) are all based on data of a comprehensive, longitudinal German cohort study (ILSE, Sattler et al., 2015), (2) use state-of-the-art longitudinal analyses across a long time interval of 12-years, (3) compare two distinct adult age cohorts (middle adulthood and old age) and (4) investigate the reciprocal longitudinal interrelationships of the Big Five personality traits (Costa & McCrae, 1992a, 1992b) with the important and impactful constructs of different psychological life domains (i.e., life satisfaction, health, cognitive abilities).

Chapter 1 introduces the basic concepts, defines the field of research and describes the general and specific research questions. Moreover, it introduces the data set, namely the "Interdisciplinary Longitudinal Study of Adult Development and Aging (ILSE)", and, further on, deals with issues of longitudinal statistic modelling. **Chapter 2** comprises the manuscript concerned with the longitudinal interrelationship of personality with life satisfaction. **Chapter 3** contains the manuscript on the longitudinal interrelationship of personality with different conceptualizations of health. **Chapter 4** comprises the manuscript investigating the longitudinal interrelationship of

personality with different domains of cognitive functioning. Lastly, ***Chapter 5*** covers the synoptic integration of the different researches of *chapters 2-4* into the broad scope of the literature, discusses strengths and limitations, and, finally, addresses future directions in theory and practice regarding personality development in adulthood.

Personality across the life span

Research on personality differences can be traced way back to ancient Greece philosophers and scientists (Amelang, Bartussek, Stemmler, & Hagemann, 2006). For instance, Hippocrates (460-377 BC) divided individuals by their temperament into four personality types, i.e. sanguine, phlegmatic, choleric and melancholic persons, who are characterized by resembling and recurring conglomerates of different attributes and features. It is common knowledge that people differ widely from one another regarding preferences, behavior patterns, intelligence, et cetera. As an example, some people tend to be easy going and relaxed, while others are anxious and prone to influences of stressors. Explaining the origins and consequences of these interindividual differences inspired a whole research tradition – personality research as part of the discipline of differential psychology. Modern psychological research on interindividual differences in personality commenced in the early 20th century (e.g., Allport, 1937; Cattell, 1944) and proceeds to this date. Personality has been investigated by many renowned scientists throughout the years, for example Gordon W. Allport, Joy P. Guilford, Raymond B. Cattell and Hans-Jürgen Eysenck, but the precise definition, operationalization and capturing of personality is still, even today, an issue of energetic debate (e.g., Amelang et al., 2006).

Current proponents of personality research agree that an individual's personality is describable using the concept of *personality traits*. Personality traits are defined as combinations of thoughts, feelings and behaviors that are relatively consistent across different situations, contexts and over time (e.g. Specht et al., 2014; McCrae & Costa, 2008; Roberts, Wood, & Caspi, 2008). The trait concept encompasses stable, inner-psychic patterns of different descriptive dimensions that distinguish a single individual from others and, moreover, by its temporal, trans-situational stability, provides individuals with a sense of sameness throughout their lifetimes.

There are different personality trait frameworks that arose from lexical, questionnaire and factor analytical investigations. Historically, there was the approach of Cattell (1944) who envisioned 12 different distinguishable dichotomous personality factors like, e.g. emotional maturity and character stability versus demoralized general emotionality or intelligence versus mental defect and, equally importantly, the Giant Three of H.-J. Eysenck (Eysenck & Eysenck, 1975) who condense human personality to the three factors neuroticism, extraversion and psychoticism. Despite many different conceptualizations of personality, the Big Five framework of Costa and McCrae (1992a, 1992b) emerged as the most prominent and influential personality trait conception through today (Matthews, Deary, & Whiteman, 2009; Amelang et al., 2006). According to this framework, personality can be comprehensively captured by 5 different continuous factors, namely neuroticism, extraversion, openness, agreeableness and conscientiousness. *Neuroticism* describes an individual's anxiety, hostility, depression-proneness and vulnerability for negative emotions. An individual scoring low on neuroticism can be described as self-assured and emotionally stable. The trait of *Extraversion* covers an individual's

gregariousness, activity, warmth and affinity for positive emotions. People scoring low on extraversion tend to be calm, withdrawn, self-sufficient and are generally reported to have smaller social networks. The trait *openness* for new experiences comprises creativity, curiosity, sensitivity to beauty and delight in trying new activities. Its opposite is defined by conservativeness and proneness to consistency. The trait of *agreeableness* describes an individual's tender-mindedness, altruism, modesty and compliance. Individuals scoring low on agreeableness are more detached from others, but can also be more rivalling, hostile and disagreeable. Lastly, the trait *conscientiousness* encompasses self-discipline, deliberation, proclivity for order, achievement striving and dutifulness. People who score low on conscientiousness can be described as easy-going, careless, flexible and tentatively more chaotic. Even though the Big Five framework has been target of extensive critique directed at the interpretation of the five factors and/or the exact number of factors, it provides a comprehensive framework to investigate personality traits and is, moreover, supported by numerous investigations (e.g. O'Connor, 2002; McCrae & Allik, 2002; De Raad, 2000; Amelang et al., 2006). In summary, cited from Kandler, Kornadt, Hagemeyer and Neyer (2015), the Big Five cover the general trait landscape in many different languages, societies and across cultures.

Inner locus principle, causal primacy principle and causality.

Theoretically, there are two stereotypic principles regarding personality trait research, regardless of the comprising trait-framework that need to be addressed (Matthews, Deary, & Whiteman, 2009): (1) the inner locus principle of personality traits and (2) the causal primacy principle of personality traits. The *inner locus principle of personality traits* states that traits are linked to inner qualities of individuals being genetic and/or physiological in nature. Traits are, therefore, according to this

perspective, biologically based, heritable and, most importantly, fixed characteristics of individuals. Evidence of twin and adoption studies support this principle, by indicating that personality traits are, indeed, highly heritable and in a broad sense stable across time (e.g. Kandler et al., 2015, McCrae & Costa, 2003; McCrae & Costa, 2008). Despite this theoretical foundation and the compelling empirical evidence, it is important to mention that personality researchers today also acknowledge personality to feature variable components, possibly affected by environmental influences (e.g. Specht et al., 2014). As Bleidorn, Kandler and Caspi (2014) demonstrate, genetic and environmental factors in conjunction are the driving forces of continuity and change in personality development. This issue will be addressed in following paragraphs. The following section, in particular, presents empirical studies covering stability and change of personality traits across the adult life span.

The *causal primacy principle of personality traits* puts forth the notion that the dominant direction of causality between traits and behaviors is exclusively directed from traits to behaviors (e.g., McCrae, Costa, Ostendorf et al., 2000). This means that the origin of a situationally observed behavior is strictly and primarily attributed to the underlying traits of the individual. This way of thinking has determined personality research throughout many years. Traits undoubtedly influence behaviors, but the relationship should, from a modern perspective, more precisely be perceived as interactional (with environmental factors) or reciprocally (derived from Matthews et al., 2009).

Causality in itself is a prime issue in science. In most scientific disciplines detecting causality is the final and ultimate goal and purpose, but establishing a definite causal relationship of two variables is nearly impossible to achieve,

especially in psychological research for several theoretical and practical reasons. For instance, given two closely associated concepts like personality and health, the relationship of the two can be that (1) personality causes health, (2) health causes personality, (3) personality and health change might cause each other reciprocally (4) personality and illness might be causally influenced by a third (unknown) variable, and, lastly, (5) that mediating and moderating processes might be crucial for the interpretation of the causal relationship (Matthews et al., 2009). Furthermore, to approximate causality, temporal sequencing of events is required, which is a necessary—but not a sufficient—condition to detect true causality. Due to this critique, overconfident derivation of possibly wrong causal inferences should be omitted whenever possible. Considering the present work and its comprised manuscripts, the more cautious concept and associated phrase of *predictors* was predominantly used. Nonetheless, it is important to keep in mind that longitudinal investigations have an affinity for causal language and that caution is warranted when interpreting findings, because it is impossible to control for all potential confounding influences.

Taken together, personality traits are a widely recognized working definition of the concept of personality at large and the Big-Five personality factors are currently the best-established and most influential framework. Personality traits are linked to inner-individual qualities, which are presumably interacting with behaviors and environmental influences. It is important to note that by being inner psychological entities in nature, the measurement of personality traits is fundamentally limited to self-reports and observational inferences known to be valid trait indicators (McCrae et al., 2000; originally by: Tellegen, 1988). Therefore, they are subject to the classical

critiques of questionnaire and observational data as discussed in the limitations of the present dissertation.

Personality and developmental psychology. The discipline of *developmental psychology* focuses on changes and stability in human aging (Montada, 1998). It is especially interested in developmental conditions, as well as developmental goals and, furthermore, aims at extensively describing changes of psychological concepts with time. One dominant general perspective in developmental psychology is *life span psychology*. Life span psychology is characterized by the general view that developments and changes arise throughout the entire human life span (Baltes, 1987; Baltes, Lindenberger, & Staudinger, 1998) and are not limited to specific life stages, i.e. infancy, adolescence, etc. Following Smith and Spiro III. (2002), life span psychology is characterized as follows: (1) change is multi-directional, (2) change has multiple causes, (3) change occurs embedded in social and historical contexts, (4) change can affect multiple and differing dimensions of constructs, and, (5) change is an intraindividual phenomenon that can differ intensively between individuals (*interindividual differences in intraindividual changes*). Of course, these principles of life span psychology similarly apply to life span personality development (Mroczek, Spiro III., & Griffin, 2006).

Even though many changes do occur across the life span, it is important to remark that these changes do not arise without a process that initiates the change. As Wohlwill (1970) discusses, aging (per se) is not an independent variable when investigating change processes, but changes are influenced and predicted by other inner and outer psychological phenomena that are temporally aligned. Therefore, it is important to go beyond a plain description of changes across the life span, and to investigate the relevant predictor dynamics to understand *why* psychological

constructs change with age. The manuscripts 1-3 all deal with different predictor dynamics of personality with important psychological constructs.

When asking: *how* does *personality change* across the life span, a conflict arises between the original definition of personality as a stable, highly reliable and conceptually time-invariant construct and the perspective that changes in personality are not only possible, but also normal signs of life long, as well as being adaptive and healthy, personality development. As Matthews et al. (2009) argue, a trait needs to have a substantial degree of stability over time or the entire theory of traits fails at its core. Even though, the prime empirical finding of developmental personality research on traits is that there is ample stability across time (e.g. McCrae & Costa, 2003), recent empirical studies report that personality is susceptible to changes across the life span (e.g. Roberts, Walton, & Viechtbauer, 2006; Roberts & Del Vecchio, 2000). As noted by Mroczek and Spiro III. (2003), the question of change and stability of personality traits has for a long time, and misleadingly, been framed as a *yes* or *no* question, i.e. stability versus change, while it is more plausible that personality development across the life span is a result of both processes (stability and change) (read also: Ryff, Kwan, & Singer, 2001). Therefore, to merge the perspectives, *personality change* is defined as systematic variation in personality traits that are *relatively* enduring over time (Specht et al., 2014; Luhmann, Orth, Specht, Kandler, & Lucas, 2014). This definition acknowledges that personality traits can have both, substantial stability at its core and a scope for adaptive processes of plasticity and changes. The following section continues by defining personality *stability* and *change* across adulthood more precisely.

Change and stability of personality across the adult life span

As mentioned before, the issue of personality development across the adult

life span has been discussed highly controversially with proponents reporting

dominant stability (e.g. McCrae & Costa, 2003), others highlighting meaningful

changes (e.g. Specht et al., 2014) and others arguing for a synthesis of the two

perspectives (Mroczek & Spiro III., 2003). It is important to acknowledge that change

and stability are indeed complex concepts and individuals might vary on different

manifestations of personality change and stability, which depends highly on the

underlying conceptualization and modeling of change. As Mroczek, Spiro III., and

Griffin (2006) argue, "change is an individual differences variable in and of itself" (p.

365). Following this thought, conceptual precision is crucial when addressing the

issue of personality change and stability (e.g. Allemand, Steiger, & Hill, 2013;

Allemand, Zimprich, & Martin, 2008). The following section defines the most

prominent kinds of change and stability – conceptions across the life span in

conjunction with supporting empirical findings. The relevant concepts are (1) mean-

level stability, (2) rank-order/differential stability and (3) the concept of interindividual

differences in intraindividual changes and (4) structural continuity (Allemand, Steiger,

& Hill, 2013; Allemand, Zimprich, & Hertzog, 2007).

Mean-level stability refers to the stability of a personality trait's average level

over time and/or across different ages. Roberts, Walton and Viechtbauer (2006)

conducted an extensive meta-analysis on 92 investigations regarding change and

stability of the Big Five traits across the human life span. They find that the traits of

agreeableness, conscientiousness and emotional stability (*i.e. the inverted value of

trait neuroticism*) increase systematically across the entire life span from the age of

10 up to the age of 70 years. The trait of openness shows an increase in the early life

stage from 10 to 22 years and remains almost stable until old age, when it decreases again after the age of 60. Extraversion was split into two sub-factors, namely social vitality and social dominance. While social vitality increases in very early age (10-22 years) and decreases very slightly thereafter until very old age, social dominance increases enormously until the age of 40 and plateaus until old age. Taken together, Roberts et al. (2006) comprehensively present meaningful mean-level personality trait changes across all of adulthood. Even though these changes are singularly rather small (i.e. change of one trait from the 20s to the 30s), they accumulate across the entire life span.

Differential/rank-order stability describes the extent to which individuals keep or change their relative position in relation to other individuals in the reference group. Rank-order stability of personality increases across young and middle age until the age of 50 as specified by the cumulative continuity principle (Roberts & Del Vecchio, 2000; Roberts & Wood, 2006) and decreases again in old age (Ardelt, 2000), resulting in an inverted U-shaped function of personality rank-order consistency across the life span (e.g. Specht et al., 2014). Derived from these findings, personality change should be strongest in early adulthood and late life, while the life phase of mid adulthood should (standardly) be characterized by stability.

A lot of research has so far focused on mean-level and rank-order stability of personality across the life span, but research directly targeting at the investigation of *interindividual differences in intraindividual changes* are still scarce. Prior studies investigating differential personality changes, indeed, found significant and noteworthy, but admittedly small, interindividual differences in intraindividual change dynamics for all Big Five personality traits across adulthood (e.g. Allemand, Zimprich, & Hertzog, 2007; Allemand, Zimprich, & Martin, 2008; Soto & John, 2012). In direct

comparison to mean-level and differential stability there is still a lot unknown and many issues available for future investigation, especially when it comes to conditions and implications of interindividual differences in intraindividual personality changes.

Lastly, s*tructural continuity* deals with the degree of continuity and change in interrelations of the specific indicators of the personality factors over time (Allemand, Zimprich, & Hertzog, 2007). It is a concept that is very closely related and possibly better known by the statistical modeling issue of longitudinal measurement invariance (e.g. Horn & McArdle, 1992; Meredith & Horn, 2001). If a construct is measured by different indicators, it is important to ensure that the meaning of the latent construct has not changed across the years. For this reason, the invariance in factor loadings, intercepts and residual variances is tested between the two temporally different measurement models (e.g. Meredith, 1993; Horn & McArdle, 1992). If the factor loadings can be set equal across groups, the two constructs have weak invariance. If, additionally, the intercepts can be set equal the constructs have strong measurement invariance, which is a prerequisite for comparing the two latent constructs. Moreover, if the residual variances of the indicators can be set equal between the groups the two latent constructs can be considered as temporally different equivalents, which is termed strict invariance. The treatment of the issue of invariance is very important when interpreting latently modelled longitudinal constructs and will be discussed in a following section on statistical analyses and modeling issues.

Theoretical models of life span personality change and stability

The present section addresses several different basic theoretical frameworks, principles and models explaining personality change and stability across the life span (for a more extensive overview on the frameworks read: Specht et al., 2014).

According to the *neo-socioanalytic approach* (Roberts & Wood, 2006; Roberts, 2005, 2006), mainly advocated by Brent W. Roberts, personality stability and changes are adaptive for an individual's aging process and describable across the life span by several basic principles. Personality changes in adulthood are primarily triggered by influences of changing environments (*plasticity principle*) and social roles (*social investment principle*). Stability and coherence in personality is a result of an increasingly developing identity (*identity development principle*) and a commitment to stable roles and related role demands (*role continuity principle*). The *corresponsive principle* of personality development suggests that life experiences affect personality development in strengthening the characteristics that ultimately have caused those experiences. For example, an individual scoring high on extraversion might attend a social event, feel positively reinforced in the following and ultimately adapt his or her personality to the experience and score even higher in subsequent tests measuring extraversion. The neo-socioanalytic framework builds on two additional principles, namely (1) the *cumulative continuity principle* (Roberts & Wood, 2006; Caspi, Roberts, & Shiner, 2005), stating that rank-order consistency of the personality traits increases across adulthood, and (2) the *maturity principle* which argues that people become more emotionally stable, agreeable, conscientious and socially dominant, i.e. mature, with increasing age (e.g. Roberts, Walton, & Viechtbauer, 2006).

Another theoretic framework highlighting the adaptive role of personality changes across adulthood is the *model of self-regulated personality change* (Denissen, van Aken, Penke, & Wood, 2013). In this framework personality is conceptualized as functional behavior towards an individual's developmental goals, social norms and hedonic preferences, in summary named *reference values*. Change is initiated to primarily achieve desired environmental features (*primary goal*) and/or secondarily to optimize personal behavior in these situations (*secondary goal*). For example, when a person begins a new job, agreeable behavior protects him or her from arguments with the superior. Agreeable behavior should, therefore, be adaptive to the new environment and in response be conducted more often and generally preferred to aggressive and hostile behaviors. Constant repetition of the rewarded behaviors reduces effort and difficulty making these self-regulatory endeavors easier until they become automatic. These behavior patterns will in the long term manifest in trait level changes until the environmental challenges change again, consequently demanding new adaptive behaviors.

Another basic model of personality change and stability is the *dynamic equilibrium model* (e.g. Ormel, Riese, & Rosmalen, 2012). It states that there are genetically influenced and determined set-points for an individual's personality traits around which the personality trait itself is expected to fluctuate. Therefore, the actual and current manifestation of a trait is not only person-specific, but also changeable in response to changing environmental circumstances. Personality change in this framework is describable as permanent changes in these set points and occurs due to far-reaching life experiences. As has been shown, life events can influence developmental trajectories leading to systematic differences between those who lived

these specific life events and those who did not (e.g. Lüdtke, Roberts, Trautwein, & Nagy, 2011; Specht, Egloff, & Schmukle, 2011).

Another important theoretical connection, especially inspired by research on life span personality change, is the *mastery of age-specific developmental tasks* (Havighurst, 1972). Admittedly, this concept is not a comprehensive model like the previously mentioned, but nonetheless another important theoretical driving force behind individuals' adaptive personality trait changes. As life span psychology argues, the ratio of gains and losses changes across adulthood. When the ratio is positive, individuals experience processes of growth and expansion. A negative ratio forces processes of loss management (Mueller, Wagner, & Gerstorf, in press; Baltes & Baltes, 1990; Heckhausen, Wrosch, & Schulz, 2010). For example, if an individual is hit by debilitating health issues or chronic diseases, it becomes difficult for him or her to maintain an adequate lifestyle and properly contest environmental demands, leading to possible long-term personality changes (Baltes, Lindenberger, & Staudinger, 2006; Roberts & Wood, 2006), such as an increase in neuroticism. Life stages of adolescence and early adulthood should ordinarily be characterized by a positive gains to losses ratio, eliciting broadening, optimistic and expanding personalities, while this ratio in late life might bring loss related changes to individuals' personalities (Baltes, Lindenberger, & Staudinger, 2006; Staudinger & Fleeson, 1996).

Taken together, there are different theoretical notions, mechanisms and principles considering personality stability and change across the life span. The theoretical conceptions share that personality stability and change is an issue of individual adaptability. The present dissertation and included manuscripts aims to investigate this adaptation process more closely, trying to detect longitudinal

predictors of personality and its changes. Even though the present work can offer

only a limited glimpse at the ongoing and expanding research on personality trait

change, it sets the needed frame for evaluating the publications 1-3 and the

discussion of the results in chapter 5. To obtain a more in-depth overview on

theoretical notions on personality change and stability the reading of Specht et al.

(2014) is suggested.

Predictor dynamics of personality with life satisfaction, health and cognitive abilities – introducing a conceptual model

The construct of personality is in general perceived as an influential predictor

for various important late life outcomes (e.g. Roberts, Kuncel, Shiner, Caspi, &

Goldberg, 2007; Ryff, Kwan & Singer, 2001; Matthews et al., 2009). This section

introduces a conceptual model as a basic reference and means of inclusion for the

different investigations on the predictor dynamics of personality.

Starting point for the construction of the conceptual model (Figure 1.1) is the

work by Mueller et al. (in press). Their model illustrates that change and stability

(*consistency and variability*) of personality predict subsequent health. Health within

this framework is very broadly conceptualized, incorporating the constructs of

physical functioning, cognitive functioning, sensory functioning and subjective well-

being. According to the model, health will in turn influence later manifestations of an

individual's personality. The predictions depend on different behavioral, physiological

and social mediators, which, in accumulation, influence later health or personality. As

an example, an individual might score high on neuroticism and therefore be highly

prone to influences of stress. The individual may begin to cope with its life problems

by drinking alcohol, which in turn changes the individual's subsequent health (*in a*

broad sense). These health changes will influence who this individual becomes in later life, due to life circumstances, such as limited resources and changes in the individual's social environments. These health changes will, in turn, influence later health, and so forth.

Hill and Roberts (2016) extensively discuss the interrelationship of personality and health. They state two important central ideas for current and future research, namely that (1) "age has the potential to moderate all links in the framework" (p. 215) and that (2) "research must strive toward understanding health as a potential feedback loop throughout the model" (p. 215). Additionally, as previously discussed, individual adaptability plays a key role considering personality development (following the theoretical ideas imbedded in the work by Specht et al., 2014). These three theoretical approaches were merged with the model by Mueller et al. (in press) to create the basic framework model of the present dissertation, which is pictured in Figure 1.1. The model highlights the reciprocal interrelationship of personality and important domains of individual functioning, i.e., well-being (manuscript 1), health (manuscript 2), and cognitive ability (manuscript 3). The system changes across time, which exerts its influence on the framework *distally* through, for example, changing environments, critical life events and related adaptation pressures. The pathways from personality traits to the domains of individual functioning are, in line with Mueller et al. (in press), behavioral, social, and biological in nature, and moderated by the processes of adaptation and age-related dynamics. The domains of individual functioning and personality traits adapt in an interdependent manner to one another with a time lag in impacts. It is important to note that the model does not claim to be exhaustive, nor is it conceptualized as closed or isolated.

The following section addresses empirical studies regarding personality as a longitudinal predictor for important late life outcomes. Furthermore, longitudinal influences of the domains of individual functioning for later life personality are discussed.
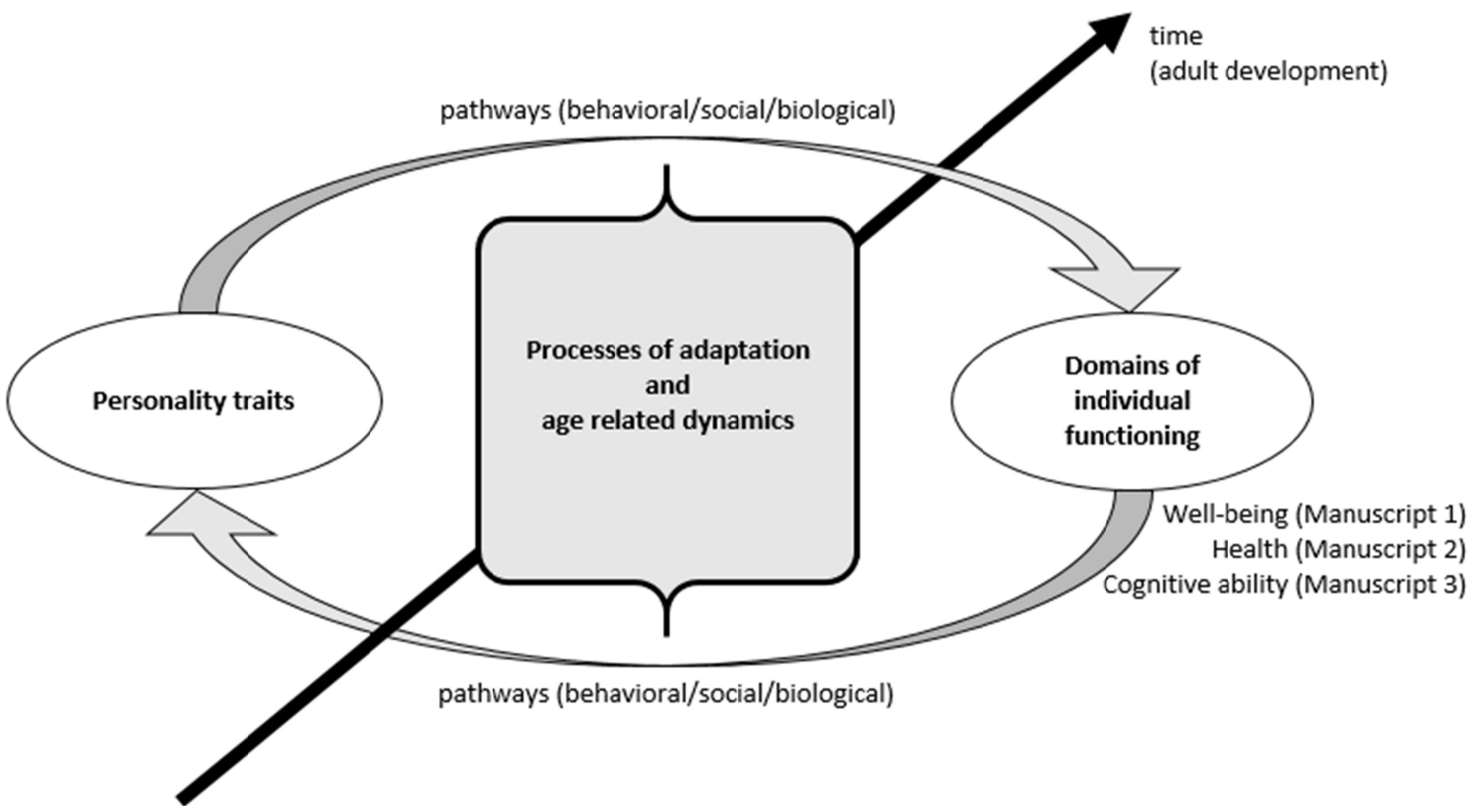

Figure 1.1. The interrelationship of personality and domains of individual functioning – the role of processes of continued adaptation. Based on the model by Mueller, Wagner and Gerstorf (in press) and enhanced and adapted by theoretical ideas from Hill & Roberts (2016) and theoretical perspectives on adult personality development (Specht et al., 2014).

The issue of bi-directionality

Research on the predictive power of personality for important late life outcomes is extensive and, as a consequence, the current section features a selection of key studies, namely studies emphasizing the importance of personality as a predictor in the domains of individual functioning previously introduced. Personality is related to well-being and its determinants (read e.g. Steel, Schmidt, & Shultz, 2008) as well as to basic health outcomes (read e.g. Smith & Spiro III., 2002). Especially the personality factors of neuroticism and conscientiousness are highly relevant considering health outcomes (Hill & Roberts, 2016). For example, neuroticism has been shown as a risk factor for poor physical health (Friedman, 2000) and is related to stress proneness and the vulnerability to psychiatric symptoms, as well as to maladaptive life style factors (read e.g. Amelang et al., 2006, Matthews et al., 2009; Mueller, Wagner, & Gerstorf, in press), ultimately leading to impaired psychological striving across the life span. Additionally, the personality factor of conscientiousness has often been reported as being very protective for various different variables of late life health (e.g. Chapman, Roberts, Lyness, & Duberstein, 2013; Human et al., 2013; Turiano et al., 2012; Hill & Roberts, 2016). The factor of extraversion is, on the one hand related, to positive emotionality and social support—hinting at its protective power for later health—but on the other hand also to health risk behaviors like alcohol consumption, smoking, etc. (e.g. Matthews et al., 2009). Researchers have shown that high neuroticism and low conscientiousness are related to lack of exercise, unhealthy eating habits and smoking (Bogg & Roberts, 2004; Rhodes & Smith, 2006; Malouff, Thorsteinsson, & Schutte, 2006). As summarized by Mueller et al. (in press), studies show more emotionally stable, extraverted, agreeable and conscientious individuals to

experience less (interpersonal) stress (e.g. Bolger & Schilling, 1991), receive more social support (e.g. Cukrowicz, Franzese, Thorp, Cheavens, & Lynch, 2008) and have more favorable neuroendocrine, inflammatory and cardiovascular parameters (e.g. Chapman et al., 2009a; Sutin et al., 2010; Nater, Hoppmann, & Klumb, 2010), which has most likely positive effects on later life well-being, general health and overall personal ambition.

All in all, the concept of personality, or more precisely the Big Five traits, has proven to predict a variety of important late life outcomes such as mortality/longevity, divorce, occupational attainment, health, risk behaviors and well-being and is, therefore, considered as one of the most important determinants of adult development and optimal aging (e.g. Roberts et al., 2007; Ryff, Kwan, & Singer, 2001). This is why understanding the sources and conditions of personality development is not only a theoretical issue, but also one of practical importance, because knowing how to protect, enhance or facilitate an adaptive and positive personality development may open pathways for professional health care practitioners and psychotherapists to help people achieve so called 'successful aging' (Rowe & Kahn, 1997; for an overview on the concept of successful aging read: Wahl, Siebert, & Tauber, 2015). The following section discusses the predictors of personality and personality change across the life span attempting to complete the feedback loop (Figure 1.1).

What psychological constructs predict personality changes? A classic distinction separates predictors of personality change into *biological* and *environmental* influencing factors (e.g. Specht et al., 2014). The biological perspective considers genes, brain structure and the general physiology (e.g. McCrae & Costa, 2008; Scarr & McCartney, 1983; Roberts & Wood, 2006; McAdams

& Pals, 2006) as influential predictors, while the environmental perspective highlights the importance of life events, cultural norms and social roles, settings and dynamics (e.g. McCrae & Costa, 2008; Caspi & Moffitt, 1993; Roberts & Wood, 2006; McAdams & Pals, 2006; Roberts & Wood, 2006; Reitz, Zimmermann, Hutteman, Specht, & Neyer, 2014).

The present work focuses on important and influential psychological constructs that yield interesting predictor dynamics with personality. Different domains of individual functioning, namely health, well-being and cognitive ability, are supposedly complexly interwoven with personality (Figure 1.1). The following section very briefly reviews the interrelationships of these three psychological domains of individual functioning (well-being, health, cognitive abilities) with personality to introduce the general starting points for the three different manuscripts contained in this dissertation.

Well-being. Well-being is most comprehensively defined as a combination of an individual's general satisfaction with life itself (life satisfaction), satisfaction with important life domains (e.g. work satisfaction, family satisfaction), high levels of positive affect and low levels of negative affect (Diener, 2000; Deci & Ryan, 2008).

Prior research has extensively investigated the cross-relationship of well-being and personality (Diener, Suh, Lucas, & Smith, 1999). Two meta-analyses have pointed out the general importance of personality as a predictor of well-being and the vice versa relationship (DeNeve & Cooper, 1998; Steel, Schmidt, & Shultz, 2008). Theoretically, well-being is a developmental goal and, therefore, also a driving force of successful adaptation processes. Numerous studies point to the importance of personality for predicting well-being (e.g. Charles, Reynolds, & Gatz, 2001; Griffin, Mroczek, & Spiro, 2006), but more recent studies also suggest the possibility of a

reciprocal longitudinal relationship of well-being and personality (Specht, Egloff, & Schmukle, 2013; Soto, 2015). A recent study by Kandler, Kornadt, Hagemeyer and Neyer (2015), however, contradicts this notion, indicating only personality (i.e. Neuroticism, Conscientiousness) to be predictive for subsequent well-being, but not vice versa. Taken together, available results seem inconclusive regarding the bi-directionality of the personality well-being interrelationship. Manuscript 1 of the present dissertation specifically targets this issue, investigating the longitudinal cross-relationship of personality and life satisfaction, the cognitive component of general well-being.

Health. Psychologically, health is a multi-dimensional construct (Spiro, 2001) that incorporates both, objective and subjective sub constructs under its umbrella term (Pinquart, 2001). Despite the elaborate definition by the WHO that health "is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (Preamble to the Constitution of WHO as adopted by the International Health Conference; World Health Organization, 1948), health in psychological studies is most commonly operationalized as a continuous construct that is indicated by the subjective perception of a human about his or her general health (subjective health) and/or, additionally, more objective measures like disease lists, physician ratings, laboratory blood tests, tests of physiological functioning, etc. (objective health; for a basic discussion read e.g. Lippke & Renneberg, 2006).

The Big Five personality traits (except openness) have been shown to be important predictors for subsequent (self-rated) health (Chapman, Roberts, Lyness, & Duberstein, 2013; Turiano et al., 2012), but findings on the opposite direction are still scarce. Some researchers found weak predictive effects of health (disease list) on subsequent personality (e.g. Sutin, Zonderman, Ferrucci, & Terracciano, 2013),

while another study reports significant effects of the loss of health (diagnosis of serious diseases) on nearly all Big Five personality factors, i.e. decreases in extraversion, emotional stability, conscientiousness and openness, but no changes for agreeableness (Jokela, Hakulinen, Singh-Manoux, & Kivimäki, 2014). A recent article by Hill and Roberts (2016) reviewed the reciprocal relationship of personality and health, highlighting healthy behaviors and illnesses as predictor mechanisms for personality development as well as discussing the importance of age as a moderator for the interrelationship of the two constructs.

Again, empirical results do not seem exhaustive. In the light of the comprehensive empirical work by Jokela et al. (2014) and the theoretical review by Hill & Roberts (2016), health might currently be undervalued as a predictor for personality changes in adulthood. Therefore, manuscript 2 specifically investigates the possibly reciprocal longitudinal interrelationships of personality with two distinct health constructs, a subjective self-rating and an objective health rating done by a physician. The rationale behind including different health modes was that prior investigations show objective and subjective health to unfold differently across adulthood (e.g. French, Sargent-Cox, & Luszcz, 2012; Pinquart, 2001) and they might, as a consequence, demonstrate differential effects.

Cognitive Abilities. Cognitive abilities, as used in the present work, is an umbrella term incorporating three different constructs of mental capacity following the earlier works by Daniel Zimprich and colleagues (e.g.; Zimprich, Allemand, & Dellenbach, 2009; Zimprich & Mascherek, 2010), namely crystallized intelligence, fluid intelligence (Cattell, 1987), and the concept of information processing speed (McGrew, 2005). According to the well-established Cattell-Horn-Carroll Theory (McGrew, 2005), these constructs cover three of nine different broad cognitive

abilities that together form human intelligence, which can be considered a representative proportion. Also of importance are the different cognitive abilities that underlie different aging dynamics (e.g. Park & Reuter-Lorenz, 2009; Baltes, Lindenberger, & Staudinger, 2006; Martin & Zimprich, 2005). Both processing speed and fluid abilities show noticeable decline, beginning as soon as early adulthood (Salthouse, 2009), whereas crystallized abilities are largely stable or even increase until old age (e.g. Finkel, Reynolds, McArdle, Gatz, & Pedersen, 2003; Singer, Verhaeghen, Ghisletta, Lindenberger, & Baltes, 2003; Park & Reuter-Lorenz, 2009). These differing age trends might lead to differential predictor dynamics of personality and cognitive abilities across adulthood.

There are strong hints by research on pathological cognitive development that indicate cognitive degeneration to be highly associated with personality changes (Rankin, Baldwin, Pace-Savitsky, Kramer, & Miller, 2005). Furthermore, noteworthy small-to-moderate relationships of cognition and personality are reported (e.g. Curtis, Windsor, & Soubelet, 2015; Salthouse, 2014; Soubelet & Salthouse, 2011). Empirical findings are still ambiguous regarding the strength of the interrelationships, i.e. whether they are small, moderate or even strong (e.g. Curtis et al., 2015). Overall, more research is needed to investigate the longitudinal interconnection of the two constructs. Manuscript 3 directly targets this issue, utilizing latent change regression models to investigate the reciprocal longitudinal interconnection of personality and cognitive abilities. More precisely, the influence of cognitive abilities at baseline on subsequent personality changes and vice versa are analyzed.

Effects of adult developmental phase on the predictor dynamics: Midlife versus old age

As numerous influential theories of life-span psychology suggest (e.g. Heckhausen, Wrosch, & Schulz, 2010; Baltes, Lindenberger, & Staudinger, 2006), individuals and their needs and goals, as well as their environmental demands and social roles change dramatically over the course of one's life, especially when approaching old age. Key developmental strains comparing mid with old age are (e.g. Filipp, 2007): (1) facing the challenges of retirement versus being part of the workforce, (2) facing the increasing risk of health restrictions and cognitive decline, and (3) keeping and maintaining satisfying social-relationships. Interestingly, these are also in line with the psychological basic needs as described by self-determination theory (Ryan & Deci, 2000). To maintain high well-being, people need to adapt their thoughts, feelings and behaviors (i.e. their personality). Therefore, personality change across adulthood arises as a fundamental process of successful adaptation to the changing demands of the (social) environment. This is, for example, supported by empirical investigations demonstrating considerable mean-level personality changes across the adult life span (e.g. Roberts, Walton, & Viechtbauer, 2006) and findings demonstrating personality adaptation following major critical life events (e.g. Lüdtke, Roberts, Trautwein, & Nagy, 2011; Specht, Egloff, & Schmukle, 2011).

As considered in the theoretical framework model (Figure 1.1), time varying processes of adaptation and age related dynamics are crucial for the longitudinal, reciprocal interplay of personality and the domains of individual functioning. Across their lifetimes, individuals face different hardships, are torn between various social roles and effected by various pressures of the 'external world'. Personality development apparently depends on the ratio of capacity to fit one's environment and

social roles to one's personal needs in relation to the changing pressures on the individual to adapt themselves to their environments. Ontogenetically, this adaption pressure is presumably highest in very young age and old age, while capacity to change the environment is lowest, theoretically increasing the probability of personality development before the age of 30 and after the age of 60 (e.g. Lucas & Donnellan, 2011). This is supported by the findings on rank-order stability of personality, which operates as an inverted U-shape across the life span (e.g. Specht, et al., 2014; Lucas & Donnellan, 2011; Specht et al., 2011), as resumed in the *cumulative continuity principle* (Roberts & Wood, 2006) and the findings by Ardelt (2000). Overall, this leads to the notion that the interrelationship of personality and the domains of individual functioning should hypothetically be stronger in old age when compared to mid adulthood. The heterogeneity (variability) of personality development across the adult lifespan increases (e.g. Maddox & Douglass, 1974; Bengtson, Kasschau, & Ragan, 1977; Baltes, 1979; Neugarten, 1982), which might lead to two possible outcomes. First, the interrelationship might fall apart, due to the increasing heterogeneity in the constructs of personality and the domains of individual functioning, because the relationship becomes more 'noisy' or collapses. Second, the predictor dynamic might become stronger in old age, because there is more explainable variability in both constructs that mutually interrelates. This means, more precisely, that the possibility of joint variability increases. I argue that the second outcome is more likely.

The process widely labelled as personality maturation (e.g. Roberts & Wood, 2006; Specht, Egloff, & Schmukle, 2013) states that emotional stability, conscientiousness and agreeableness increase across the life span, as a means to adapt to the needs of society. As outlined above and in line with the *model of*

selection, optimization and compensation (SOC, Freund & Baltes, 2002), old age is less focused on dynamics of personal growth (i.e. contributing to society), but on successfully managing loss and effectively coping with adverse and often uncontrollable life experiences (e.g. death of loved ones, physical impairment, and pathological cognitive development; Baltes, Lindenberger, & Staudinger, 2006; Staudinger & Fleeson, 1996; Baltes & Baltes ,1990; Heckhausen, Wrosch, & Schulz, 2010). For example, the compensation of losses in cognitive abilities is a major developmental challenge in late adulthood imposing considerable adaptation pressure on the individual (e.g. Freund & Baltes, 2002). Since the capacity to change, adapt and optimize the environment to face personal needs decreases with aging, it seems plausible that the converse trend of adaptation increases, i.e. individuals' personalities should increasingly adapt to the needs of the 'external world', when compensating for loss dynamics (e.g. Brandstädter & Rothermund, 2002). Accordingly, Kandler et al. (2015) argue that personality traits develop contrary to the process labelled personality maturation when old and very old age are considered. These authors refer to (1) the change of health status as a source of an older persons' increase in neuroticism; (2) the coping with cognitive changes as a source of decreasing openness; (3) the focus on specific, close personal relationships (e.g. Carstensen, 2006) and activities as a source for decreasing extraversion and agreeableness; and (4) the transition to retirement as a source for decreases in conscientiousness. Although some of these changes in living circumstances (environment) and behavior are rather normative, I argue that most of these transitions are idiosyncratic (e.g. Baltes, Reese, & Lipsitt, 1980).

In summary, there are convincing theoretical notions of life span developmental research that suggest the interrelationship of personality with domains

of individual functioning (i.e. with health, well-being and cognitive functioning) might become stronger in old age, when compared to middle adulthood. This general hypothesis represents another guiding research question considering the three different manuscripts of the present dissertation.

Research questions and respective contributions of dissertation-related publications

In summary, more research on long-term predictors of personality traits is needed. As discussed in the previous sections on the framework model and longitudinal predictor dynamics, the relationships between personality traits and important domains of individual functioning should be both *reciprocal* and *susceptible to age group differences*.

The present research investigates these longitudinal interrelationships more closely, using data from the "Interdisciplinary Longitudinal Study of Adult Development (ILSE)" (Sattler et al., 2015). The ILSE design and study population allows testing the cross-predictor dynamics across a comparatively long-term time interval of 12 years in two distinct age groups, a midlife sample and an old age sample, making the data set particularly suited for performing the statistical modeling needed to answer the research questions.

More precisely, the current dissertation has three specific hypotheses. First, it is presumed that personality traits and other psychological domains are mutually important as longitudinal predictors for each another. Second, the cross-predictor dynamics are assumed to be stronger in the old cohort than in the mid-life cohort. Third, it is expected that results vary immensely depending on the specific personality trait and domain of individual functioning considered.

Taken together, the following manuscripts investigate the 12-year longitudinal, reciprocal interrelations of personality with three different domains of individual functioning (Figure 1.1) in two distinct age groups (mid adulthood/old age). Manuscript 1 investigates the longitudinal interplay of personality traits (i.e. Neuroticism, Extraversion) with life satisfaction. Manuscript 2 deals with the longitudinal interplay of personality (i.e. all of the Big Five personality traits) with objective and subjective health. Finally, Manuscript 3 addresses the longitudinal interplay of personality traits (i.e. all of the Big Five personality traits) and cognitive abilities (processing speed, fluid intelligence and crystallized intelligence).

The ILSE-Study – an introduction

This section briefly introduces the "Interdisciplinary Longitudinal Study of Adult Development and Aging (ILSE)" (Sattler et al., 2015), which contains the data set used in all three manuscripts. The description of the study population included here is, due to being incorporated in all three manuscripts, brief.

The "*Interdisciplinary Longitudinal Study of Adult Development and Aging (ILSE)*" (read e.g. Sattler et al., 2015; Martin & Martin, 2000; Schmitt, Wahl, & Kruse, 2008) is a longitudinal German cohort study of mid adulthood and old age. Goal of the ILSE-Study is to investigate individual, societal and socio-structural preconditions for aging well (Sattler et al., 2015). Therefore, the ILSE is most helpful for investigating long-term predictor and change dynamics of various important constructs, featuring an interdisciplinary approach, in which psychologists, physicians, geriatricians, dental physicians, sociologists and even linguists jointly collaborate with each other. The ILSE started in 1993 under the auspices of Prof. Dr. Dr. Ursula Lehr and has occupied, since its first implementation, many influential

researchers of psychological and medical aging research, like Prof. Dr. Hans Thomae, Prof. Dr. Dr. Andreas Kruse and Prof. Dr. Johannes Schröder to name a few. Currently, project directors are Christine Sattler, Johannes Schröder, and Hans-Werner Wahl.

The basic design of the ILSE-Study is a 2 (cohort) x 2 (region) x 2 (sex/gender) x 3 (measurement point) design (Martin & Martin, 2000). Participants were either born between the years 1930-1932 (old cohort) or 1950-1952 (younger cohort). Regions of data collection at measurement time 1 were Heidelberg, Leipzig, Bonn, Erlangen-Nürnberg and Rostock (all centers are situated in Germany). Across the years the centers in Heidelberg (former West-Germany) and Leipzig (former East-Germany), which contributed the biggest samples at time 1 into the ILSE data-pool, continued their data collection endeavors and are, currently, the referred centers when the term "ILSE-Study" is used. Participants were randomly drawn from city registers (register sample: n = 4,000 per region). The sample was stratified by gender and birth cohort to achieve approximately equal distributions considering participants sex and age. Further sample descriptions and cohort analyses can be found in the study populations sections of the manuscripts 1-3. Historically, the most important difference between the two cohorts is that the elder cohort went through the hardships of WWII. Both cohorts, though, witnessed the separation of Germany into the Federal Republic of Germany (BRD, West) and the German Democratic Republic (DDR, East), the fall of the Berlin Wall and the reunification of Germany in 1989. All in all, the two cohorts experienced different socio-cultural contexts during their transition into adulthood and across their whole lives.

Measurement took place between the years 1993-1996 (t1), 1997-2000 (t2) and 2005-2008 (t3), leading to a 4-year time interval from t1 to t2 and a 12-year time

interval from t1 to t3. On top of this, the fourth measurement wave (t4) from 2013 is currently being compiled, and will be ready for statistical analyses in 2017 providing the ILSE with an investigation interval that covers up to 20 years in each cohort (for more information read Sattler et al., 2015). ILSE measurements include (1) a semi-standardized biographical interview, (2) a medical examination, (3) a psychogeriatric examination, (4) a dental examination, (5) a multi-dimensional cognitive testing battery, and (6) a comprehensive battery of questionnaires (e.g. demographic, educational, social, psychological, and medical) (Sattler et al., 2015). This research uses the ILSE personality, subjective health and life satisfaction measurements drawn from the set of questionnaires. Furthermore, objective health based on medical and psychogeriatric examinations, as well as a subsample of cognitive abilities drawn from the cognitive test battery, were used. Participants' sex and education were conducted as control variables.

Issues related to statistical modeling and effect interpretation

Longitudinal statistical modeling is a consistently complex issue in developmental science. Even though there are many good recommendations and guidelines (e.g. McArdle, 2009; Hu & Bentler, 1999), there is, currently, no generally established best-practice approach for longitudinal modeling. On the other hand, the research questions and data nature of ILSE suggest certain procedural approaches as more convincing than others. These are described below.

First, the *longitudinal models* used in manuscripts 2-4 reveal similarities and differences regarding their key statistical approach. In terms of similarities, all data-analysis are based on multi-group analyses (McArdle, 2009). This enables the integration of both cohorts into the same model by separately estimating parameters

for each cohort. The most important advantage of this procedure is that the whole sample is used at once, increasing statistical power (i.e. model fit parameters). Furthermore, differences between models are directly testable via nested model comparisons. This is especially important when the issue of measurement invariance is considered (here: measurement invariance across groups).

Regarding differences, the analyses in manuscripts 1 and 2 are based on *dual-cross-lagged autoregressive models* (McArdle, 2009) with two measurement points, respectively. Figures 2.1 and 3.1 illustrate the different used modeling approaches. The models illustrate the *cross-predictions* from one construct to the subsequent other construct, controlled for the respective auto-regression of the variable (*cross-path/cross prediction*). Furthermore, the model gives the baseline correlation and the concurrent correlation at the follow-up measurement time. Furthermore, the auto-regressive parameters can be interpreted as measures of rank-order stability of individuals over time and the cross-lagged parameters as a measure of variation in one construct at baseline to predict variation in the other construct at follow-up adjusted for controls. This enables the detection of bi-directional (mutual/reciprocal) or uni-directional longitudinal predictions between the studies' variables of interest.

Analyses in manuscript 3 are based on *dual-change-regression models* (McArdle, 2009) and depicted in Figure 4.1. The change-regression models are based on classic change score models. In such a model, instead of a correlation from measurement time 1 to the change variable, a regression coefficient is used. This enables the model to be more independent from the precise time the change occurred (McArdle, 2009). In short this model is better suited to the change process at hand, because of our long study interval and the nature of the studied change

process. The dual-change-regression model features two change scores, predicted by their respective variables at baseline, the baseline correlation, the correlations of unexplained change and the construct (at baseline) to change in the other construct cross predictions (*intervariable cross-lagged predictions*). Stability and change is contained in the respective change variables and not in predictor paths, which is a key difference when compared to the previously introduced autoregressive models. Conceptually speaking, the change scores represent interindividual differences in intraindividual changes of personality and cognition as well as their cross prediction from baseline, which represents the theoretically interesting change prediction.

Measurement invariance. Groups might systematically differ in their interpretation of indicators. More precisely, if a construct is measured with one single questionnaire in two distinct groups (or at two measurement times) the same questions might be interpreted systematically different by the two groups and, therefore, the latent constructs might yield different meaning (interpretation value) in each group. Measurement invariance counteracts this important problem, but despite being of high importance, it has often times been neglected by previous research. Establishing measurement invariance is achieved by constraining parameters in measurement models to be equal across groups and in longitudinal analyses also across measurement occasions (e.g. Horn & McArdle, 1992; Meredith & Horn, 2001). There are different degrees of measurement invariance, namely weak, strong and strict (Meredith, 1993). Very briefly, weak measurement invariance is given when pattern matrices are fully invariant (across groups and/or time). Strong measurement invariance is given, when, additionally, the intercepts of the manifest indicators are invariant (across groups and/or time). Strict invariance is given when, in addition to the two previous conditions, also the unique variances are invariant (across groups

and/or time), meaning more precisely that the residual variances are equal. In practice, establishing measurement invariance is a highly problematic issue. Meredith (1993) acknowledged that the different stages of invariance are, despite their enormous application value, idealizations. Especially strict factorial invariance is often times not achievable. Strong measurement invariance allows for interpretation of the cross-predictor paths, which were the target variables of the analyses in the upcoming manuscripts. Therefore, strong measurement invariance was perceived as mandatory for interpretation of path coefficients in the following analyses and set as a precondition in the basic modeling process. The rationale behind this approach is the following: Every psychological model is a simplification of reality to statistically investigate and evaluate phenomena and derive conclusions with necessary parsimony and accuracy. Therefore, preconditioning strong measurement invariance is implemented in the current research in the basic modeling procedure. If the restricted models fit reasonably well to the data, strong measurement invariance can be perceived as given for the present investigations. Taken together, if latent modelling was used in the following manuscripts, strong measurement invariance was preconditioned and is evaluated in conjunction with the model fit.

Interpretation of effects. As mentioned before, results should be interpreted cautiously with regard to causality. Even though the analyses of the present study fulfill the criterion of temporal alignment, the used analyzes cannot rule out the possibility of important moderators and mediators that were not captured in the present study as being explanatory for the described results. Moreover, additional third variables that were not investigated could also account for the found effects. This critical remark and advice for caution is, therefore, of high importance considering the effect interpretation of the present manuscripts (1-3).

The classical method of effect interpretation is by null-hypothesis significance testing using *p*-values. There are a couple of problems concerned with significance tests. First, significance tests are dependent on multiple parameters of statistical testing, namely the sample size, the liability to the relationship of alpha- and beta-error and the "true" effect in the population. Furthermore, statistical tests give no predication about the actual size of the effect. An alternative option is to interpret the path coefficients not based on their significance, but on their effect sizes, namely the magnitude of their standardized path coefficients (on interpretation of general effect sizes read: Cohen, 1992). The present dissertation uses a two-step approach. First, significance values are used to *indicate* a possible effect. Second, the actual sizes of the standardized path coefficients are consulted whether the result *demonstrates* practical relevance. These both are discussed separately in the discussion (chapter 5), when the results of the manuscripts are summarized and interpreted.

In summary, having established a general basis for interpretation and critical discussion of the used method and statistical modeling, the stage is set for the three manuscripts (1-3) printed in the chapters 2-4 of this dissertation.

Chapter 2: Manuscript – Publication 1

Personality and Life Satisfaction Over 12 Years: Contrasting Mid and Late Life

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Date of manuscript preparation: 12/16/2015

Abstract

Theoretical reasoning and empirical data suggest that personality and well-being have substantial interrelationships. However, more longitudinal evidence is required and the relationship lacks research attention from a lifespan perspective. We examined mid-term and long-term interrelations of neuroticism and extraversion with life satisfaction in 2 cohorts of middle and late adulthood, using data from the "Interdisciplinary Longitudinal Study on Adult Development and Aging (ILSE)". Multi-group, cross-lagged models reveal personality to be more predictive of life satisfaction than vice versa. Furthermore, an aging effect occurs regarding the relationships between life satisfaction and personality, with life satisfaction being predictive for personality only in the old cohort. Controlling for health weakens the interrelationship. Results add to the understanding of life-span dynamics among personality and life satisfaction.

Keywords: personality, life satisfaction, longitudinal, age effect, adulthood

Longitudinal Intertwine of Personality and Life Satisfaction in Middle and Late

Adulthood

A close interrelationship of personality and subjective well-being seems theoretically plausible and is empirically well documented (e.g., meta-analysis of Steel, Schmidt & Schultz, 2008). However, most of the evidence so far is restricted to cross-sectional data; longitudinal evidence typically has not exceeded 4-year observational intervals. Hence, it is still not clear how long-term personality development in adulthood may affect change in well-being and vice versa. In particular, longitudinal data targeting the interrelation between personality and life satisfaction in middle versus late adulthood remains scarce. This paper aims to contribute to filling this void by analyzing 12 years of personality and life satisfaction change data of the Interdisciplinary Longitudinal Study on Adult Development and Aging (ILSE) (Sattler et al., 2015). We restrict the treatment of personality to the traits neuroticism and extraversion, because of two reasons: (1) These traits have been generally revealed at the meta-analytical level (Steel et al., 2008) as highly influential for life satisfaction (neuroticism: $\rho = -.45$; extraversion: $\rho = .35$) and have also been found to be more strongly associated to life satisfaction than other traits such as openness ($\rho = .04$), conscientiousness ($\rho = .27$) or agreeableness ($\rho = .19$). (2) Neuroticism and extraversion have most frequently been considered in the previous literature, when it comes to interlinkages between personality and life satisfaction (see again Steel, et al., 2008). Hence, when we use the omnibus term personality in what follows, we always mean neuroticism and extraversion.

Rationale behind the Personality and Life Satisfaction Intertwine

In order to better understand possible interlinkages between personality and well-being, we refer to a theoretical framework based on person-environment-fit

considerations that also draws from the sociogenomic model suggested by Roberts and Jackson (2008). This perspective predicts that if a person perceives an enhanced personality-environment fit (e.g., adequate living conditions, etc.) higher life satisfaction will result. More importantly, if a person experiences higher levels of life satisfaction, he or she might, in a second step, enhance his or her endeavor to maximize the congruence of personality and environment demands. Theoretically, these changes might manifest at first in short-term momentary thoughts, feelings, and behaviors; later, they may transition into deep-seated, long-term personality and life satisfaction developments. Throughout the course of their lives, individuals are confronted with hardships, changing social roles and demands, such as establishing and maintaining success at work or mastering family roles. As is argued, coping with stressful events and maintaining a coherent identity and personality requires constant adjustment. Successful fit achievement is awarded with higher levels of life satisfaction, while unsuccessful fit corresponds to lower levels, which again may trigger subsequent future personality change processes. Supporting empirical evidence for this framework comes from studies on self-regulation and adaptation factors. High extraversion and low neuroticism are, for instance, related to less stress-sensitivity (e.g. Bolger & Schilling, 1991), the application of more adaptive coping styles (Cosway, Endler, Sadler & Deary, 2000), and available opportunities to recruit more and better social support (Russell, Booth, Reed & Laughlin, 1997). Such constellations might foster subsequent positive developments in long-term well-being and, in turn, be perceived as a motivation to readjust one's personality. High well-being supports positive personality developments through increasing social investment and increased efforts to maximize person-environment fit (e.g. Roberts & Wood, 2006; Specht, Egloff & Schmukle, 2013).

Empirical Evidence Concerning the Interrelationship of Personality and Life Satisfaction

The interrelationship of personality and well-being has been the target of two meta-analyses by DeNeve and Cooper (1998) and Steel, Schmidt, and Shultz (2008). While DeNeve and Cooper (1998) found—in light of what has been said above—surprisingly weak connections (overall correlation = .19), Steel et al. reported 10 years later, based on newly generated data and more refined analyses, approximately twofold higher relationships. Therefore, substantial correlations between personality and life satisfaction are considered established, but unfortunately, there are currently few longitudinal studies targeting the interrelationship of personality and life satisfaction and even fewer that target cross-lagged effects.

Scollon and Diener (2006) conducted cross-lagged analyses on work and relationship satisfaction with extraversion and neuroticism in 1,130 participants across an 8-year interval. Results revealed both traits to be significant longitudinal predictors of work satisfaction (extraversion: β = .10, p < .001; neuroticism: β = -.09, p < .01), while work satisfaction had only significant cross-effects with extraversion (β = .09, p < .01) and no significant role-to-trait-effect with neuroticism. On the other hand, only neuroticism was a significant predictor of relationship satisfaction (β = -.06, p < .05), while extraversion was not. Role satisfaction was longitudinally only marginally predictive for extraversion (β = .05, p = .08) and was not significant in predicting neuroticism. Specht, Egloff, and Schmukle (2013) used data from the German Socioeconomic Panel (SOEP) and investigated the relationship of 14,718 participants (M = 47.21; SD = 16.28) across 4 years. Combined dual latent change models—comprised of a latent change approach and a latent growth approach—

revealed the change correlations of personality and well-being to be moderate to high in magnitude. Furthermore, life satisfaction was more influential for personality change than the other way around. Going further, Soto (2015), similar to the Specht et al. study, analyzed data from a large representative sample (n = 16,367, M = 40.39, SD = 18.88). Soto's latent growth curve models on the interrelationship revealed subjective well-being to also predict personality changes better than the other way round. Soto also conducted completely prospective cross-lagged analysis and found well-being and personality to predict each other equally well.

All in all, longitudinal evidence points to both effects of personality on life satisfaction and vice versa. However, seen as a whole, the current state of evidence is limited, for two primary reasons. First, both the studies by Specht et al. (2013) and Soto (2015)—so far the most ambitious studies in terms of sophisticated data analysis—were restricted to 4-year observational intervals, which may be a too short period to address the linkage between personality and life satisfaction; in particular, as suggested by the environment-fit and self-regulation perspective introduced above (e.g. Roberts & Jackson, 2008), underlying change processes may operate slowly and thus only surface across longer time intervals. Moreover, Soto (2015) argues that the mutual prospective effects of personality and life satisfaction on each other might accumulate over time, which also supports the assumption that stronger relationships will be found in longer time intervals (e.g., a decade or longer) as compared to rather short observational periods such as observational periods of less than 5 years. So far, it remains largely an open question of how personality and life satisfaction are cross related under the condition of such longer time intervals. Second, to our knowledge, no previous study has addressed the issue of age effects related to the adult lifespan—particularly, the later window from mid- to late

adulthood. Addressing this question is important, because old age comes with a range of significant changes in day-to-day life, such as no longer being in the labor force ecosystem and undergoing health and functioning challenges.

Personality, Life Satisfaction, and the Transition from Middle Adulthood to Old Age

Here, we rely on a set of elements primarily derived from lifespan concepts of various origins. First, classic theories of human development, such as those of Erikson (1950), as well as more recent theories, such as socio-emotional selectivity theory (Carstensen, 2006), all have the common fundamental premise that individuals undergo important motivational changes as they age. More specifically, most lifespan models assume a transition from an outward orientation to a more inward orientation, such as an increased focus one's own life story and self-narrative, as well as values such as intimacy. Second, prominent lifespan developmental models, such as the motivational theory of lifespan development (Heckhausen, Wrosch, & Schulz, 2010), point to the importance of circumscribed "windows" for goal engagement opportunities as people age. In particular, the opportunity to be engaged in the workforce as a major and decade-long developmental context ends in many countries (such as Germany) at around 65 years of age; thus, it can no longer serve as a source for life satisfaction and purpose in life considerations. Combined with the increasing aging-related inward focus described above, this may result in stronger referral to "what we have in us," i.e., what has been wired as our personality. Third, established models on emotional development, such as the strength and vulnerability integration model (SAVI; Charles, 2011), support the notion that older individuals are highly efficient in selecting and maintaining ecologies that best fit with their personalities. As SAVI argues, by doing so, older adults maintain and secure positive

affect and the avoidance of negative affect. Hence, older adults may be seen as ideal candidates for the ecology-fit perspective as suggested by Roberts and Jackson (2008). Taken together, we assume that the linkage between personality and life satisfaction will increase as we move from middle adulthood to old age.

However, it may be asked whether this assumption proves to be true when health is also considered. Across the lifespan, major and minor health problems emerge and accumulate. This new source of life stress is particularly important, because when comparing mid-life with old age, the probability of facing bodily decline and illness continually increases, limiting developmental possibilities and straining people's adaptation capacities. Regarding neuroticism, in accordance with reinforcement sensitivity theory (Gray, 1987), highly neurotic individuals are especially prone to experiencing accumulated health burdens and related stress, and perceive health problems as more severe than emotionally stable people (Matthews, Deary & Whiteman, 2009), which—combined with the age-related aggregation of health burdens—leads to high neuroticism being a risk factor for life satisfaction in late life (e.g., Wahl, Heyl & Schilling, 2013). Extraversion has proven to be important for stress buffering, is viewed as a protective factor against influences of life stress and is theoretically related to the dopaminergic system and positive affect (e.g., Gray, 1987; Matthews et al., 2009); people scoring high on extraversion are better at choosing and using effective coping strategies and have better mental health, making them, overall, more superior at enduring harmful influences of health burdens (e.g. Matthews et al., 2009).

Empirically, health demonstrated to be a longitudinal predictor of life satisfaction across many studies (e.g. Gana et al., 2013), but there are also studies that present a somewhat mixed picture of the relationship of personality and health.

For example, one study shows neuroticism and conscientiousness to be important predictors of subsequent health (Chapman, Roberts, Lyness & Duberstein, 2013), while Turiano et al. (2012) found that each of the Big Five traits, except openness, are important predictors for subsequent self-rated health. Focusing on the reciprocal relationship between health and subsequent personality impacts, Sutin, Zonderman, Ferrucci, and Terracciano (2013) found no evidence for the predictive power of health for personality, while Jokela, Hakulinen, Singh-Manoux, and Kivimäki (2014) observed a rather consistent role of lowered health, being related with decreases in extraversion and increases in neuroticism.

In conclusion, we arrive at the following predictions regarding the relationship of neuroticism and extraversion with life satisfaction. For one, we expect that the relationship becomes stronger in old age as compared to midlife, because, in the light of the arguments described above as well as the person-environment fit model at large, older adults are better in selecting and maintaining best-fitting ecologies. Second, because the need to cope with increasing health burdens becomes increasingly important throughout the course of one's life, and particularly in old age, controlling for health should reduce the effect of age on the interrelationship between personality and well-being.

The Present Study

The goal of the present study is to examine longitudinal interrelationships of neuroticism and extraversion with life satisfaction. We aim to extend previous insights with three elements: (1) We are in a position to lengthen the time interval of 4 years, commonly used in prior research and also available in our data, to 12 years, which allows for comparing rather short and long-term relationships. Based on this larger data set, we expect personality and life satisfaction to be more strongly interrelated in

their cross-paths in the 12-year interval as compared to the 4-year interval. (2) Regarding the impact of the transition from middle to old age for the relationship between personality and life satisfaction, we expect a closer relationship in the period of old age as compared to mid age. (3) Based on the previous findings, we expect that the consideration of health will weaken possible differences in the strength of relationships between personality and life satisfaction from middle adulthood to old age.

Method

Study Population and Sample Description

Data are obtained from the "Interdisciplinary Longitudinal Study on Adult Development and Aging (ILSE)" (Sattler et al., 2015). The ILSE-Study consists of three finished times of measurement: 1993-1996 (n = 1002), 1997-2000 (n = 896), and 2005-2007 (n = 789). There is an approximately 4-year time interval between measurement occasions 1 and 2 and a 12-year time interval between measurement occasions 1 and 3. The ILSE-participants can be divided in two cohorts by age, either born before WWII (1930-1932; older cohort) or afterwards (1950-1952; younger cohort) and two cohorts by residence (Heidelberg/Leipzig, Germany). Data collection was conducted by questionnaires, testing of cognitive abilities, and an extensive medical assessment executed by the study's trained geriatricians. Further information, like additional sample characteristics and attrition analyses, have already been compiled and reported (e.g., Sattler et al., 2015; Allemand, Zimprich & Hertzog, 2007).

Measures

Life satisfaction. Life satisfaction is measured using a 1-item questionnaire. The question targets general satisfaction with life itself at the "precise moment".

Answer options range from 1 = "not at all satisfied" to 5 = "totally satisfied". Life satisfaction provides good longitudinal convergent validity and moderate-to-good discriminant validity (Lucas, Diener & Suh, 1996). Moreover, single-item measures of life satisfaction are found to cross the frequently cited heuristic of 0.70, indicating acceptable reliability (Lucas & Donnellan, 2012).

Neuroticism and extraversion. Neuroticism and extraversion were assessed using the corresponding subscales of the NEO-Five Factor Inventory (NEO-FFI; Costa & McCrae, 1992b). The NEO-FFI consists of 60 items (12 per subscale), worded as defining statements, which are rated on personal accordance by the participant on 5-grade scales ranging from 1 = "strongly disagree" to 5 = "strongly agree". The questionnaire has proven internal and temporal reliability (e.g., Murray, Rawlings, Allen & Trinder, 2003) and is widely recognized as a well-normed, robust, reliable and valid measure (e.g., Lang & Lüdtke, 2005). Internal consistencies (Cronbach) regarding neuroticism are .79/.82/.84 at t1/t2/t3. Respective internal consistencies for extraversion are .71/.71/.77.

Health. Health at time 1 was assessed via two separate ratings. First, a self-rating for subjective health was conducted and participants were asked to rate their personal health perception "at the precise moment". Answer options on the 6-point Likert scale ranged from 1 = "very bad" to 6 = "very good". Second, an objective health assessment—comprising an anamnesis, a blood analysis, a gero-psychiatric assessment, and a medical checkup, conducted by one to two trained study geriatricians—was also available (see Miche, Elsässer, Schilling & Wahl, 2014, for more details). The professionals aggregated the data and rated the participants' state of health on 6-point Likert scales. Answer options ranged from 1 = "very bad; professional health care is urgent" to 6 = "very good".

Statistical Analyses

Utilizing Mplus (Version 6, Muthén, & Muthén, 2011), multi-group, cross-lagged-path models were constructed, which are depicted in Figure 2.1. The grouping variable was cohort (mid adulthood/old age). The different personality factors at times 1 and 2 (4-year time interval) or times 1 and 3 (12-year time interval) were measured latently, using 3 indicator-parcels of 4 items for each parcel. Item parceling was conducted due to reasons of parsimony. Life satisfaction, due to being a single-item measurement, was entered as a manifest variable. In a following step, the model (Model 1) was enhanced by adding objective and subjective health at time 1 as control variables (Model 2) to predict time 2 (4-year interval) or, respectively, time 3 (12-year interval) of personality and life satisfaction. The logic behind including the health variables only at time 1 was to operate with prospective predictors of equal time intervals. Strong measurement invariance was assessed following recommendations by van de Schoot, Lugtig, and Hox (2012). Cut-off criteria of model-fit indices were used following Hu and Bentler (1999).

Results

Descriptive Data and Examination of Basic Model-Fit

The descriptive statistics of the study variables are given in Table 2.1. At time 1, 500 participants of the older cohort and 502 participants of the younger cohort were investigated. At measurement time 3, only 381 of the older cohort population remained, while the younger cohort population still consisted of 408 participants. The sex ratio in both cohorts at time 1 amounts to roughly 48% women to 52% men. The overall means depict only small changes. Life satisfaction remained stable for the older cohort, but decreased slightly for the younger cohort. The means for both

neuroticism and extraversion were decreasing, for both cohorts, respectively. There were no remarkable differences in participant's self- and externally rated health (i.e., subjective health, objective health) at time 1.

The model-fit indices of the multi-group cross-lagged models are shown in Table 2.2, separated for Model 1 (without health) and Model 2 (with health). The fit indices of the sub-models of Model 1 (E/N, 4/12) ranged from .027 to .055 for the RMSEA, from .975 to .992 for the CFI, and from .042 to .052 for the SRMR, indicating good-excellent fit. The four implementations of Model 2, likewise, revealed good-to-excellent model fits. The RMSEA values ranged from .025 to .052, the CFI values from .971 to .981, and the SRMR values from .038 to .046. In what follows, the model paths of Model 1 and Model 2 for neuroticism and extraversion are extensively reported. Tables 2.3-2.4 illustrate the respective correlations and prospective paths.

Examination of Stability, Cross-sectional Correlations, and Longitudinal Interrelationships

There was high stability for neuroticism and extraversion across all models regardless of cohort, time interval, or the inclusion of health as a predictor. The path coefficients of neuroticism at time 1 to neuroticism at time 2, or respectively, time 3, ranged from $\beta = .683$ to $\beta = .870$ (all $p < .001$). The path coefficients of extraversion at time 1 predicting extraversion at time 2 or time 3 ranged from $\beta = .685$ to $\beta = .890$ (all $p < .001$). Life satisfaction revealed mild to moderate stability across all models. Overall, the coefficients of life satisfaction at time 1 predicting life satisfaction at time 2 and time 3 ranged from $\beta = .248$ to $\beta = .397$ (all $p < .001$). Looking at the cross-section, both neuroticism and extraversion correlated significantly with life satisfaction, revealing mild to moderate relationships (neuroticism: r = -.207 to r = -

.465; extraversion: r = .196 to r = .394) across all measurement occasions and both cohorts (all p < .001).

In Model 1, neuroticism significantly predicted 4-year-later life satisfaction (older cohort: β = -.142, p = .004; younger cohort: β = -.126, p = .016). Respectively, extraversion's ability to predict life satisfaction 4 years later was significant for both cohorts (older cohort: β = .137, p = .009; younger cohort: β = .120, p = .025). The opposing prediction of life satisfaction for personality (neuroticism, extraversion) 4-years-later, showed a different picture. Here, only in the older cohort, life satisfaction significantly predicted neuroticism 4 years later (β = -.018, p = .019). Briefly summarizing, the present data support personality significantly predicting life satisfaction 4 years later, but contradicts regarding the opposing idea that life satisfaction predicts personality factors 4 years later.

Extending the time interval from 4 to 12 years has significant impact on extraversion's interrelationship with life satisfaction, while revealing almost no effect considering the interrelationship with neuroticism. The path from neuroticism to life satisfaction 12 years later barely missed significance for the older cohort (β = -.125, p = .054), but remained highly significant for the younger cohort (β = -.164, p = .007). The relationships between life satisfaction to neuroticism 12 years later were significant for the older cohort (β = -.030, p = .006) and not significant for the younger cohort (β = -.010, p = .855). Regarding extraversion, both relationships between personality and life satisfaction 12 years later were not significant (older cohort: β = .003, p = .964; younger cohort: β = .045, p = .468); surprisingly, however, the relationship between life satisfaction to later extraversion became significant for the older cohort (β = -.042, p < .001). The corresponding relationship for the younger cohort failed to reach significance (β = .041, p = .441).

Examination of Differences in the Relationship of Personality and Life

satisfaction between Middle Adulthood and Old Age

While the magnitudes and significances of the relationships between both personality factors and life satisfaction indicated almost no differences between the cohorts, with the exception of the relationship between neuroticism and life satisfaction 12 years later, which missed the statistical significance level in the old cohort (see Table 2.3), the opposing relationships between life satisfaction and personality differed systematically. Life satisfaction was in 3 out of 4 cases a significant predictor for subsequent personality in the older cohort (N 4: β = -.018, p = .019; N 12: β = -.030, p = .006; E 4: β = -.008, p = .307; E 12: β = -.042, p < .001); however, in the younger cohort, life satisfaction was on no account a significant longitudinal predictor (N 4: β = -.002, p = .969; N 12: β = -.010, p = .855; E 4: β = .017, p = .678; E 12: β = .041, p = .441). All in all, there is evidence for an aging effect that is concerned with life satisfaction being predictive of subsequent neuroticism (both intervals) and extraversion (only long time interval).

The Role of Health

The inclusion of health (Table 2.4) did not remarkably change the stability effects and cross-sectional relations, but the longitudinal interrelationships were weakened, and of the former 8 significant longitudinal cross-effects, only 4 remain. In the short time interval, the relationships between neuroticism and subsequent life satisfaction were significant for both cohorts (older cohort: β = -.112, p = .034; younger cohort: β = -.117, p = .028). Furthermore, the relationship between extraversion and life satisfaction 4 years later were significant for the older cohort (β = .115, p = .028) and barely missed significance for the younger cohort (β = .109, p = .052). In the long time interval, only the relationship between neuroticism and later-

life satisfaction in the younger cohort showed significance (β = -.131, p = .027). In conclusion, the results hint at three findings. First, in the short time interval and controlled for health, personality remains a predictor of later-life satisfaction, while life satisfaction does not significantly predict later neuroticism or extraversion. Second, in the long time interval, when controlled for health, the interrelationship gets slightly weakened and only one effect remains significant. Third, it is particularly noteworthy that all life satisfaction to later personality factor effects became insignificant after entering health into the models, indicating that the life satisfaction to personality age effect might vanish when controlled for health.

As expected, objective and subjective health were highly correlated with each other (r's ranging from r = .452 to r = .495; all p < .001). Cross-sectional, subjective health was mild to moderately correlated to neuroticism (r's ranging from r = -.269 to r = -.362; all p < .001), extraversion (r's ranging from r = .199 to r = .261; all p < .001), and life satisfaction (r's ranging from r = .177 to r = .222; all p < .001), across both time intervals and cohorts. Longitudinally, subjective health was not significantly predictive of neuroticism, extraversion, or life satisfaction, with one exception. The relationship between subjective health at time 1 to life satisfaction 12 years later was significant in the older cohort (β model with neuroticism = .165, p = .009; β model with extraversion = .196; p = .002). Objective health showed a more complex cross-sectional and longitudinal relationship pattern, being mildly correlated with neuroticism (r's ranging from r = -.138 to r = -.230; all p < .01) and extraversion (r's ranging from r = .112 to r = .133; all p < .05) at time 1 across all cohorts and in all calculated models. Moreover, objective health was mildly correlated to life satisfaction at time 1 in the older cohort (r = .166, p < .001), but not in the younger cohort (r = .044, p = .324). Objective health at time 1 revealed no significant

longitudinal relations to the personality factors at time 2 or time 3, with one exception. In the older cohort, a significant longitudinal effect of objective health to 12-year-later extraversion reached significance ($\beta = .132$, $p = .026$). In the models with neuroticism, the paths of objective health predicting life satisfaction in the older cohort barely missed significance (4: $\beta = .093$, $p = .066$; 12: $\beta = .131$, $p = .052$), which was reached in the long time interval of the younger cohort (12: $\beta = .208$, $p < .001$). In the model with extraversion, these paths emerged as significant longitudinal predictors (older cohort 4: $\beta = .103$, $p = .042$; older cohort 12: $\beta = .135$, $p = .046$; younger cohort 12: $\beta = .208$, $p = < .001$). Therefore, the longitudinal influences of subjective and objective health showed relevance, especially for life satisfaction and the long time intervals.

Discussion

The research goal of the present study was to add long-term evidence to the relationship of personality (neuroticism, extraversion) and life satisfaction. Additionally, and for the first time, two very important enhancements were made to the present body of research. First, in contrast to the usually rather short-term observation intervals (e.g., 2-6 years), we offered long-term, longitudinal, cross-lagged data on the relation between personality and life satisfaction, amounting to 12 years. Second, we contrasted for the first time mid-adulthood and old age, based on theoretical reasoning regarding the link between personality and life satisfaction.

The overall results of stability and cross-sectional correlations of the cross-lagged models were in line with previous research in terms of confirming high stability for both personality factors across the 4- and 12-year time intervals (e.g., Roberts & Del Vecchio, 2000); we also found smaller yet substantial stability coefficients for life

satisfaction. Moreover, our cross-sectional correlations of neuroticism and extraversion with life satisfaction accord well with the meta-analytical results of DeNeve and Cooper (1998) and Steel et al. (2008), revealing mild to moderate relationships.

Across all our models—meaning both those controlled and uncontrolled for health—the relationships between the personality factors predicting life satisfaction 4 years later reach significance in 7 out of 8 cases, with one relationship barely missing significance (p = .052). On the other hand, only one prospective relationship between life satisfaction and neuroticism 4 years later reached significance (cohort 30). While the standardized betas of personality predicting later-life satisfaction were small but statistically meaningful, their counterparts from life satisfaction to personality were practically in the zero range. These results are quite surprising, when compared to Specht et al.'s (2013) and Soto's (2015) findings, who argued that well-being effects on traits are equally predictive or even stronger than vice versa. Our data do not support this notion. We found personality clearly predicting life satisfaction 4 years later, but almost no effect for the reversed cross-lagged relationships.

Interpreting these results, some key differences between the present study and Specht et al.'s (2013) and Soto's (2015) analyses must be addressed. First, there is a wide gap between sample sizes. They investigated very large samples of 14,718 and 16,367 participants, while we were restricted to only 1,002 participants at time 1. Second, their study samples covered the full adulthood period (i.e., early, mid, and late), while we concentrated only on mid-adulthood versus old age. Third, they investigated the whole set of personality factors, whereas we restricted ourselves to

neuroticism and extraversion alone[1]. A comparison of the present study's results with

Soto's (2015) results revealed the same pattern of significant relationships regarding

life satisfaction and neuroticism/extraversion with one remarkable difference: the

standardized trait effects in the present study are far larger in magnitude (Soto's

neuroticism trait effect: β = -.084; extraversion trait effect: β = .045). Fourth, Soto

(2015) included measurements of positive and negative affect in addition to life

satisfaction and, sixth, modelled life satisfaction latently. All these reasons might

account for the differences in results. It is plausible that life satisfaction might predict

later-life personality, specifically in its early stages. It is also possible that

conscientiousness, agreeableness, and openness may be more reactive to earlier life

satisfaction than neuroticism and extraversion. All in all, we were partly able to

replicate previous research regarding the short-term interrelationship of personality

and life satisfaction. Our study, however, does not support the importance of life

satisfaction as a predictor for personality change across 4 years.

Turning to our long-term observations—covering 12 years with a focus on

neuroticism—the long-term, cross-lagged paths were of equal magnitude and thus

different from the short-term observations. This, however, was not true for

extraversion. Extraversion was well predictive for life satisfaction 4 years later, but in

the long-term models, these relationships became insignificant and, surprisingly, very

small. Although it appears hypothetical, it is possible to derive from our results that

neuroticism might address the more long-term oriented (e.g., health behavior,

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[1] In response to one of our reviewers' comments, we conducted additional analyses on the remaining three personality traits of the Big-Five, namely conscientiousness, agreeableness and openness. Overall, only two out of 24 possible cross-lagged paths reached significance (old/young cohort, 4/12 years, cross-lagged trait/life satisfaction effect). One significant relationship is between conscientiousness at time 1 and life satisfaction at time 2, while the other significant relationship is between life satisfaction at time 1 and agreeableness at time 3. The two effects remained unaffected by the inclusion of health into the models.

tendency for social isolation) and extraversion the more short-term oriented components (e.g., participation in social activities) of life satisfaction, which is an open question for future studies. It is of additional interest that the relationship between life satisfaction and extraversion became significant in the long time interval (older cohort). As Soto (2015) argued, the prospective effects of life satisfaction and personality might grow larger when allowed to accumulate in longer time intervals. Overall, our data do not consistently support the theoretically assumed stronger interrelations of longer time intervals when compared to shorter time intervals. Obviously, more research is needed to further clarify this issue and observations even longer than 12 years may be helpful in this regard.

In terms of possible age effects regarding the relation between personality and life satisfaction, we also expected (based on theoretical reasoning) that the longitudinal interrelationship might be stronger in old age as compared to mid-adulthood. We also assumed that health may be an important control variable for such possible differences in cross-lagged effects. According to our findings, no difference between the two age cohorts was observed, when it comes to the cross-paths from neuroticism or extraversion to later life satisfaction, which supports rejection of the assumed age effect. However, our data also revealed that the corresponding cross-lagged effects from life satisfaction to neuroticism were predictive for the old cohort, but not for the mid-adulthood cohort. Regarding extraversion, in the long time interval and old cohort, the same pattern is observed. Taken together, the relationship between life satisfaction and subsequent personality change seems—at least for neuroticism and partly for extraversion—to be systematically different between the two age groups, supporting the existence of an age effect. It thus seems that a differential argument is needed to better understand

possible differences in personality–life satisfaction relations in mid-adulthood versus old age.

Finally, the inclusion of health weakened the cross-lagged relationships between personality and life satisfaction and vice versa, leaving only 4 of the former 8 effects as significant and erasing the partial age effect as described above. Thus, health seems to have an important influence on life satisfaction predicting later personality, when middle adulthood and old age are contrasted. Furthermore, in line with our theoretical argument, we cautiously interpret that health is partly responsible for the cross-relationships of neuroticism and extraversion with life satisfaction as indicated by the differences in results after health has been included. It, however, remains unclear how health unfolds its influence on the interrelationship. We therefore recommend future studies on the interrelationship to include health as a time varying covariate.

Furthermore, the two health variables revealed the expected cross-sectional results with each other, life satisfaction, neuroticism, and extraversion, with only one exception. In the younger cohort, objective health and life satisfaction were not significantly correlated. We interpret that in mid-adulthood, objective health constraints are seemingly superimposed by other sources of life satisfaction, like, for example, success at work and striving in family roles, which changes when people grow older and bodily decline becomes a more frequent issue. The longitudinal results of health were surprising to us, because subjective health scarcely showed a significant relationship to life satisfaction or personality. Objective health, in contrast, showed a couple of interesting prospective relationships. According to our long-term data, objective health seems indeed to be more important than subjective health, which questions to some extent the now-classic but mostly cross-sectional based

priority of subjective health as compared to objective health, when it comes to the prediction of life satisfaction and well-being in general. Surprisingly, personality was hardly affected by objective health.

Limitations and Future Research Needs

The present study analyzed data from the German "Interdisciplinary Longitudinal Study on Adult Development and Aging (ILSE)", which has numerous important strengths: its long study interval, multidisciplinary data gathering, and refined cohort design to explicitly cover mid- and late adulthood. However, the study has also considerable limitations. First, the present investigation, as well as Specht et al. (2013) and Soto (2015), heavily relied on very short assessment formats (and, indeed, 1-item formats to some extent). Although such short assessments are found to be acceptable in terms of reliability and validity (e.g., Diener, Suh, Lucas & Smith, 1999; Lucas & Donnellan, 2012; Diener, Inglehart & Tay, 2013), findings need to be replicated and extended, driven by the spirit of a multi-trait, multi-method analysis (Campbell & Fiske, 1959). Second, the used measurements were mostly self-reports. Even though self-reports are state-of-the-art in psychological panel studies, external assessments might shed further light on the subject. Third, the modeling became asymmetrical, because personality was measured latently and life satisfaction was implemented into the models as a manifest variable. More indicators for life satisfaction than one item would certainly improve the plausibility of the construct and help equalize the relationship. The lacking predictability of life satisfaction for later-life personality changes might be partly due to the chosen approach. Fourth, a different modeling—as compared to the multi-group, cross-lagged models—could be promising. Specht et al. (2013) and Soto (2015) partly used latent-growth curve models to describe the interrelationship. Even though this approach is not fully

prospective, change correlations and the cross level to change effects might be affected by the implementation of health and the enlarged time intervals. Fifth, to better understand the impact of health on the interrelationship, a more refined measurement approach and modeling of health seems promising. We included health only at time 1 to align with the prospective cross-lagged effects, but recommend future studies to include health as a dynamic change variable.

Conclusion

Despite the limitations of the present study, a number of conclusions were supported by our data. First, neuroticism and extraversion were shown in our data to predict subsequent life satisfaction in the short time interval. In the long time interval, however, a mixed picture appeared and only neuroticism was able to predict life satisfaction longitudinally. Furthermore, a (partial) age effect regarding the intertwining of personality and life satisfaction emerged. Life satisfaction was predictive for neuroticism in old age, but not in mid-adulthood, which was also true for extraversion (but only in the long time interval). This age effect appeared nevertheless as health dependent. Overall, our data support taking a differential perspective to understand better developmental trajectories and interlinkages of multi-dimensional constructs like personality and life satisfaction.

Conflict of interest

None.

Acknowledgement

Table 2.1

Publication 1: The Basic Descriptive Statistics.

		t1	t2	t3
Population				
older cohort		500 (♀ = 47.9%)	449	381
younger cohort		502 (♀ = 48.2%)	447	408
Life satisfaction				
older cohort		3.94 (SD = .798)	4.11 (SD = .644)	3.94 (SD = .814)
younger cohort		3.82 (SD = .837)	3.82 (SD = .790)	3.55 (SD = 1.051)
Neuroticism				
older cohort		18.63 (SD = 6.88)	18.17 (SD = 6.84)	17.43 (SD = 6.59)
younger cohort		17.74 (SD = 6.99)	16.27 (SD = 7.14)	16.97 (SD = 7.46)
Extraversion				
older cohort		26.51 (SD = 5.67)	26.23 (SD = 5.40)	25.43 (SD = 6.00)
younger cohort		28.50 (SD = 5.71)	28.27 (SD = 5.56)	27.68 (SD = 5.83)
Health				
older cohort	obj.	3.53 (SD = .876)		
	subj.	3.45 (SD = .912)		
younger cohort	obj.	3.73 (SD = .782)		
	subj.	3.53 (SD = .813)		

Note. Table displays the participant count in the first two rows and mean values with their associated standard deviations (SD) in the following rows. Measurement times 1, 2, and 3 are abbreviated as t1, t2, and t3. Older cohort = cohort born 1930-1932; younger cohort = cohort born 1950-1952; ♀ = female participants; Obj. = objective health; Subj. = subjective health.

Table 2.2

Publication 1: Model-Fit Indices of the Multi-group and,-Cross-lagged Models.

Model-Fit Indices		χ^2	df	*p*	RMSEA	CFI	SRMR
Model 1	N 4	128.315	51	*.000*	.055	.975	.042
Model 1	N 12	109.786	51	*.000*	.048	.975	.047
Model 1	E 4	69.172	51	*.045*	.027	.992	.049
Model 1	E 12	78.851	51	*.007*	.033	.984	.052
Model 2	N 4	158.394	67	*.000*	.052	.971	.038
Model 2	N 12	135.001	67	*.000*	.045	.973	.043
Model 2	E 4	87.200	67	*.049*	.025	.991	.043
Model 2	E 12	98.289	67	*.007*	.031	.983	.046

Note. N = neuroticism; E = extraversion; 4 = 4-year time interval; 12 = 12-year time interval; Model 1 = Model without health; Model 2 = Model with health; χ^2 = chi-square value; df = degrees of freedom; *p* = probability value; RMSEA = root mean squared error of approximation; CFI = comparative fit index; SRMR = standardized root mean square residual.

Table 2.3

Publication 1: Correlations and Standardized Prospective Paths of Model 1 (Without Health), Separated for Personality Factor, Time Interval, and Cohort.

Paths		Neuroticism		Extraversion	
		4	12	4	12
Base correlations	older cohort	-.299***	-.304***	.219***	.201***
(P t1 ↔ LS t1)	younger cohort	-.369***	-.370***	.246***	.245***
Subsequent correlations	older cohort	-.217**	-.316***	.394***	.386***
(P t2/t3 ↔ LS t2/t3)	younger cohort	-.465***	-.383***	.255***	.277***
Trait stability	older cohort	.849***	.744***	.890***	.850***
(P t1 → P t2/t3)	younger cohort	.748***	.709***	.841***	.706***
Life satisfaction stability	older cohort	.362***	.290***	.356***	.327***
(LS t1 → LS t2/t3)	younger cohort	.294***	.342***	.311***	.397***
Cross-lagged trait effects	older cohort	-.142**	-.125†	.137**	.003
(P t1 → LS t2/t3)	younger cohort	-.126*	-.164**	.120*	.045
Cross-lagged life satisfaction effects	older cohort	-.018*	-.030**	-.008	-.042***
(LS t1 → P t2/t3)	younger cohort	-.002	-.010	.017	.041

Note. Values represent standardized model parameters. P = personality factor; LS = life satisfaction; t1/t2/t3 = measurement times 1/2/3; 4 = 4-year time interval; 12 = 12-year time interval; older cohort = cohort born 1930-1932; younger cohort = cohort born 1950-1952; ↔ = correlation; → = directed path. *$p < .05$, **$p < .01$, ***$p < .001$, †$p < .1$

Table 2.4

Publication 1: Correlations and Standardized Prospective Paths of Model 2 (With Health), Separated for Personality Factor, Time Interval, and Cohort.

Paths		Neuroticism		Extraversion	
		4	12	4	12
Base correlations	older cohort	-.302***	-.302***	.209***	.196***
(P t1 ↔ LS t1)	younger cohort	-.369***	-.370***	.246***	.245***
Subsequent correlations	older cohort	-.207**	-.294***	.382***	.382***
(P t2/t3 ↔ LS t2/t3)	younger cohort	-.464***	-.351***	.256***	.257***
Trait stability	older cohort	.870***	.736***	.877***	.850***
(P t1 → P t2/t3)	younger cohort	.736***	.683***	.839***	.685***
Life satisfaction stability	older cohort	.339***	.248***	.334***	.271***
(LS t1 → LS t2/t3)	younger cohort	.288***	.330***	.305***	.382***
Cross-lagged trait effects	older cohort	-.112*	-.073	.115*	-.049
(P t1 → LS t2/t3)	younger cohort	-.117*	-.131*	.109†	-.007
Cross-lagged life satisfaction effects	older cohort	-.003	-.046	.020	-.022
(LS t1 → P t2/t3)	younger cohort	.006	.000	.015	.037

Table 2.4 – *Continued*

Paths				Neuroticism		Extraversion	
				4	12	4	12
Subj. health	↔	Obj. health	older cohort	.495***	.494***	.494***	.495***
			younger cohort	.453***	.452***	.453***	.452***
Subj. health	↔	LS t1	older cohort	.222***	.221***	.222***	.221***
			younger cohort	.178***	.181***	.177***	.181***
Subj. health	↔	P t1	older cohort	-.362***	-.354***	.199***	.215***
			younger cohort	-.271***	-.269***	.257***	.261***
Obj. health	↔	LS t1	older cohort	.166***	.165***	.166***	.165***
			younger cohort	.044	.044	.043	.044
Obj. health	↔	P t1	older cohort	-.230***	-.223***	.120*	.133*
			younger cohort	-.142**	-.138**	.112*	.114*
Subj. health	→	LS t2/t3	older cohort	.056	.165**	.076	.196**
			younger cohort	.050	.079	.043	.104†
Subj. health	→	P t2/t3	older cohort	.052	.017	-.011	-.087
			younger cohort	-.038	-.075	.023	.039
Obj. health	→	LS t2/t3	older cohort	.093†	.131†	.103*	.135*
			younger cohort	-.003	.208***	-.001	.208***
Obj. health	→	P t2/t3	older cohort	-.025	-.050	.064	.132*
			younger cohort	-.047	-.097†	-.043	.068

Note. Values represent standardized model parameters. P = personality factor; LS = life satisfaction; t1/t2/t3 = measurement times 1/2/3; 4 = 4-year time interval; 12 = 12-year time interval; older cohort = cohort born 1930-1932; younger cohort = cohort born 1950-1952; ↔ = correlation; → = directed path; Obj. = objective; Subj. = subjective. $^*p < .05$, $^{**}p < .01$, $^{***}p < .001$, $^†p < .1$
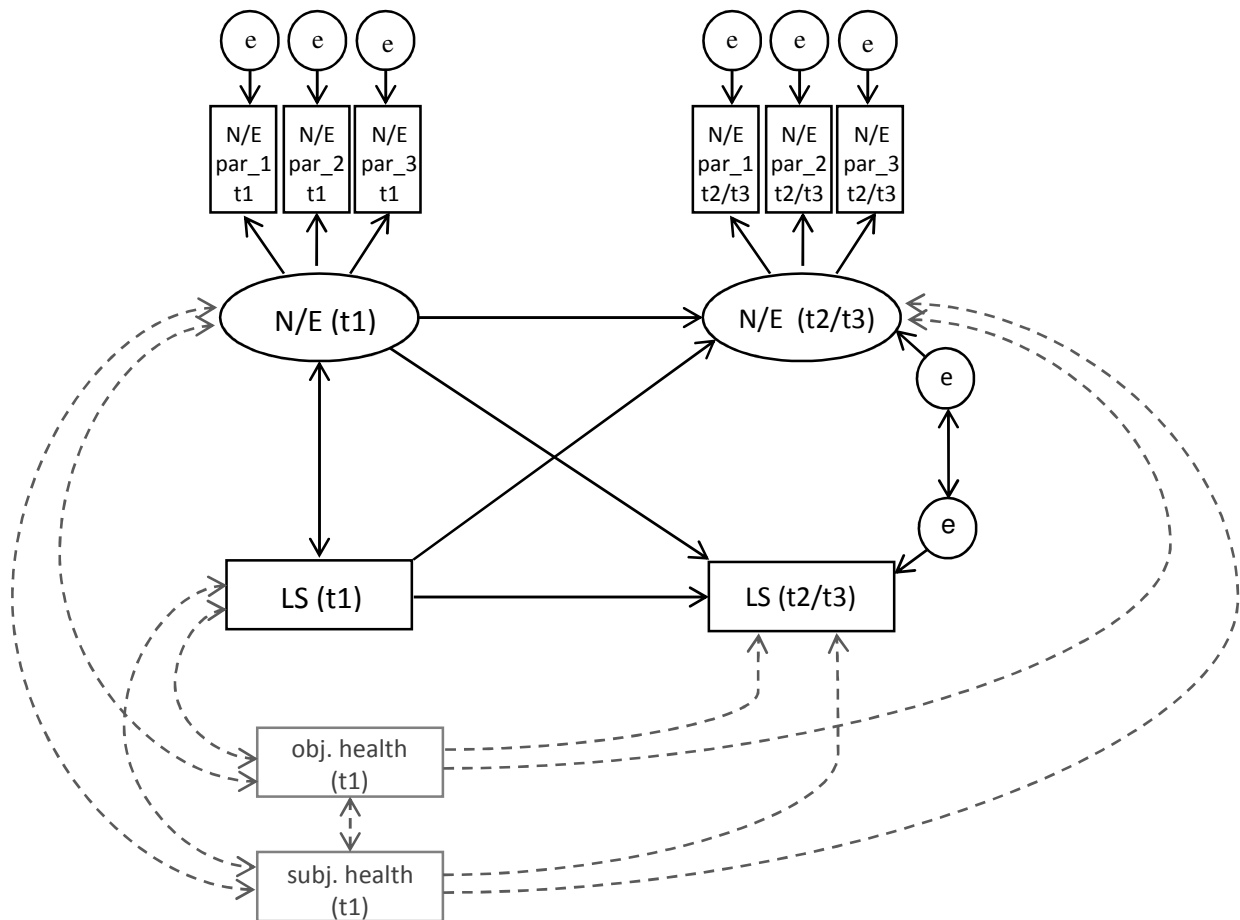
Figure 2.1

Multi-group, cross-lagged-path model with two latent variables for personality (N/E =

Neuroticism/Extraversion) measured by respectively three item parcels (e.g. par_1) and two

manifest variables modeling life satisfaction (LS) (Model 1). Objective and subjective health

variables are added as controls (Model 2; with dashed lines). Grouping variable is cohort.

Model is either defined by time 2 or time 3.

Chapter 3: Manuscript – Publication 2

12-Year Associations of Health with Personality in the Second Half of Life:

Being versus Feeling Healthy

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Abstract

We examined longitudinal associations between personality, objective (physician-rated) and self-rated health over 12 years in two German cohorts (midlife cohort, born 1950/52, n_{T0} = 502; late life cohort, born 1930/32, n_{T0} = 500) from the "Interdisciplinary Longitudinal Study of Adult Development (ILSE)". Based on cross-lagged panel design analyses controlling for gender, education, depression and cognitive abilities, we found that better baseline objective health predicted lower neuroticism and higher agreeableness after 12 years, whereas baseline extraversion and conscientiousness were positive predictors of later self-rated health. Our findings thus illustrate that the direction of longitudinal personality-health associations is dependent on whether objective or self-rated health is considered, whereas relations do not seem to be considerably different in midlife vs. in old age.

Key words: Personality, health, middle adulthood, old age, Big Five, neuroticism, extraversion, agreeableness, openness, conscientiousness

Introduction

Both personality and health are changeable across the entire life span

(Morack, Infurna, Ram, & Gerstorf, 2013; Wagner, Ram, Smith, & Gerstorf, 2015).

The aim of this study is to examine reciprocal longitudinal associations between the

"Big Five" personality traits (Costa & McCrae, 1992a) and health over 12 years in a

midlife (baseline age 43-46 years) and a late-life cohort (baseline age 61-65 years).

Given the multidimensionality of health (Spiro, 2001), we will investigate the interplay

of both objective health (rated by a physician) and self-rated health with personality.

Rather than focusing on single diseases, we are interested in how individuals'

position on a *general* health continuum, as rated by themselves as well as by

physicians, interacts with personality traits. We argue that most of previous research

has (1) considered personality only as a predictor, rather than as both an antecedent

and an outcome, of health, and (2) neglected the potentially differential role of

objective vs. self-rated health regarding the longitudinal personality-health interplay.

Moreover, we will investigate whether personality-health association patterns are

different in midlife vs. late life.

Personality as a Predictor of Health

Most existing research on the longitudinal personality-health interplay has so

far been dedicated to the question whether personality traits predict health outcomes

(Friedman & Kern, 2014; Smith & MacKenzie, 2006). Various interacting

mechanisms may underlie such associations, including behavioral (e.g., Lodi-Smith

et al., 2010), physiological (Luchetti, Barkley, Stephan, Terracciano, & Sutin, 2014),

and social pathways (Hill, Nickel, & Roberts, 2014).

Regarding empirical evidence, the role of personality as a predictor of health,

particularly *neuroticism,* has frequently been investigated. High neuroticism seems to

play a consistent role as a risk factor for poor health: For instance, Sutin, Zonderman,

Ferrucci, and Terracciano (2013) found that neuroticism (and particularly its sub-facet

impulsiveness) was associated with a higher risk of developing disease or of getting

more ill. Moreover, apart from predicting future self-rated health (Human et al., 2013;

Magee, Heaven, & Miller, 2013; Turiano et al., 2012) and decline in self-rated health

(Löckenhoff, Terracciano, Ferrucci, & Costa, 2012), neuroticism also acts as an

important prospective risk factor when an individuals' health is rated by a physician

rather than self-reported (Chapman, Roberts, Lyness, & Duberstein, 2013).

Furthermore, *extraversion* seems to be a protective trait regarding health outcomes,

with higher scores and increases in extraversion over time being associated with

better prospective self-rated health (Magee et al., 2013; Turiano et al., 2012).

Regarding *openness to experience*, most studies so far found no meaningful

relationship between baseline openness and prospective health outcomes or health

changes (Magee et al., 2013; Morack et al., 2013; Tolea, Costa, et al., 2012; Turiano

et al., 2012). In contrast, *agreeableness* may play a more meaningful role with regard

to health: For instance, lower agreeableness was found to be associated with faster

accumulation of morbidity (as assessed by a physician) over time (Chapman et al.,

2013). However, regarding subjective health outcomes, Turiano et al. (2012) reported

that higher agreeableness scores as well as increases in agreeableness over time

were prospectively associated with *worse* self-rated health. *Conscientiousness* may

be, together with neuroticism, the most important health predictor (Reiss, Eccles, &

Nielsen, 2014; Shanahan, Hill, Roberts, Eccles, & Friedman, 2014). Specifically,

higher conscientiousness was found to be associated with a lower prospective risk of

"getting sicker" as well as with lower future disease burden (Sutin et al., 2013).

Additionally, higher conscientiousness also predicts lower physician-assessed illness

burden accumulation over time (Chapman et al., 2013). Moreover, individuals with higher baseline conscientiousness as well as with increases in conscientiousness over time were found to report better subsequent self-rated health (Human et al., 2013; Magee et al., 2013; Turiano et al., 2012).

Personality as an Outcome of Health

However, a one-sided perspective, focusing on personality as a determinant of health, may not fully capture the complexity of the longitudinal personality-health interface. Health deterioration and the onset of an illness may challenge personality stability. For instance, the experience of health restrictions may upset individuals and complicate the engagement in social and other activities, consequently leading to tendencies of social withdrawal and avoidance of new experiences which may be too exhausting once health is compromised. Thus, poor health may result in an increase in neuroticism as well as a decrease in extraversion and openness to experience. In addition, severe health problems may also challenge an individual's capacity to maintain a certain level of agreeableness, e.g. due to feelings of envy with regard to others' health.

Although the overwhelming majority of empirical studies has considered personality as an antecedent of health, there is also some evidence in favor of meaningful health effects on later personality. For instance, the onset of chronic disease was found to be associated with an increase in neuroticism and a decrease in extraversion, openness, and conscientiousness (Jokela, Hakulinen, Singh-Manoux, & Kivimäki, 2014). Sutin et al. (2013) observed that an increase in illness burden was associated with a decrease in openness and – though only marginally significantly– with a decline in extraversion. Similarly, in a sample of very old adults, higher self-reported disability emerged as risk factor for declines in extraversion and

openness (Wagner et al., 2015). Finally, turning to specific health conditions, the experience of late-life sensory (vision or hearing) impairment seems to be associated with an increase in neuroticism (Lißmann, 2003), and hearing impairment is related with steeper declines in extraversion (Berg & Johansson, 2014; Lißmann, 2003).

To summarize, personality (particularly neuroticism and conscientiousness) seems to meaningfully predict health outcomes, but there is also some evidence pointing at the role of health as a predictor of personality change. However, there is still a lack of studies simultaneously investigating both directions of the personality-health interface instead of (or in addition to) considering personality as only a determinant of health.

Are Objective and Self-rated Health Differentially Related With Personality?

So far, many studies investigating personality-health associations have either focused on self-rated or objective/physician-rated health. However, the strength and direction of associations may vary according to whether self-rated or objective health is considered. Regarding neuroticism, for instance, it seems that this trait is more strongly related with self-rated than with objective health (Israel et al., 2014), and the relationship between neuroticism and self-rated health also holds when controlling for objective health indicators (Duberstein et al., 2003). As another example, agreeableness was found to be a protective factor for later objective health as rated by a physician in one study (Chapman et al., 2013), but in another study in which health was assessed by self-reports, agreeableness turned out to be a negative predictor (Turiano et al., 2012).

Generally, correlations between indicators of self-rated and objective health are far from deterministic (French, Sargent-Cox, & Luszcz, 2012; Pinquart, 2001), which implies that self-rated and objective health represent empirically distinguishable constructs. The discrepancy between these both health modalities seems to increase with advancing age (French et al., 2012; Pinquart, 2001; Schnittker, 2005). A reason for this discrepancy could be that different factors predict self-rated vs. objective health, and personality might be one of these factors. Specifically, self-rated health may be more strongly influenced and predicted by personality than objective health. Indeed, most of the studies which examined personality effects on later health considered self-rated rather than objective health (e.g., Löckenhoff et al., 2012; Magee et al., 2013). In contrast, though evidence regarding the effects of health on personality change may still be too scarce for firm conclusions, personality may rather change in reaction to objective health conditions (such as sensory impairment or chronic disease; Berg & Johansson, 2014; Jokela et al., 2014; Lißmann, 2003) than to self-rated health.

To summarize, we assume that objective health predicts personality change to a larger extent than being predicted by personality. In contrast, self-rated health may be rather predicted by personality traits than acting as a prospective predictor of personality.

The Personality-Health Interplay in Midlife and in Late Life

Finally, associations between personality and health may be different at different life phases. Health is generally good in middle adulthood (Lachman, 2004; Lachman, Teshale, & Agrigoroaei, 2015), whereas old age is usually associated with declining health (Jacobs et al., 2012; Morack et al., 2013). This could imply that

health affects personality more strongly in late life than in midlife, because as long as health is good (i.e., in midlife), it should not have a major impact on personality.

However, the opposite scenario is also plausible: Considering that health decline in old age is rather "normative" (Moser et al., 2013; Sprangers & Schwartz, 1999) and can be anticipated by aging individuals, health restrictions in old age may not represent a severe challenge for personality stability. In contrast, experiencing health problems in middle adulthood is a rather non-normative, "off-time" experience, because "biologically based changes are typically not as dramatic in midlife as in other periods of the lifespan" (Lachman, 2004, p. 325), so that the impact of health restrictions on personality could as well be stronger in midlife than in late life.

Turning to self-rated health, empirical evidence is inconclusive. Some studies report stronger associations between personality and self-rated health with advancing age (Canada, Stephan, Jaconelli, & Duberstein, 2016; Duberstein et al., 2003), whereas other studies state the opposite effect (Magee et al., 2013), and still other studies found no age trend at all (Morack et al., 2013).

Given the paucity of empirical findings comparing personality-health associations across different age groups in general, and particularly based on *longitudinal* and *reciprocal* personality-health relations, we will not derive specific predictions for this study regarding differences between middle-aged and older adults in the personality-health interplay.

Research Questions and Expectations

In this study, we examine 12-year longitudinal relationships between personality traits and self-rated as well as objective health in middle-aged and older adults. Our predictions are: (1) Generally, associations are reciprocal, i.e., personality is not only

a determinant of health, but also predicted by health; (2) self-rated and objective (physician-assessed) health are differentially related with personality [for objective health, stronger effects are expected for the direction "health → personality"; for self-rated health, stronger effects are expected for the direction "personality → health"]. Moreover, we investigate whether cohort membership moderates longitudinal personality-health associations as an exploratory research question.

Methods

Study Population and Sample Description

The data of the present study was obtained from the „Interdisciplinary Longitudinal Study of Adult Development" (ILSE; Sattler et al., 2015), a German population-based study which started in the early 1990's. The ILSE sample was stratified by gender and region (with one subsample drawn in the cities Heidelberg, Mannheim, and Ludwigshafen, and the other subsample recruited in Leipzig) and consists of two cohorts, a late-life cohort born 1930-1932 and a mid-life cohort born 1950-1952. The sample was drawn with the help from city registries (for further information on the sampling procedures, see Martin & Martin, 2000) and was representative for the two regions in which the sampling took place. The overall participation rate at the first measurement occasion was 42.3%. The study comprises three completed measurement waves (i.e. first wave: 1993-1996, $n = 1002$, second wave: 1997-2000, $n = 896$, third wave: 2005-2008, $n = 769$; response rate at third wave: total sample 76.7%, late-life cohort 74.84%, mid-life cohort 81.45%). For the following analyses, we focused on the entire study interval of 12 years, because we were interested in the longitudinal personality-health interplay over an *extended* time period; investigating this interplay over only 4 years may not adequately capture the reciprocal associations because very high rank-order stability of personality traits and

health across this rather short time interval can be expected. In the following, the first measurement occasion will be denoted "T_0" and the third measurement occasion (which took place 12 years later) will be denoted "T_{FU}" (FU = follow-up).

Significant group differences favoring the younger cohort were found for education, physician-rated health, cognitive abilities and depressive symptoms. Basic descriptive data of the sample is shown in Table 3.1. Correlations between study variables are shown in Table 3.2.

To investigate potential effects of selective dropout as well as to compare the size of these dropout effects between both cohorts, we computed 2x2 analyses of variance with the factors "T_{FU} Participation" (yes vs. no) and "cohort" (mid-life vs. late-life) as well their interaction. Regarding education, T_{FU} study participants had significantly more years of education compared to the dropout sample ($F[1, 946] = 15.64$, $p < .001$), but this difference corresponded to a small effect size (partial $\eta^2 = .016$). Similarly, there was a statistically significant interaction effect of cohort and T_{FU} study participation ($F[1, 946] = 5.14$, $p = .024$), with the difference between dropouts and non-dropouts in mean years of education being more pronounced in the mid-life cohort compared to the late-life cohort, but the effect size of this interaction effect was also small (partial $\eta^2 = .005$). The gender distribution of dropouts vs. non-dropouts was not significantly different in both cohorts. Regarding depression, there was no significant difference between the dropout and the non-dropout sample, and the interaction of cohort and T_{FU} study participation did also not reach significance. General cognitive abilities were significantly higher in T_{FU} study participants compared to the dropouts ($F[1, 965] = 34.61$, $p < .000$), though this effect was small (partial $\eta^2 = .16$), and there was no significant interaction with cohort. Regarding differences in our target variables, both self-rated health ($F[1, 948] = 19.07$, $p < .000$,

partial η² = .020) and physician-rated health (F [1, 951] = 24.80, $p < .000$, partial η² = .025) were significantly poorer in the dropout sample than in non-dropouts. Regarding self-rated health, this difference between dropouts and non-dropouts was significantly larger in the late-life sample than in the mid-life sample (F [1, 951] = 7.42, $p = .007$, partial η² = 0.008). Remarkably, T$_{FU}$ participants and dropouts did *not* significantly differ in any of the Big Five personality traits, and interaction effects with cohort were consistently not significant.

To summarize, selective dropout occurred regarding some, but not all of the study variables, and all of the selective dropout effects that reached statistical significance were of small effect size. The mid-life and late-life samples only differed in the size of two selective dropout effects and these differences were also of small effect size.

Measures

Personality traits.

Personality traits were measured by the German version of the NEO-Five-Factor Inventory (NEO-FFI; Borkenau & Ostendorf, 1993; Costa & McCrae, 1992b). The NEO-FFI consists of 60 items, i.e. 12 items per personality trait (Cronbach's alphas at both measurement occasions: neuroticism .79/.84, extraversion .71/.77, openness .54/.61, agreeableness .62/.71, and conscientiousness .75/.79).

Health.

Self-rated *health* was assessed using a single-item measurement. Participants were asked to rate how satisfied they were with their health. The answer options ranged from 1 = "very dissatisfied" to 5 = "very satisfied". Second, *physician-rated health* was based on the judgment of one-to-two trained study geriatricians (for a

detailed description, see Miche, Elsässer, Schilling, & Wahl, 2014). Overall the clinical health ratings of the physicians were a summary score based on four in-depth examinations, namely an anamnesis, a medical check-up, a laboratory blood test and a geriatric assessment. Each of the clinical examinations consisted of several subtests (such as hearing and vision assessment or blood pressure measurement). Geriatricians integrated the results from the four examinations into one rating of each study participant's overall health, with the response scale ranging from 1 = "participant exhibits a serious medical condition, which is immediately life-threatening – professional health care is urgent" to 6 = "participant exhibits very good health (i.e., no chronic disease, no chronic pain, all clinical assessments conducted led to non-pathological findings)".

Covariates.

In analogy to other studies addressing relationships between personality traits and health measures, we controlled for gender and education (Chapman et al., 2013; Jaconelli, Stephan, Canada, & Chapman, 2013; Löckenhoff et al., 2012; Sutin et al., 2013; Turiano et al., 2012). In addition, some previous studies addressing the personality-health interplay also controlled for depressive symptoms (e.g., Tolea, Ferrucci, et al., 2012) and cognitive abilities (e.g., Israel et al., 2014; Tolea, Costa, et al., 2012). As these both variables are meaningfully associated with personality (Curtis, Windsor, & Soubelet, 2015; Klein, Kotov, & Bufferd, 2011) and health (Schilling, Wahl, & Reidick, 2013; Tolea, Morris, & Galvin, 2015), we decided to additionally include baseline depression and cognitive abilities as covariates. Education was measured in years (of attending school and university). Depression was measured by the 20-item self-rated Zung depression scale (SDS; Zung, 1965; α = .42). To control for cognitive abilities, we included a composite score of global

cognitive ability based on a set of well-established and widely used cognitive measures implemented in the regular data protocol of the ILSE (for a detailed description of the cognitive assessment which took place as part of the ILSE study and of each single cognitive test that was conducted, see Zimprich, Allemand, & Dellenbach, 2009; Zimprich & Mascherek, 2010). Specifically, we included tests of information processing speed (Number-Connecting Test and Digit Span Substitution task; Oswald & Roth, 1987; Tewes, 1991), crystallized abilities (Information and Similarities tests from the Wechsler Adult Intelligence Scale; Tewes, 1991), memory (Picture Recall, Delayed Picture Recall and Word List Recall from the Nuremberg Inventory of Old Age; Oswald & Fleischmann, 1995), and working memory capacity (Digit Span Forward and Digit Span Backward from the Nuremberg Inventory of Old Age; Oswald & Fleischmann, 1995). The scores of these different cognitive tests were z-transformed and then averaged, resulting in a composite score representing global cognitive ability.

Statistical Analyses

The 12-year longitudinal interplay between personality traits and health indicators as well as the role of cohort (midlife vs. late-life) as potential moderator were investigated by multi-group cross-lagged panel analyses (Kenny, 2005) which are illustrated in Figure 3.1 and can be considered as "best possible option for investigating causal directionality when experiments are not available" (Newsom, 2015).

For the evaluation of goodness of fit in our models, we relied on established recommendations (McDonald & Ho, 2002). Specifically, we took both the Comparative Fit Index (CFI) and the root mean squared error of approximation (RMSEA) into account. A CFI score ≥ .90 or above indicates an acceptable model fit,

and scores ≥ .95 indicate a good model fit. RMSEA scores ≤ .08 indicate an acceptable model fit, and a good model fit is indicated by RMSEA values ≤ .05 (Hu & Bentler, 1999). IBM SPSS Statistics 20 and IBM SPSS Amos 22 (Arbuckle, 2013) were used for statistical analyses.

Parameter estimation was done via Full Information Maximum Likelihood (FIML). With regard to missing data treatment, FIML has been recommended as state-of-the art approach, using the full data information available and relying on less restrictive "missingness pattern" assumptions compared to approaches such as list-wise deletion (Schafer & Graham, 2002).

Regarding model specification, a stepwise approach was chosen by successively testing additional restrictions: First, the (unstandardized) autoregressive paths of the personality and health indicators, denoted *a* and *b* in Figure 3.1, were constrained to be equal across groups (i.e., between the midlife and the late-life cohort). If this restricted model led to a significant misfit as indicated by the χ^2 difference test, the unrestricted model was accepted. If no significant misfit resulted, the cross-sectional personality-health correlations (*e* and *f* in Figure 3.1 and both cross-lagged paths (*c* and *d* in Figure 3.1) were additionally set equal across groups. If this "more restricted" model did not reveal a significantly worse fit than the "less restricted" model, it was accepted. Otherwise the alternative model (with only autocorrelations set equal between groups) was selected.

Results

Table 3.3 shows the results of the multi-group cross-lagged panel analyses. Goodness-of-fit of all models was very good, with RMSEA scores ranging between

.00 and .08 (all RMSEA values not significantly deviating from the cut-off criterion of .05) and CFI values ranging between .99 and 1.

Regarding potential differences between cohorts regarding rank-order stabilities, we found that all autocorrelations of the personality traits as well as of the health indicators could be set equal across cohorts without a significant loss in model fit. Stability coefficients of the Big Five personality traits ranged from .45 to .70, indicating high, but not perfect rank-order consistency. The rank-order stability estimates for the health indicators were generally lower than the ones of personality, ranging between .21 and .49.

Notably, most cross-lagged paths coefficients could also be set equal between both cohorts. Only the cross-lagged paths between neuroticism and self-rated health could not be constrained to be equal between groups when controlling for covariates, though in the adjusted models these cross-lagged paths were not significant in both groups. Therefore, all cross-lagged effects that we describe in the following refer to both cohorts.

Regarding neuroticism, better baseline objective health was significantly associated with lower neuroticism 12 years later. This association remained significant in the adjusted models. Higher neuroticism was significantly related with worse health after 12 years in the unadjusted model, but this association did not remain significant when controlling for covariates.

Higher T_{FU} extraversion was significantly related with better objective health at T_0; however, this relationship was no longer significant when covariates were taken into account. In contrast, higher baseline extraversion was a significant positive

predictor of later self-rated health, and this association remained significant in the adjusted model.

Higher openness at T_0 was a significant predictor of better objective health 12 years later, but this effect was no longer significant after controlling for the covariates. Moreover, the adjusted cross-lagged relations between openness and self-rated health were all not significant.

Agreeableness at T_{FU} was significantly associated with T_0 objective health, with better baseline health predicting higher subsequent agreeableness. This association remained significant in the adjusted model. Better self-rated health at baseline was also associated with higher agreeableness scores after 12 years, but this relationship did not remain significant when including the covariates.

Higher baseline conscientiousness was significantly associated with both better objective and self-rated health after 12 years. However, only the relationship with self-rated health remained significant when adjusting for the covariates. Moreover, better self-rated health at T_0 was significantly related with higher conscientiousness 12 years later, but this association did not remain significant when adjusting for the covariates.

Regarding the effects of the covariates included, we observed the following significant effects (in both cohorts): In the models including neuroticism, gender was significantly related to neuroticism (higher neuroticism scores in women). Moreover, depression was significantly positively related to T_0 and T_{FU} neuroticism as well as to T_{FU} physician-rated health and T_0 self-rated health. In the models containing extraversion, depression was also a significant negative predictor of baseline extraversion as well as of T_0 and T_{FU} physician-rated health and T_0 self-rated health.

In the models with openness to experience, education was a significant predictor of both baseline and follow-up openness. Moreover, the relationship between depression and baseline openness was negative and significant. Depression was also significantly related with baseline physician-rated and self-rated health, and cognitive abilities were a significant positive predictor of T_0 physician rated health. Regarding the models with agreeableness, gender was significantly associated with baseline agreeableness (higher agreeableness scores in women), and depressive symptoms were a significant negative predictor of baseline agreeableness, T_0 self-rated health, and both T_0 and T_{FU} physician-rated health. Finally, in the models with conscientiousness included, depressive symptoms were a significant negative predictor of baseline conscientiousness as well as of baseline physician-rated and self-rated health. It thus seems that – also in line with the bivariate correlation pattern among the variables (see again Table 3.2) - depression was the covariate with strongest and most consistent associations with both personality traits and health variables[2].

Discussion

Our expectation of reciprocal personality-health relationships in the second half of life could be confirmed, implying that personality is not only a predictor of health as reported in multiple studies and reviews (Friedman & Kern, 2014; Smith & MacKenzie, 2006), but may as well be an outcome of personality. Specifically, we

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[2] Following the suggestion of one reviewer, we further investigated the role of the different covariates by first including only the demographic variables (gender, education) as covariates before additionally controlling for cognitive abilities and depression. Most of the cross-lagged paths that were significant in the unadjusted models remained significant when controlling only for the demographic covariates; only the path from baseline openness to T_{FU} physician-rated health was no longer significant, and the path from baseline self-rated health to T_{FU} agreeableness was slightly above the significance threshold (p = .055). It thus seems that adjusting for demographic variables hardly altered the cross-lagged relations between personality and health, whereas additional adjustment for cognitive abilities and particularly for depression did.

found that better physician-rated health at baseline was significantly associated with lower neuroticism and higher agreeableness after 12 years in both cohorts. These associations remained significant when controlling for gender, education, depression, and cognitive abilities. Meaningful relations between health and later neuroticism have also been reported by other studies (Jokela et al., 2014; Lißmann, 2003). Better physician-rated health was also significantly related with higher subsequent extraversion in both cohorts (for comparable findings, see Berg & Johansson, 2014; Jokela et al., 2014; Sutin et al., 2013; Wagner et al., 2015), but this association did not remain statistically significant after adjusting for covariates. Aspects of physical and functional health may thus not be major and robust predictors of change in extraversion, which has also been reported by other studies (Mõttus, Johnson, Starr, & Deary, 2012). Regarding self-rated health, some associations between T_0 self-rated health and T_{FU} personality (agreeableness and conscientiousness) reached significance in both cohorts, but were reduced to non-significance when adjusting for covariates. It thus seems that – in line with our assumptions – physician-rated health challenges personality stability to a larger extent than self-rated health. Specifically, having the objective confirmation that one's health is poor may worry individuals, resulting in an increase in neuroticism. Suffering from poor (objective) health may also complicate the maintenance of agreeableness; for instance, realizing that many peers are in better health may provoke feelings of envy or hostility. In contrast, regarding self-rated health, the mere feeling that one's health gets poorer may affect personality to a lesser extent than having objective evidence via a physician. Moreover, given that the relationships between T_0 self-rated health and T_{FU} agreeableness and conscientiousness did not remain significant when controlling for covariates, it seems that the relationship between self-rated health and later

personality is – unlike the one between physician-rated health and personality - to some extent spurious. Among the covariates, particularly depression may have acted as a "common cause" by influencing both self-rated health (Despot Lucanin & Lucanin, 2012; Pinquart, 2001; Schnittker, 2005; Spuling, Wurm, Tesch-Römer, & Huxhold, 2015) as well as personality change (Klein et al., 2011) over time. Indeed, we found that depression was the covariate which exhibited strongest associations with both personality traits and health measures, and adjusting only for demographic variables attenuated the personality-health cross-lagged relationships to a lesser extent than additionally adjusting for depression and cognitive abilities. However, more research is needed to investigate the role of potential third variables in the personality-health interplay. Some of these third variables may actually be important mediators or moderators of personality-health associations. For instance, personality-health associations have been found to vary according to gender (Chapman, Fiscella, Duberstein, Coletta, & Kawachi, 2009) and education (Jaconelli et al., 2013). The identification of such mediating and moderating factors requires further research.

Our finding of significant associations of objective health with subsequent personality may imply that the well-known effect of health on quality of life and well-being (e.g., Kunzmann, Little, & Smith, 2000) is mediated by personality. That is, poorer objective health seems to predict unfavorable personality levels 12 years later which could in turn affect well-being. Indeed, previous research has shown that personality traits act as meaningful predictors of well-being (Charles, Reynolds, & Gatz, 2001; Mroczek & Spiro, 2005; Tauber, Wahl, & Schröder, 2016).

Considering the opposite paths, from baseline personality to later health, both higher baseline openness and conscientiousness were significantly related with

better subsequent physician-rated health in both cohorts which is in line with other findings (Chapman et al., 2013; Sutin et al., 2013; Tolea, Costa, et al., 2012; Tolea, Ferrucci, et al., 2012); however, associations were no longer significant when controlling for covariates. In line with our assumption, associations between personality and later self-rated health were stronger and more robust compared to the associations between personality and later physician-rated health. Specifically, higher extraversion and conscientiousness scores at T_0 were significantly related with better self-rated health 12 years later in both cohorts, and relationships remained significant when controlling for covariates. This potentially protective role of both extraversion and conscientiousness for self-rated health has also been found in other studies (Human et al., 2013; Magee et al., 2013; Sutin et al., 2013; Turiano et al., 2012) and could be due to social and lifestyle factors (such as health-related behaviors; Friedman, Kern, Hampson, & Duckworth, 2014; Shanahan et al., 2014).

Moreover, in analogy to other reported findings (Human et al., 2013; Löckenhoff et al., 2012; Sutin et al., 2013; Turiano et al., 2012), the relationship between baseline neuroticism and later self-rated health was also significant in both cohorts, with lower neuroticism predicting better health. However, when adjusting for covariates, this association did not remain significant.

Our finding that some personality traits (extraversion and conscientiousness) are significant and robust predictors of self-rated health may have meaningful implications regarding interventions. As self-rated health is a meaningful marker of functioning, significantly predicting mortality above and beyond objective health (DeSalvo, Bloser, Reynolds, He, & Muntner, 2006; Idler & Benyamini, 1997), interventions to improve self-rated health could be beneficial for "distal" health outcomes such as longevity. Specifically, following our findings, interventions

targeting at personality change could also affect self-rated health, and there is indeed first promising evidence for the changeability of personality traits via interventions (Chapman, Hampson, & Clarkin, 2014; Magidson, Roberts, Collado-Rodriguez, & Lejuez, 2014). Moreover, an interesting question for future research could be whether the well-established effect of personality on mortality (e.g., Turiano, Chapman, Gruenewald, & Mroczek, 2015) is mediated by self-rated health.

Notably, unlike other studies (Canada et al., 2016; Duberstein et al., 2003; Magee et al., 2013), we found weak evidence for the moderating role of age/birth cohort regarding longitudinal personality-health associations: apart from the covariate-adjusted model relating neuroticism with later self-rated health, all other associations between personality and health could be set equal between groups. However, most of the research reporting age differences in personality-health associations has been based on cross-sectional study designs. It may thus be that when considered longitudinally, associations between personality and health do not (or only negligibly) change from middle adulthood to old age. Alternatively, the cohorts in our study may still have been too similar regarding mean age, with our late-life sample representing "young-old age" rather than "old-old age"; the age-associated increase in associations between self-rated health and personality, as reported in other studies (Duberstein et al., 2003), may not occur before the onset of very old age. Further research including additional age cohorts (particularly old-old samples) will be needed to investigate this assumption.

The present study has several strengths, including the extensive measurement of physician-rated health, the long measurement interval, and the low attrition rate. However, there are also some limitations. First, the present study investigated longitudinal interrelationships of (admittedly) broad concepts of

personality and health. Investigations of associations between personality trait sub-facets (such as impulsiveness; Sutin et al., 2013) - or even single personality scale items (Murray & Booth, 2015) - and health, and more refined, multidimensional assessments of health based on additional health indicators might offer deeper, "micro-level" insights in the personality-health interplay.

Second, possible mechanisms underlying the personality-health interplay were not investigated in the present study. For instance, it seems that the combination of (daily) stress (Neupert, Mroczek, & Spiro, 2008; Rickenbach, Almeida, Seeman, & Lachman, 2014) or sensory impairment (Gaynes, Shah, Leurgans, & Bennett, 2013; Wettstein, Kuźma, Wahl, & Heyl, 2016) with high neuroticism is particularly detrimental for cognitive functioning. Whether this is also true for health in general (and not only for cognitive health), remains unclear and an important issue for future investigations. Moreover, personality-health associations may be stronger when considering trait interactions (e.g., Tolea, Terracciano, Milaneschi, Metter, & Ferrucci, 2012; Turiano, Mroczek, Moynihan, & Chapman, 2013) instead of isolated, single personality traits only which requires further research. Further, associations of personality traits with health (or health-related behaviors; Armon & Toker, 2013) could be nonlinear which also deserves future empirical investigation.

Third, regarding measurement issues, self-rated health was measured by one single item only so that psychometric properties of this variable may be questionable. However, single-item measures of self-rated health are commonly utilized, "parsimonious" and exhibit consistent and meaningful correlates with objective health parameters (DeSalvo et al., 2006; Idler & Benyamini, 1997; Pinquart, 2001). Therefore such single-item measures can be considered as valid. Fourth, the issue of sample selectivity must be addressed. Overall, participants who continuously take

part and remain in longitudinal studies are healthier (Vestergaard et al., 2015), which can be subsumed under the term "healthy volunteer bias". Similarly, personality traits have been found to be systematically related with both study participation (Walsh & Nash, 1978) and missing data patterns (Jerant, Chapman, Duberstein, & Franks, 2009). This, of course, limits the extent to which the results can be transferred to the general population. Regarding the ILSE-sample, there is a similar selective dropout dynamic as in other longitudinal studies (Sattler et al., 2015), but the very low attrition rates which we observed for both sample cohorts may counteract this problem to some extent. We also want to point out that our selectivity analyses suggest that there is no evidence for selective dropout with regard to personality traits in our sample. Regarding health and the covariates, some selective dropout effects were significant, but all of them were of minor effect size. This is also true regarding differences between cohorts regarding the size of selective dropout effects. Therefore, it is rather unlikely that our findings were severely biased due to selective dropout. Moreover, sample selectivity might have contributed to lower inter-individual variability in health and personality traits so that the results of the present study may have actually *underestimated* the "true" size of personality-health associations. Fifth, it is important to point out that our rather restrictive control for covariates, which has resulted in several attenuated (and no longer significant) longitudinal relationships, may to some extent reflect an "over-adjustment". For instance, depressive symptoms are (both conceptually and empirically) closely related to personality traits such as neuroticism (Klein et al., 2011; Matthews, Deary, & Whiteman, 2009), and depressive symptoms and cognitive abilities (i.e. as a marker for mild cognitive impairment (MCI) or dementia) were also an explicit criterion for the rating of participants' health by the study physicians. Therefore, the "true" strength of associations between personality

and health may lie somewhere in between the coefficients from the unadjusted models and the ones estimated in the adjusted models. Sixth, the availability of more measurement occasions would have been desirable. According to Kenny (2005), the unfolding of processes and their interrelations over time may not be sufficiently informed (and described) based on two assessments only (see also Johnson et al., 2012). Therefore, future studies including more measurement occasions are necessary.

Our study provides important conclusions regarding the general longitudinal interplay of personality and health in the second half of life. First, our findings suggest that the longitudinal relationships of personality and health are indeed reciprocal. Second, we found objective health to be a stronger predictor of later personality, particularly of neuroticism and agreeableness, than self-rated health. Third, considering the opposite direction, personality (particularly extraversion and conscientiousness) seems to be more strongly related to later self-rated than to objective health. Fourth and finally, no differences regarding the interrelationships according to cohort were found, implying that longitudinal associations are similar in midlife and early late life.

Conflict of interest

None.

Acknowledgement

Table 3.1

Publication 2: Sample Description.

Variable	Total	Midlife Cohort	Late-Life Cohort	Statistical Test[a]
N	1,002	502	500	
Age (*M*, *SD*)	53.50 (9.40)	44.17 (0.91)	62.87 (0.89)	
Gender (%) Male	520 (51.9%)	260 (51.8%)	260 (52.0%)	χ^2 (1) = 0.00, ns
Education (years) (*M*, *SD*)	13.48 (2.70)	14.07 (2.50)	12.89 (2.76)	*t* (980) = -7.05, *p* < .001
Self-rated health[1] (*M*, *SD*)	3.74 (0.97)	3.77 (0.96)	3.72 (0.98)	*t* (983) = -0.83, ns
Physician-rated[1] health (*M*, *SD*)	4.63 (0.84)	4.73 (0.78)	4.53 (0.88)	*t* (966.19) = -4.71, *p* < .001
Depression (*M*, *SD*)	1.67 (0.36)	1.61 (0.35)	1.73 (0.36)	*t* (984) = 5.31, *p* < .000
Cognitive Abilities (*M*, *SD*)	-0.00 (0.60)	0.19 (0.54)	-0.20 (0.59)	*t* (1000) = -10.96, *p* < .000

Note.

[a] t-test for continuous variables and Chi-square-test for categorical variables. ns = not significant.

[1] Higher values indicate better health.

Table 3.2

Publication 2: Overview of Bi-Variate Relations Between Study Variables, Separately For Each Cohort.

C3 \ C5	Sex	Educ	SDS	Cog	S-R Health T_0	S-R Health T_{FU}	P-R Health T_0	P-R Health T_{FU}	N T_0	N T_{FU}	E T_0	E T_{FU}	O T_0	O T_{FU}	A T_0	A T_{FU}	C T_0	C T_{FU}
Sex	1	-.066	.222**	-.003	-.064	-.055	.022	-.075	.291**	.271**	.003	-.033	-.041	.001	.179**	.100	-.032	.014
Educ	-.270**	1	-.162**	.476**	.084	.212**	.240**	.231**	-.088	-.227**	-.062	.075	.333**	.324**	.001	.040	-.058	-.004
SDS	.230**	-.219**	1	-.239**	-.371**	-.251**	-.188**	-.221**	.665**	.517**	-.289**	-.266**	-.185**	-.120*	-.185**	-.199**	-.258**	-.231**
Cog	-.001	.474**	-.219**	1	.099*	.101	.193**	.186**	-.133**	-.122*	.045	.017	.330**	.225**	.091*	.037	-.068	-.071
S-R Health T_0	.008	.068	-.371**	.103*	1	.338**	.378**	.207**	-.243**	-.203**	.240**	.152**	.123**	.090	.138**	.144**	.121**	.160**
S-R Health T_{FU}	-.046	.059	-.304**	.120*	.506**	1	.332**	.407**	-.240**	-.421**	.238**	.319**	.098	.165**	.025	.103	.124*	.175**
P-R Health T_0	.007	.061	-.294**	.204**	.488**	.431**	1	.409**	-.129**	-.179**	.090*	.138*	.095*	.120*	.050	.103	.006	.110*
P-R Health T_{FU}	.077	.028	-.183**	.210**	.239**	.430**	.383**	1	-.115*	-.267**	.070	.064	.117*	.134*	.003	.075	.121*	.103
N T_0	.266**	-.274**	.666**	-.216**	-.269**	-.155**	-.182**	-.092	1	.624**	-.331**	-.266**	-.088*	-.030	-.202**	-.133*	-.328**	-.197**
NT$_{FU}$	.195**	-.241**	.593**	-.354**	-.249**	-.319**	-.183**	-.163**	.651**	1	-.139*	-.406**	-.119*	-.149**	-.112*	-.230**	-.256**	-.303**
E T_0	-.027	.032	-.348**	.016	.165**	.158**	.112*	.070	-.361**	-.300**	1	.618**	.148**	.078	.129**	.038	.277**	.185**
E T_{FU}	-.017	.028	-.365**	.093	.170**	.269**	.138*	.156**	-.361**	-.445**	.697**	1	.135*	.188**	.091	.168**	.214**	.325**

Table 3.2 – *Continued*

C3 \ C5	Sex	Educ	SDS	Cog	S-R Health T$_0$	S-R Health T$_{FU}$	P-R Health T$_0$	P-R Health T$_{FU}$	N T$_0$	N T$_{FU}$	E T$_0$	E T$_{FU}$	O T$_0$	O T$_{FU}$	A T$_0$	A T$_{FU}$	C T$_0$	C T$_{FU}$
O T$_0$	-.023	.317**	-.195**	.207**	.102*	.138*	.034	.092	-.169**	-.221**	.204**	.246**	1	.628**	.038	.066	-.106*	-.113*
O T$_{FU}$	-.025	.405**	-.162**	.338**	.109	.174**	.013	.134*	-.181**	-.284**	.171**	.236**	.630**	1	-.016	.087	-.127*	-.033
A T$_0$	.160**	.063	-.145**	.075	.029	.073	.036	.126*	-.240**	-.168**	.240**	.238**	.041	.001	1	.612**	.246**	.190**
A T$_{FU}$	.274**	-.022	-.133*	.079	.096	.153**	.111	.181**	-.126*	-.275**	.194**	.234**	.017	.048	.627**	1	.173**	.245**
C T$_0$	-.117**	.026	-.279**	.032	.072	.124*	.154**	.104	-.322**	-.266**	.240**	.234**	-.012	-.036	.241**	.135*	1	.615**
C T$_{FU}$	-.073	.040	-.247**	.052	.099	.202**	.128*	.077	-.252**	-.397**	.285**	.391**	.052	.073	.164**	.371**	.627**	1

Note. Values below the diagonal represent Pearson-correlation coefficients of the late-life cohort (C3), and values above the diagonal represent correlations of the mid-life cohort (C5). Educ = education, SDS = Zung self-rated depression scale, Cog = composite of global cognitive ability, S-R Health = self-rated health, P-R Health = physician-rated health, N = neuroticism, E = extraversion, O = openness, A = agreeableness, C = conscientiousness, T$_0$ = baseline measurement occasion, T$_{FU}$ = follow-up measurement occasion. * $p < .05$; ** $p < .01$.

Table 3.3

Publication 2: Overview of Standardized Path Coefficients in Cross-Lagged Models.

Person-ality Trait	Model	Health Domain	Correlation Health T_0 – Personality T_0	Correlation Health T_{FU} – Personality T_{FU}	Autoregressive Path (Personality $T_0 \rightarrow T_{FU}$)	Autoregressive Path (Health $T_0 \rightarrow T_{FU}$)	Health $T_0 \rightarrow$ Personality T_{FU}	Personality $T_0 \rightarrow$ Health T_{FU}
			C3/C5	C3/C5	C3/C5	C3/C5	C3/C5	C3/C5
Neuro-ticism	No Covariates	Physician-R. Health[1]	-.15***/-.16*** [a]	-.18***/-.18*** [a]	.64***/.61*** [a]	.41***/.42*** [a]	-.12***/-.10*** [a]	-.05/-.06 [a]
	Adjusted[2]	Physician-R. Health	.00/.00 [a]	-.14***/-.13*** [a]	.46***/.44*** [a]	.37***/.37*** [a]	-.06*/-.06* [a]	.06/.07 [a]
	No Covariates	Self-R. Health [1]	-.26***/-.26*** [a]	-.35***/-.28*** [a]	.64***/.61*** [a]	.45***/.40*** [a]	-.06/-.06 [a]	-.09*/-.09* [a]
	Adjusted[2]	Self-R. Health	-.04/.00	-.24***/-.34***	.46***/.45*** [a]	.43***/.36*** [a]	.01/-.02	.08/-.13
Extra-version	No Covariates	Physician-R. Health	.09**/.10** [a]	.10*/.10* [a]	.67**/.64*** [a]	.42***/.42*** [a]	.07*/.06* [a]	.03/.03 [a]
	Adjusted[2]	Physician-R. Health	.03/.04 [a]	.08*/.08* [a]	.63***/.62*** [a]	.37***/.37*** [a]	.05/.04 [a]	.00/.00 [a]
	No Covariates	Self-R. Health	.20***/.21*** [a]	.25***/.20*** [a]	.67***/.65*** [a]	.46***/.39*** [a]	.02/.02 [a]	.11**/.10** [a]
	Adjusted[2]	Self-R. Health	.10**/.10** [a]	.23***/.18*** [a]	.63***/.63*** [a]	.41***/.35*** [a]	-.03/-.03 [a]	.09*/.08* [a]
Openness	No Covariates	Physician-R. Health	.07*/.07* [a]	.10*/.09* [a]	.65***/.61*** [a]	.42***/.42*** [a]	.03/.02 [a]	.07*/.09* [a]
	Adjusted[2]	Physician-R. Health	-.03/-.03 [a]	.08/.07 [a]	.58***/.56*** [a]	.37***/.37*** [a]	.01/.01 [a]	.03/.04 [a]
	No Covariates	Self-R. Health	.12***/.11*** [a]	.14**/.09** [a]	.64***/.61*** [a]	.48***/.41*** [a]	.02/.01 [a]	.06/.06 [a]
	Adjusted[2]	Self-R. Health	.04/.04 [a]	.13**/.08** [a]	.57***/.56*** [a]	.42***/.36*** [a]	.01/.01 [a]	.02/.02 [a]

Table 3.3 – *Continued*

Person-ality Trait	Model	Health Domain	Correlation Health T_0 – Personality T_0	Correlation Health T_{FU} – Personality T_{FU}	Autoregressive Path (Personality $T_0 \rightarrow T_{FU}$)	Autoregressive Path (Health $T_0 \rightarrow T_{FU}$)	Health $T_0 \rightarrow$ Personality T_{FU}	Personality $T_0 \rightarrow$ Health T_{FU}
			C3/C5	C3/C5	C3/C5	C3/C5	C3/C5	C3/C5
Agree-ableness	No Covariates	Physician-R. Health	.04/.05 [a]	.10*/.10* [a]	.62***/.61*** [a]	.42***/.42*** [a]	.10**/.08** [a]	.02/.02 [a]
	Adjusted[2]	Physician-R. Health	-.01/-.01 [a]	.08/.08 [a]	.58***/.60*** [a]	.37***/.,37*** [a]	.08*/.07* [a]	-.01/-.01 [a]
	No Covariates	Self-R. Health	.09**/.09** [a]	.11*/.09* [a]	.62***/.61*** [a]	.49***/.41*** [a]	.07*/.06* [a]	.01/.01 [a]
	Adjusted[2]	Self-R. Health	.02/.02 [a]	.10*/.08* [a]	.59***/.60***	.43***/.36*** [a]	.03/.03 [a]	.00/.00 [a]
Cons-cien-tious-ness	No Covariates	Physician-R. Health	.08*/.08* [a]	.02/.02 [a]	.64***/.63*** [a]	.39***/.42*** [a]	.07/.06 [a]	.06*/.07* [a]
	Adjusted[2]	Physician-R. Health	.03/.03 [a]	.00/.00 [a]	.60***/.62*** [a]	.36***/.37*** [a]	.05/.04 [a]	.06/.07 [a]
	No Covariates	Self-R. Health	.10**/.10** [a]	.14**/.11** [a]	.62***/.63*** [a]	.49***/.41*** [a]	.08*/.07* [a]	.09*/.08* [a]
	Adjusted[2]	Self-R. Health	.00/.00 [a]	.12**/.10** [a]	.61***/.62*** [a]	.43***/.36*** [a]	.05/.04 [a]	.08*/.07* [a]

Note. C3 = Cohort born 1930/32, C5 = Cohort born 1950/52. [a] unstandardized paths set equal between cohorts.

* $p < .05$; ** $p < .01$; *** $p < .001$.

[1] Higher values indicate better physician-rated health and higher health satisfaction.

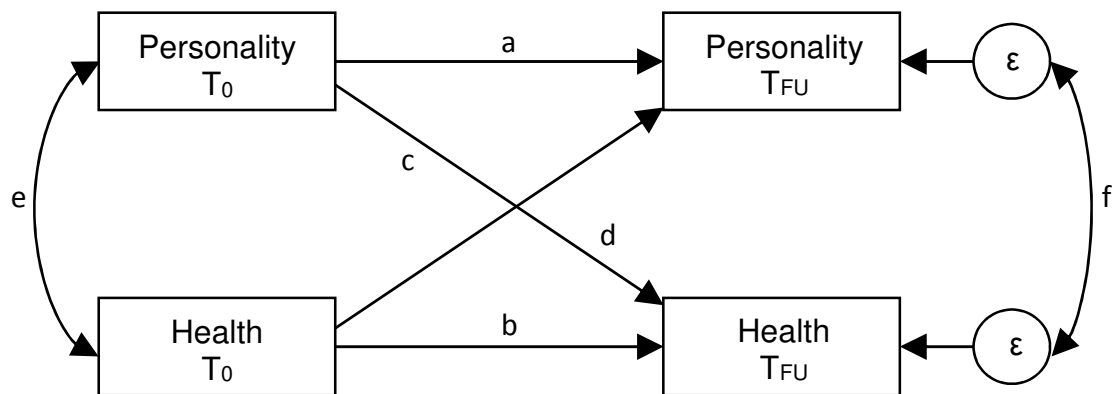[2] Covariates: gender, education, depression, general cognition score

Figure 3.1. Illustration of a cross-lagged panel design of a personality trait and a health indicator at two measurement occasions lying 12 years apart (here: T_0 and T_{FU}).

Note. The two measurement occasion are abbreviated with T_0 and T_{FU}, respectively.

a and b: auto-regression path coefficients; c and d: cross-lagged path coefficients; e and f: concurrent correlations at both measurement occasions.

Chapter 4: Manuscript – Publication 3

The Interplay Between Personality and Cognitive Ability Across 12 Years in Middle and Late Adulthood: Evidence for Reciprocal Associations

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Abstract

Research on relationships between personality and cognitive abilities has so far resulted in inconsistent findings regarding the strength of the associations. Moreover, relationships have rarely been compared longitudinally and bi-directionally between midlife vs. late-life cohorts by considering different personality traits as well as multiple cognitive domains over a long-term follow-up period. We hypothesize that the interplay between the "Big Five" personality traits (Neuroticism, Extraversion, Openness to Experience, Agreeableness and Conscientiousness) and cognitive abilities (information processing speed, crystallized intelligence, fluid intelligence) may change from midlife to old age due to differential dynamics of cognitive decline across the adult lifespan and due to age-associated changes in cognitive and personality. We used data from the German Interdisciplinary Longitudinal Study of Adult Development (ILSE study; n = 1,002). Participants were either born in 1950/52 (midlife sample, n = 502) or in 1930/32 (late-life sample, n = 500) and followed up for up to 12 years. Based on bi-variate latent change score regression models (adjusted for gender, education, self-rated and physician-rated health), we observed that, apart from very few exceptions, the intervariable cross-lagged associations between personality traits and cognitive abilities were generally similar between cohorts. Moreover, in case of neuroticism, extraversion, and openness, the effects of cognitive abilities on change in personality were stronger than the reversed effects. Our findings thus suggest that the so far predominant perspective of personality in middle adulthood and late-life as a predictor, rather than as an outcome, of cognitive abilities needs more differentiation and reconsideration.

Key words: Big Five, fluid intelligence, crystallized intelligence, information processing speed, midlife, old age

Introduction

Previous research has shown that both personality and cognitive abilities are subject to change across the entire life span (McArdle, Ferrer-Caja, Hamagami, & Woodcock, 2002; Roberts & Mroczek, 2008). Moreover, in every life phase, substantial interindividual differences in intraindividual trajectories of personality (Allemand, Zimprich, & Hertzog, 2007; Allemand, Zimprich, & Martin, 2008; Wagner, Ram, Smith, & Gerstorf, 2015) and cognitive functioning (Martin & Zimprich, 2005; Mungas et al., 2010; Zimprich & Mascherek, 2010) have been observed. Given this life-long interindividual heterogeneity in both personality change and cognitive trajectories, it is an important empirical question *if* and *to what extent* both constructs drive each other's changes. Previous, mostly cross-sectional studies report meaningful, small-to-moderate relationships between both domains (Schaie, Willis, & Caskie, 2004; Soubelet & Salthouse, 2011; von Stumm & Ackerman, 2013), with openness (Ackerman & Heggestad, 1997; DeYoung, 2014; DeYoung, Peterson, & Higgins, 2005) and conscientiousness (e.g., Curtis, Windsor, & Soubelet, 2015) representing the personality traits most closely associated with cognitive abilities. However, findings on the personality-cognition interplay have been inconsistent and heterogeneous regarding the strength of the relationship (Ackerman & Heggestad, 1997; Curtis et al., 2015) with some studies reporting weak effects (e.g., Schaie et al., 2004), whereas others found moderate or even strong associations (e.g., Terracciano et al., 2014).

Moreover, associations between personality traits and cognitive indicators have rarely been investigated longitudinally, bi-directionally, and across longer time spans over the second half of life. Personality traits and cognitive abilities may mutually influence each other. Further, given that change dynamics in personality

and cognitive abilities may be different in middle adulthood compared to old age (Lachman, 2004; Martin & Zimprich, 2005; Willis & Schaie, 1999) and that middle adulthood and old age represent distinct life phases, also regarding functional and developmental domains (and their changes) beyond personality and cognitive ability (such as health, subjective well-being, daily ecologies, and social relationships; Lachman, 2004; Lachman, Teshale, & Agrigoroaei, 2015), longitudinal personality-cognition relationships may as a consequence change from midlife into old age.

Longitudinal Personality-Cognition Associations: A Bi-Directional and Cohort-Differential Perspective

In the current study, we aim to investigate the potential bi-directional nature of the long-term relationship between personality traits and different cognitive abilities across 12 years in two subsamples: a "midlife cohort," aged 43-46 years at baseline (T1) and a "late-life cohort" (61-65 years at T1). In terms of personality, this study's focus is on the "Big Five" personality traits (Costa & McCrae, 1995; McCrae & John, 1992), i.e., neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness. These traits are well established (Goldberg, 1990; Matthews, Deary, & Whiteman, 2013) and frequently used in personality research. Regarding cognitive abilities, we focus on three established subdomains of cognitive functioning, namely information processing speed, fluid/mechanic abilities (e.g., spatial abilities), and crystallized/pragmatic abilities (e.g., general knowledge). These three broad domains of cognitive abilities are influenced by different determinants (Lövdén, Ghisletta, & Lindenberger, 2004) and – when considered on a mean-level perspective - unfold differentially across the adult lifespan (Baltes, Lindenberger, & Staudinger, 2006; Martin & Zimprich, 2005; McArdle et al., 2002; Park & Reuter-Lorenz, 2009): Decline in processing speed and fluid intelligence begins already in

early adulthood (Salthouse, 2009), whereas crystallized abilities are largely maintained into old age and do not decline before the 8th or 9th life decade (Singer, Verhaeghen, Ghisletta, Lindenberger, & Baltes, 2003).

The Big Five Personality Traits and Cognitive Abilities: A Bi-Directional View

The mechanisms underlying the personality-cognition relationships may vary according to the specific personality trait considered: First, *neuroticism*, which is characterized by higher general distress proneness, greater exposure to stressors, and less efficient strategies to cope with stressors (Gunthert, Cohen, & Armeli, 1999), seems to exacerbate the well-known detrimental effect of stress on the brain and on (everyday) cognitive functioning (Neupert, Mroczek, & Spiro, 2008; Sapolsky, 1996). Indeed higher distress proneness as a specific component of neuroticism has been found to be associated with steeper cognitive decline among older adults (Wilson et al., 2005). Second, individuals who are more *extraverted* may experience lower arousal when working on cognitive tasks, which may result in better cognitive performance (Curtis et al., 2015). Extraversion also seems to be associated with higher positive affect (Charles, Reynolds, & Gatz, 2001; Isaacowitz & Smith, 2003) that in turn may facilitate certain cognitive processes (Fredrickson, 2004; Graham & Lachman, 2014; Isen, 2008). Third, individuals with higher levels of *openness to experience* (and also extraversion) tend to seek more cognitive and social stimulation and "environmental enrichment," which in turn contributes to better cognitive, particularly fluid abilities (Ziegler, Cengia, Mussel, & Gerstorf, 2015; Ziegler, Danay, Heene, Asendorpf, & Bühner, 2012). This is also in line with intellectual investment theories which postulate that so-called "investment traits" (such as openness to experience) have a strong influence on how and to what extent people invest their time and resources in their intellect (e.g., von Stumm & Ackerman, 2013). More

generally, the principle of "gene-environment correlation" (Scarr & McCartney, 1983) states that an individual's genotype – which also contains aspects of personality (e.g., openness) – influences the exposure to environmental conditions (such as the amount of cognitive stimulation). Among the Big Five personality traits, particularly openness to experience seems to be a primarily "cognitive trait" (DeYoung et al., 2005) determining the extent to which individuals seek cognitive stimulation (DeYoung, 2014; Ziegler et al., 2015; Ziegler et al., 2012). Fourth, higher *conscientiousness* may be related to better cognitive functioning via prudent health behaviors (Booth-Kewley & Vickers, 1994) and stronger adherence to cognitively stimulating activities. Regarding *agreeableness*, Curtis et al. (2015) summarize that "current research provides no conceptual rationale for a relationship between agreeableness and cognitive ability" (p. 60).

However, there are good reasons to assume the opposite direction, i.e., considering cognitive abilities as predictors of personality (e.g., Mueller, Wagner, & Gerstorf, in press), although this direction has so far been insufficiently investigated (and mostly with a focus on personality change after the onset of cognitive impairment such as Alzheimer's disease; Robins Wahlin & Byrne, 2011; Talassi, Cipriani, Bianchetti, & Trabucchi, 2007). For example, experiencing cognitive decline may be distressing and cause anxiety, thus contribute to an increase in neuroticism. However, research findings on awareness of cognitive changes are inconsistent, with some studies reporting weak associations between changes in self-reports of everyday functions and objective cognitive changes (e.g., Tucker-Drob, 2011), whereas others reported meaningful relationships between changes in cognitive functions and cognitive complaints (e.g., Martin & Zimprich, 2003). There may thus at least be a subgroup of individuals who perceive changes in their cognitive abilities,

and this awareness may be a risk factor for an increase in neuroticism. Individuals may also withdraw from social activities when cognitive decline sets in due to embarrassment and/or feeling too challenged by social interactions, resulting in a decline in extraversion. Moreover, according to the "environmental success hypothesis" (Ziegler et al., 2015), (fluid) cognitive abilities affect the development of openness to experience; individuals with higher cognitive abilities may be more successful in solving new problems, which may motivate them to continue seeking new situations and challenges, as expressed by an increase in openness to experience. Translating this hypothesis into later life, the onset of cognitive decline may result in less "environmental success" and, consequently, a lower willingness to seek out new, challenging experiences, which may lead to a decrease in openness. Cognitive decline may also affect agreeableness. Specifically agreeableness may increase as a compensatory mechanism when cognitive resources decrease. Individuals with fewer cognitive resources may ensure social support by being more agreeable, whereas such support is less needed as long as cognitive functioning is intact (Baker & Bichsel, 2006). Finally, regarding conscientiousness, maintenance of conscientious behavior (e.g., being dutiful and reliable; keeping appointments) throughout life may require cognitive resources. Therefore, cognitive decline may precede decline in conscientiousness.

Long-Term Personality-Cognition Relationships Across the Adult Lifespan: Does the Strength of Relationships Change from Midlife into Old Age?

We investigate and compare the longitudinal personality-cognition associations in a midlife and a late-life cohort. Longitudinal relationships between personality traits and cognitive abilities in midlife and late life may be different

because both life phases are characterized by a different trade-off of resources and challenges (Lachman, 2004; Lachman et al., 2015; Martin & Zimprich, 2005; Willis & Schaie, 1999). More specifically, plasticity of both personality and cognition changes from midlife to old age, which may have meaningful implications for the bi-directional longitudinal personality-cognition relationship patterns in both cohorts.

Predicting Midlife vs. Late-Life Cognitive Changes by Personality

Across the life span, rank-order stability of cognitive abilities in general is subject to dramatic age related changes (Tucker-Drob & Briley, 2014). Specifically, rank-order stability of cognitive performance increases from middle adulthood to old age (Briley & Tucker-Drob, 2015; Hertzog & Schaie, 1986), with this increasing phenotypic stability of cognitive abilities over the life span being primarily driven by genetic factors (Tucker-Drob & Briley, 2014). Moreover, not only cognitive abilities per se, but also cognitive *plasticity* underlies lifelong changes and is reduced in old age as compared to younger ages (Baltes & Kliegl, 1992; Noack, Lövdén, Schmiedek, & Lindenberger, 2013; Schmiedek, Lövdén, & Lindenberger, 2010). This age-associated decline in cognitive plasticity may have important implications for the dynamics of personality-cognition relationships. Specifically, given that cognitive abilities are less modifiable by interventions and other environmental or lifestyle factors in old age, and given the described age-associated increase in stability of cognitive abilities, the impact of personality on cognitive changes may become smaller in old age compared to middle adulthood.

Regarding general evidence on predictive effects of personality on cognitive abilities over the second half of life, previous studies have reported significant relationships of neuroticism (Graham & Lachman, 2012; Luchetti, Terracciano, Stephan, & Sutin, 2015), extraversion (T. Y. Arbuckle, Maag, Pushkar, & Chaikelson,

1998; Gold et al., 1995), openness (Graham & Lachman, 2012; Luchetti et al., 2015), and conscientiousness (Curtis et al., 2015; Luchetti et al., 2015) with cognitive change. However, there is a lack of studies comparing middle-aged and older adults regarding the strength of effects of personality on cognitive change. Some cross-sectional studies have found that extraversion, openness (Baker & Bichsel, 2006) and neuroticism (Graham & Lachman, 2014) are more closely related with cognitive abilities in younger adults compared to older adults. Moreover, several longitudinal findings suggest that the effects of personality traits on late-life cognitive development (or maybe even on cognitive development at all adult ages; Salthouse, 2014) are weak (Jelicic et al., 2003; Sharp, Reynolds, Pedersen, & Gatz, 2010; von Stumm & Deary, 2013; Waggel et al., 2015).

Predicting Midlife vs. Late-Life Personality Changes by Cognitive Ability

The development of personality stability and plasticity with chronological age may considerably deviate from the prototypical age trajectory of cognitive plasticity. For instance, Baltes, Lindenberger, and Staudinger (2006) state that "in contrast to the domain of cognitive functioning where resources in old age are depleted to maintain a certain level of functioning, the resource situation for life span growth in self and personality might present itself more favorably" (p. 625). Indeed, although stability of personality first increases from childhood into adulthood, which has been subsumed and described as "cumulative continuity principle of personality development" (Roberts & Caspi, 2003) and which is primarily due to environmental mechanisms (Briley & Tucker-Drob, 2014), it seems that the maximum rank-order stability of personality is reached in middle adulthood (or between midlife and old age). Stated differently, midlife represents a life phase in which the overwhelming majority of individuals reveals no reliable personality change (Allemand, Gomez, &

Jackson, 2010). After middle adulthood, (slight) decreases in rank-order stability of personality have been observed (Roberts & Del Vecchio, 2000; Specht, Egloff, & Schmukle, 2011; Terracciano, McCrae, & Costa Jr, 2010; Wortman, Lucas, & Donnellan, 2012), particularly in old and very old age (Lucas & Donnellan, 2011; Mõttus, Johnson, & Deary, 2012). Moreover, recent evidence suggests that the heritability of personality decreases with age (Briley & Tucker-Drob, 2015). Therefore, given the lower rank-order personality stability in old age than in midlife, personality plasticity and interindividual heterogeneity in intraindividual personality changes seem to be even higher in late life compared to middle adulthood.

This age-differential personality plasticity may have implications for how cognitive abilities shape intraindividual personality changes in both life phases: Given the peak of personality rank-order stability in midlife (Roberts & Del Vecchio, 2000; Specht et al., 2011; Terracciano et al., 2010; Wortman et al., 2012), the influence of cognitive function on long-term personality changes in this life phase may be weaker. However, in late life, when personality plasticity increases and its rank-order stability decreases, the influence of cognitive abilities on personality changes may become stronger.

In contrast to middle adulthood, late-life is characterized by steeper mean-level decline in cognitive functions—particularly in processing speed and fluid abilities (Finkel, Reynolds, McArdle, Gatz, & Pedersen, 2003; McArdle et al., 2002; Singh-Manoux et al., 2012). Importantly, there is evidence for substantial interindividual heterogeneity around this mean-level decline trend (Martin & Zimprich, 2003; Mungas et al., 2010; Zimprich, Martin, & Kliegel, 2003). Therefore, those affected by steeper cognitive late-life decline may as a consequence experience more pronounced personality changes, e.g., an increase in neuroticism due to worries

about one's decreasing cognitive resources (or even "dementia worry"; Kessler, Bowen, Baer, Froelich, & Wahl, 2012) or a decrease in openness and extraversion because new experiences may get too cognitively challenging (Ziegler et al., 2015). In addition, late-life cognitive decline may also challenge the maintenance of conscientiousness (e.g., increasing forgetfulness may lead to declines in conscientiousness). As pointed out before, the agreeableness-cognition interplay has not been well understood so far, both conceptually and empirically (Curtis et al., 2015). However, late-life cognitive decline may, on the on hand, be troubling and lead to a decline in agreeableness. On the other hand, however, individuals may become *more* agreeable when their cognitive resources become limited which might reflect some kind of compensation (Baker & Bichsel, 2006).

Regarding empirical evidence, some findings indeed suggest that cognitive ability acts a meaningful predictor of late-life personality changes: Changes in neuroticism (Wettstein, Kuźma, Wahl, & Heyl, 2016), extraversion (Wagner et al., 2015), openness (von Stumm & Deary, 2013)— a personality trait that may be, according to first empirical evidence, even modifiable in older adults by means of cognitive interventions (Jackson, Hill, Payne, Roberts, & Stine-Morrow, 2012)— and conscientiousness (Mõttus, Johnson, Starr, & Deary, 2012) were found to be significantly predicted by cognitive abilities. Other longitudinal studies report coupled late-life changes in neuroticism and cognitive abilities (Waggel et al., 2015; Wahl, Schmitt, Danner, & Coppin, 2010), but these studies did not investigate whether neuroticism or cognitive ability is the driving force for these coupled changes.

<u>The Role of Information Processing Speed, Fluid vs. Crystallized Intelligence</u>

So far, only few studies have compared multiple cognitive abilities when investigating personality-cognition associations (Ackerman & Heggestad, 1997;

Baker & Bichsel, 2006; Soubelet & Salthouse, 2011; Ziegler et al., 2015; Ziegler et al., 2012), and most of them have been cross-sectional in nature. These previous findings are very inconsistent. As pointed out, information processing speed, fluid and crystallized cognitive abilities follow different lifespan trajectories and are driven by different factors. This may have implications for the longitudinal personality-cognition interplay.

Specifically, crystallized abilities are more closely related to socio-biographical and culture-based markers (e.g., income, education), whereas both information processing speed and fluid intelligence are generally more strongly driven by genetic, physiological, and biological influences (e.g., sensory and sensorimotor functioning; Anstey & Smith, 1999; Baltes et al., 2007; Hofer, Berg, & Era, 2003; Lövdén et al., 2004). Therefore, the impact of personality traits on cognitive changes may be stronger for crystallized abilities than for fluid abilities and information processing speed. However, personality traits may also represent genetic and biological influences and therefore be meaningfully related to components of processing speed and crystallized abilities as well. This highlights the need to further investigate the role of different cognitive components in the personality-cognition interplay.

Regarding the opposite direction from cognitive abilities to personality change, personality trajectories may be more strongly driven by processing speed and fluid rather than by crystallized abilities. Both information processing speed and fluid abilities show more pronounced and more noticeable decline, beginning already in early adulthood, whereas *crystallized* abilities usually peak in midlife (Hartshorne & Germine, 2015; Lachman, 2004; Martin & Zimprich, 2005; Willis & Schaie, 1999; Zimprich & Mascherek, 2010) and remain stable into very old age (Finkel et al., 2003; Singer et al., 2003). Therefore, interindividual differences in the extent of late-life fluid

ability decline may be associated with differential personality changes. Moreover, with respect to previous research, most studies demonstrating associations between cognitive abilities and personality changes were indeed based on fluid ability indicators (Jackson et al., 2012; Wagner et al., 2015; Wahl et al., 2010; Ziegler et al., 2015).

Research Aims and Hypotheses

To summarize existing empirical research, findings on the interplay between personality and cognitive abilities are scarce and mostly inconclusive. Most studies were either based on cross-sectional study designs and/or lacked a direct comparison of different adult age cohorts. In addition, there is a clear lack of studies considering the *longitudinal* relationship between personality and cognition bi-directionally. Finally, only few studies included multiple cognitive measures and all Big Five personality traits. As outlined above, we assume that the associations between personality traits and cognitive abilities are reciprocal, i.e. personality acts both as a predictor and as an outcome of cognitive abilities. Moreover, we examine whether the longitudinal personality-cognition interplay differs between a midlife and a late-life cohort. Given that conceptually as well based on previous research no clear prediction can be derived, we argue that such a comparison is primarily an empirical and exploratory question. We also explore whether different cognitive abilities (information processing speed, crystallized abilities, fluid abilities) are differentially related to personality over time.

Methods

Study Population and Sample Description

Our study is based on data from the Interdisciplinary Longitudinal Study of Adult Development (ILSE; Sattler et al., 2015; Schmitt, Wahl, & Kruse, 2008). Three

measurement waves have been completed so far (T1: 1993-1996, n = 1002; T2: 1997-2000, n = 896; T3: 2005-2008, n = 789), with high longitudinal response rate (78.7% of the initial sample took part at T3). Participants were followed up for a mean of 11.7 years (SD = 1.69 years). The ILSE sample consists of two age cohorts: the late-life cohort (born in 1930-1932) and the midlife cohort (1950-1952). Sample characteristics, study design, and attrition analyses have been described elsewhere (e.g., Allemand et al., 2007; Miche, Elsässer, Schilling, & Wahl, 2014; Sattler et al., 2015; Schmitt et al., 2008). Comprehensive cognitive assessments were administered in both cohorts at T1 and T3, whereas several cognitive tests were not were not assessed in the midlife cohort at T2. Therefore, we focused on T1 and T3 in our analyses, also because we were primarily interested in the long-term relationship between personality and cognitive abilities over the full measurement interval spanning 12 years; differential changes in personality and cognition may not fully unfold over a shorter time interval of only 4 years due to the generally high rank-order consistency of both constructs.

Sample characteristics are provided in Table 4.1. Mean baseline age was 44.2 years (SD = 0.91 years) in the midlife cohort and 62.9 years (SD = 0.89 years) in the late-life cohort. The gender distribution was not significantly different in both cohorts, with about 52% of the study participants being male in both subsamples. There was a significant cohort difference in education; the mean difference in years of education amounted to slightly more than 1 year and was in favor of the younger cohort. Mean self- and physician-ratings of health were overall positive in both cohorts, and only physician-ratings were significantly different between groups (again in favor of the midlife cohort). Regarding the cognitive indicators, the midlife cohort scored significantly higher than the late life cohort on all tests of processing speed (Number-

Connecting 1 and 2, Digit Symbol Substitution task) as well as on all fluid ability tests (Picture Completion, Block Design, Spatial Ability), whereas, not surprisingly, no significant group difference was observed for the tests of crystallized cognitive ability, namely Information and Similarities. With the exception of conscientiousness, cohorts were also significantly different regarding personality traits, with the late-life cohort scoring higher on neuroticism and agreeableness than the midlife cohort, whereas middle-aged older adults had higher extraversion and openness scores than older adults. Most effect sizes of cohort differences were ,according to the classification by Cohen (1992), small. Group differences that were of medium (or close-to-medium) effect size were found for education as well as the cognitive tests Number-Connecting 1 and 2, Block Design and Spatial Ability. The only difference corresponding to a large effect was observed for Digit Symbol Substitution.

Measures

Cognitive abilities. Following previous empirical and conceptual differentiations between cognitive domains based on ILSE data (e.g., Zimprich, Allemand, & Dellenbach, 2009; Zimprich & Mascherek, 2010), our analyses included multiple indicators of three broader cognitive constructs, namely information processing speed, crystallized intelligence, and fluid intelligence. This distinction was also empirically supported based on an exploratory factor analysis (using Promax rotation). *Information processing speed* as a key marker of cognitive aging (Finkel, Reynolds, McArdle, & Pedersen, 2007; Lindenberger, Mayr, & Kliegl, 1993; Salthouse, 1996) was assessed with the Number-Connecting Test (with two subtests; Oswald & Roth, 1987) and the Digit Symbol Substitution task, a subtest of the revised Wechsler Adult Intelligence Scale (WAIS-R; Tewes, 1991). *Crystallized intelligence* was assessed with the Information and Similarities tests of the WAIS-R

(Tewes, 1991). *Fluid intelligence* was assessed based on the tests Picture

Completion and Block Design, both subtests from the WAIS-R (Tewes, 1991), and on

the Spatial Ability test from the LPS (Horn, 1983).

Personality. Neuroticism, Extraversion, Openness to Experience, Agreeableness,

and Conscientiousness were assessed with the NEO-Five-Factor Inventory (NEO-

FFI; Costa & McCrae, 1992b; internal consistencies [Cronbach's α] at T1 and T3:

neuroticism: .79, .84; extraversion: .71; .76; openness to experience: .54, .56;

agreeableness: .62; .71; conscientiousness: .75, .75).

Covariates. In the following analyses, we controlled for sociodemographic variables

(gender and education in years), and – given that health is meaningfully related with

both personality traits (e.g., Friedman & Kern, 2014) and cognitive abilities (e.g.,

Deary, Weiss, & Batty, 2010)– also for self-rated and physician-rated health. Both

age cohorts also differed significantly regarding education and physician-rated health

(Table 4.1), which was another reason to include these variables as covariates in

order to rule out that potential age cohort differences in personality-cognition

associations are due to differences in education or health.

Self-rated health was assessed by a single item, with a Likert-scale response format

ranging from 1 = very good to 6 = very poor. Physician-rated health (i.e., health of

study participants rated by the examining study physician based on an in-depth

clinical examination; see Miche et al., 2014 for further details) was also assessed

using a single item with the same response format.

Statistical Analyses

To investigate the extent to which cognitive abilities predict change in

personality traits and vice versa, we computed multi-group bi-variate latent change

regression models (McArdle, 2009). In short, these models allow for the specification

of a latent change component in personality and cognitive abilities (as illustrated in

Figure 4.1), and this change component varies across individuals. By specifying

intervariable cross-lagged parameters (a and b in Figure 4.1; we adopt the term

"intervariable cross-lagged parameter" from Gerstorf, Lövdén, Röcke, Smith, &

Lindenberger, 2007), predictive effects of baseline personality on cognitive change

from T1 to T3 and effects of baseline cognitive ability on personality change from T1

to T3 can be estimated. To ensure strong measurement invariance, we constrained

factor loadings and intercepts of each latent construct to be equal both across groups

and measurement occasions.

We controlled for gender, education, self-rated and physician-rated health in

all analyses by (1) specifying correlations between these covariates and baseline

personality as well as baseline cognitive ability, and (2) adding paths from these

covariates to the latent change components of both constructs. To test whether the

age cohorts differed regarding the size of intervariable cross-lagged relations, we set

these paths (*a* and *b* in Figure 4.1) equal between groups in an additional step. If no

significant misfit (in terms of the χ^2 difference test) resulted, the model with cross-

lagged associations constrained to be equal between groups was chosen. If the χ^2

difference test indicated a significant misfit, the less restricted model with group-

specific cross-lagged relationships was selected. Statistical analyses were conducted

using IBM SPSS Statistics 22 and IBM SPSS Amos 22 (J. L. Arbuckle, 2013).

Results

Results of the multi-group bi-variate latent change regression models, without

covariates as well as adjusted for covariates (gender, education, self-rated and

physician-rated health), are shown in Tables 4.2 and 4.3. In the following, we will

focus on findings based on the adjusted models. Model fit of all specified models was

acceptable to good, with all CFI values but one (which was .893) above the threshold of .90 and all RMSEA scores close to or below the cut-off criterion of .05 (McDonald & Ho, 2002; Schermelleh-Engel, Moosbrugger, & Müller, 2003).

Predicting Change in Personality Traits and Cognitive Abilities

The intervariable cross-lagged parameters could be set equal between cohorts in all but three models. All three models with group-differential cross-lagged associations contained information processing speed: Regarding the association between neuroticism and information processing speed, the negative path from speed to neuroticism change reached significance in the late-life cohort only. Associations between agreeableness and information processing speed also varied by group, with a significant positive association between agreeableness and speed change in the late-life cohort, whereas in the midlife cohort, speed was a significant negative predictor of change in agreeableness (i.e., higher baseline speed was associated with a steeper decline/less increase in agreeableness over time). Finally, conscientiousness was a significant and positive predictor of change in information processing speed in the midlife cohort only.

All other intervariable cross-lagged associations could be set equal between groups without a significant deterioration of model fit and were as follows: For neuroticism and extraversion, crystallized and fluid abilities were significant predictors of changes in these personality traits (with negative effects for neuroticism and positive effects for extraversion), whereas the opposite effects from neuroticism and extraversion to changes in fluid and crystallized abilities were consistently nonsignificant. Regarding openness to experience, all three cognitive domains were significant positive predictors of change in openness. Baseline openness was, in turn, also significantly and positively related to change in crystallized abilities. The

model relating openness with crystallized abilities was thus the only one where both intervariable cross-lagged parameters reached significance. Baseline agreeableness was a significant negative predictor of change in fluid abilities, which was – apart from the group-differential agreeableness-speed interplay described above – the only significant cross-lagged relation between this personality trait and the cognitive components. Finally, T1 conscientiousness was a significant predictor of change in crystallized abilities, and this association was negative.

Effects of the Covariates

The effects of the covariates on the change scores of the different personality traits and cognitive components are summarized in Table 4.4. In short, more years of education were significantly associated with less increase (or stronger decrease) in neuroticism and stronger increase (or less decrease) in agreeableness only in the midlife cohort. The effects of physician-rated health on change in both extraversion and openness were consistently significant in the late-life cohort only (with better health being associated with stronger increase/less decrease in extraversion, but with less increase/stronger decrease in openness). This is also true regarding the effect of self-rated health on change in openness, with better self-rated health being associated with stronger increase or less decrease in openness. Significant gender differences occurred in the late-life cohort only with regard to openness and agreeableness (i.e., stronger increase/less decrease in both traits for women compared to men). With the exception of several significant effects of physician-rated health, the covariates included were not significantly related to change in any of the three cognitive components.

Finally, for the latent change scores of the personality traits and the cognitive domains squared multiple correlation (SMC) coefficients, which correspond to R^2

values (amount of variance accounted for by predictors) used in regression models, were computed and are shown in Table 4.5. Not surprisingly, SMC coefficients were in most cases considerably higher in the adjusted models compared to the unadjusted models, which underlines the role of included covariates (particularly health; see Table 4.4) as meaningful predictors of change in both personality and cognitive ability. Moreover, the SMC coefficients of the change scores of the Big Five personality traits (of both the unadjusted and the adjusted models) were generally higher than the ones of the change scores of the cognitive domains. This pattern seems to be due to (1) stronger predictive effects of baseline cognitive abilities on personality change than vice versa, and (2) stronger predictive effects of the covariates on personality change than on change in cognitive abilities.

Discussion

In this study, we investigated the interplay of the Big Five personality traits (neuroticism, extraversion, openness to experience, agreeableness and conscientiousness) and cognitive abilities (processing speed, crystallized intelligence, and fluid intelligence) over 12 years in a midlife (aged between 43 and 46 years at baseline) and a late-life cohort (61-65 years). We also investigated whether the longitudinal relationship between personality and cognitive abilities changes from midlife to late life, due to changes in cognitive plasticity and personality plasticity over the adult life span. In the following, we will discuss our major findings against the background of our theoretical assumptions and of existing research findings. We will also point out limitations of this study, as well as directions for future research.

Predicting 12-Year Personality Change by Cognitive Abilities

As pointed out, research has so far mostly considered personality as a predictor, rather than as an outcome, of cognitive abilities. However, we found significant effects of different cognitive domains on change in neuroticism, extraversion and openness, whereas regarding the opposite direction, only crystallized abilities were significantly related to change in openness. It thus seems that – at least when considering these three of the Big Five personality traits – cognitive abilities are consistent predictors of personality change. This is in line with previous findings reporting meaningful longitudinal neuroticism-cognition interrelations (Waggel et al., 2015; Wahl et al., 2010; Wettstein et al., 2016) as well as with findings of significant predictive effects of cognitive abilities on changes in openness (von Stumm & Deary, 2013). Moreover, according to Jackson et al. (2012), openness can even be modified through cognitive intervention.

With regard to possible explanations for the meaningful effects of baseline cognitive abilities on personality change, the distressing experience of cognitive decline or lower cognitive abilities may upset individuals and cause feelings of anxiety, resulting in higher neuroticism scores over time. Neuroticism has also been found to be one of the personality traits most susceptible to change when cognitive impairments such as Alzheimer's disease set in (Robins Wahlin & Byrne, 2011). Lower cognitive abilities may also endanger an individual's motivation to seek out novel (cognitive) stimulation and experiences because these may become too demanding so that – also in line with the "environmental success" hypothesis (Ziegler et al., 2015; Ziegler et al., 2012).- a decline in openness to experience results. In addition, lower cognitive functioning may also affect individuals' willingness to engage in (cognitively challenging) social interactions and thus lead to a decrease in extraversion.

Evidence for cohort differences in longitudinal cognition-personality associations was generally limited. However, one of the effects of cognitive abilities on personality change that varied by group was the path from baseline information processing speed to neuroticism change which reached significance in the late-life cohort only. Late-life cognitive abilities and changes have been found to be highly heterogeneous (Mungas et al., 2010; Zimprich & Martin, 2002), and those who have been affected by particularly steep declines in processing speed even before T1 may, as a consequence, have revealed an increase in neuroticism over time, possibly due to the distressing experience of cognitive decline. In contrast, only very few middle-aged older adults are affected by a strong decline in processing speed, as such accelerated declines do not usually set in before late-life (Finkel et al., 2003; McArdle et al., 2002; Singh-Manoux et al., 2012), which may explain why this effect of baseline speed on neuroticism change did not reach significance in the midlife cohort.

The other effect of cognitive ability on personality change that varied according to group was the effect of baseline speed on change in agreeableness, which was negative and significant in the midlife cohort only. This negative association may seem surprising at first glance; however, Baker and Bichsel (2006), for instance, reported a similar finding, speculating that "those who are highly intelligent are more independent" and that "non-reliance on others means Agreeableness is less necessary" (p. 9). It is thus possible that those with lower processing speed scores at T1 exhibit a stronger increase in agreeableness over 12 years because they are – due to their lower cognitive resources – more dependent on others, and higher agreeableness may help them to get the amount of social support needed. It is, however, difficult to explain why this association emerged in the midlife, rather than

the late-life sample. Experiencing impairments in processing speed already in midlife

is rather non-normative and perhaps particularly alerting, so that individuals affected

by such impairments may be particularly "reactive" in terms of personality change

(i.e., an increase in agreeableness). This is, however, highly speculative, and further

research is therefore needed to replicate and account for our finding.

None of the other associations from baseline cognitive abilities to change in

agreeableness reached significance, which is in line with other work stating that

agreeableness is not reliably associated with cognitive abilities (Ackerman &

Heggestad, 1997; Curtis et al., 2015; Luchetti et al., 2015; Mueller, Wagner,

Drewelies, et al., 2016). Moreover, none of the cognitive abilities was significantly

related to change in conscientiousness. However, conscientiousness trajectories

have been found to be affected by cognitive ability in very old age (Mõttus, Johnson,

Starr, et al., 2012). Therefore, perhaps change in conscientiousness may only be

meaningfully predicted by cognitive abilities in advanced old age when all intelligence

components, namely processing speed, fluid and crystallized abilities, exhibit

declining trends. However, more research—including also very old cohorts in addition

to midlife and late-life samples—is needed to investigate this possible explanation

and the impact of fluid vs. crystallized vs. combined ability decline on personality

change.

As pointed out, we only found limited evidence for a cohort moderation of the

associations between cognitive abilities and personality change, with only two paths

varying as a function of age cohort. Moderating effects of chronological age on the

personality-cognition interplay have been reported before (e.g., Baker & Bichsel,

2006; Graham & Lachman, 2014; Soubelet & Salthouse, 2011; Sutin et al., 2011),

but most of these findings were based on other age groups than the ones included in

this study and on cross-sectional study designs, comparing personality-cognition associations only at one point in time. More research, ideally comprising multiple adult age groups, is therefore needed to further address the role of cohort in the longitudinal personality-cognition interplay.

Our finding that cognitive abilities meaningfully predict personality change, particularly in neuroticism, extraversion, and openness, could also have relevant implications for future interventions: Undesirable personality changes potentially caused by low cognitive abilities or cognitive decline, such as increases in neuroticism and decreases in extraversion and openness—which may in the long run also be detrimental for well-being and quality of life (Charles et al., 2001; Isaacowitz & Smith, 2003; Mroczek & Spiro, 2005; Tauber, Wahl, & Schröder, 2016)—could possibly be prevented or at least attenuated by interventions aiming to improve or maintain cognitive functioning. Indeed, as pointed out before, there is promising evidence that cognitive training can also result in "positive" personality developments (such as an increase in openness; Jackson et al., 2012). Obviously, for future interventions we first need to make sure if cognitive abilities indeed affect personality change by further ruling out the existence of confounding variables beyond the ones included in this study (gender, education, self-rated health, physician-rated health). Specifically, we acknowledge that caution is warranted with regard to causal interpretation of our findings: Even if cognitive abilities precede changes in personality traits (and vice versa), there may be additional confounding influences that were not controlled for and which may have caused spurious associations. A stronger test of causality can only be achieved by experimental study designs, e.g. by investigating whether intervention-based cognitive change is also accompanied by change in personality traits (Jackson et al., 2012).

Furthermore, designing such interventions to change personality also requires that we know more about *how* and via which mechanisms cognitive abilities lead to personality change. Specifically, personality and cognitive abilities may be related with each other via multiple mediating and moderating factors (Curtis et al., 2015). Among the numerous candidates for mediation and moderation are health behaviors (Booth-Kewley & Vickers, 1994), coping strategies (Gunthert et al., 1999), (daily and chronic) stress exposure (Neupert et al., 2008), sensory impairment status (Gaynes, Shah, Leurgans, & Bennett, 2013; Wettstein et al., 2016), or environmental enrichment factors (Ziegler et al., 2015; Ziegler et al., 2012). Moreover, health – which we considered as a covariate in this study – may as well act as a mediator of personality-intelligence associations. Future research should investigate these potentially mediating and moderating factors of the personality-cognition interplay, particularly regarding the so-far theoretically and empirically neglected pathway from cognitive abilities to personality change. In addition, a more differentiated picture may emerge when distinguishing between subfacets of the different personality traits (Zimprich et al., 2009).

Predicting 12-Year Cognitive Change by Personality Traits

Only some of the prospective relationships between prior personality and later cognitive changes were significant. Neither neuroticism nor extraversion reached significance as predictors of change in any of the cognitive outcomes, which is in line with several prior findings (Jelicic et al., 2003; Salthouse, 2014; Waggel et al., 2015).

Particularly extraversion may indeed not belong to the major personality predictors of cognitive change (Curtis et al., 2015). Generally, it is still unclear how extraversion is related to cognitive abilities. Cross-sectionally, some studies report positive associations (Ackerman & Heggestad, 1997; Pearman, 2009), whereas other

found negative relationships (ForsterLee, 2007; Soubelet & Salthouse, 2011), and still others observed both positive and negative correlations, depending on the age group and on the cognitive domain considered (Baker & Bichsel, 2006). Longitudinally, *lower* extraversion may be associated with less steep cognitive decline over time (T. Y. Arbuckle et al., 1998; Chapman et al., 2012; Gold et al., 1995; Luchetti et al., 2015), but again, other studies did not find meaningful associations between extraversion and cognitive change (Graham & Lachman, 2012; Salthouse, 2014). A possible explanation for this explanation could be that the association between extraversion and cognitive trajectories is nonlinear, with moderate extraversion scores being most protective against cognitive decline (Crowe, Andel, Pedersen, Fratiglioni, & Gatz, 2006); however, more research is needed to investigate this assumption.

Openness was positively related to change in crystallized abilities in both cohorts. Positive relationships between openness and cognitive changes were also reported by other studies (Duberstein et al., 2011; Graham & Lachman, 2012; Hogan, Staff, Bunting, Deary, & Whalley, 2012; Luchetti et al., 2015; Sutin et al., 2011; Ziegler et al., 2015). The underlying mediating mechanism may be cognitive stimulation or "environmental enrichment" (Ziegler et al., 2015; Ziegler et al., 2012), which individuals high in openness seek out more frequently and more intensively than individuals with lower openness scores. Moreover, openness may, according to investment theories, represent a typical "investment trait" (von Stumm & Ackerman, 2013) and influence the extent to which individuals invest in their intellect (DeYoung, 2014; DeYoung et al., 2005).

Notably, only crystallized ability change was predicted by openness, but not change in fluid ability and processing speed, which is in line with other findings

demonstrating that fluid vs. crystallized abilities have different correlates and predictors (Lövdén et al., 2004). The effect of openness on change in crystallized abilities that was significant in both cohorts may also have important practical implications: Openness has been shown to be modifiable via interventions, also at older ages (Jackson et al., 2012; Mühlig-Versen, Bowen, & Staudinger, 2012), just like personality in general (Chapman, Hampson, & Clarkin, 2014; Magidson, Roberts, Collado-Rodriguez, & Lejuez, 2014), and such interventions to promote openness may in the long run also contribute to maintaining or even improving crystallized cognitive abilities.

Agreeableness was a significant positive predictor of change in information processing speed in the late-life cohort only. In contrast, this trait was a significant negative predictor of change in fluid abilities in both cohorts. This pattern implies that the direction of associations between personality traits and cognitive abilities may considerably vary according to the cognitive domain considered (Ackerman & Heggestad, 1997; Baker & Bichsel, 2006; Soubelet & Salthouse, 2011; Ziegler et al., 2015; Ziegler et al., 2012) and underlines the importance to take the multidimensionality of cognitive abilities into account when investigating the personality-cognition interplay. Adopting again the tentative explanation by Baker and Bichsel (2006), higher agreeableness may precede steeper decline in fluid abilities because agreeableness may represent a strategy to cope with lower cognitive abilities by relying more on others.

Conscientiousness was significantly positively related to change in processing speed in the midlife cohort only. This finding is in line with other studies reporting a protective effect of conscientiousness on cognitive change and on risk of cognitive impairment (Curtis et al., 2015; Duberstein et al., 2011; Luchetti et al., 2015). Higher

conscientiousness is associated with more prudent health behaviors (Booth-Kewley & Vickers, 1994), which may in turn contribute to less decline in processing speed scores in the midlife sample. On the contrary, less conscientious individuals may be less willing and motivated to invest in their cognitive resources, resulting in stronger processing speed decline for these persons. However, in the late-life sample plasticity of cognitive ability, and particularly of processing speed, may already be considerably compromised (Brehmer, Li, Müller, von Oertzen, & Lindenberger, 2007; Dahlin, Nyberg, Bäckman, & Neely, 2008; Noack et al., 2013; Schmiedek et al., 2010). This may explain why the effect of baseline conscientiousness on change in speed did not reach significance in this age group.

Similarly to agreeableness, there was also a shift in sign for conscientiousness, which was significantly negatively related to change in crystallized abilities in both cohorts, which means that - in contrast to the described positive effect of conscientiousness on speed change in the midlife cohort - higher conscientiousness was associated with steeper decline (or smaller increase) in crystallized abilities. As already pointed out, negative relationships between conscientiousness and cognitive abilities have been found before (Ackerman & Heggestad, 1997; Moutafi, Furnham, & Paltiel, 2004; Pearman, 2009; Soubelet, 2011; Soubelet & Salthouse, 2011). The intelligence compensation hypothesis as one possible explanation suggests that individuals may compensate for lower cognitive ability by becoming more conscientious in order to reach similar levels of achievement compared to cognitively more able individuals (who may not, or to a lesser degree, have to rely on conscientiousness for performing well). However, the reason for such negative relations remains controversial. According to Murray, Johnson, McGue, and Iacono (2014), selected samples have caused these negative

associations in prior research. Regarding our sample, those individuals with highest

conscientiousness scores at T1 may have also been the ones scoring highest on

crystallized ability tests at T1 so that – due to such a ceiling effect – they could not

further improve regarding their test scores, whereas others with lower

conscientiousness scores could. Future research is needed to further address the

relationship between conscientiousness and crystallized abilities and its underlying

mechanisms.

Our finding that the direction of the relationship between prior

conscientiousness and processing speed change in the midlife sample deviates from

the direction of the respective conscientiousness-crystallized ability association again

underlines the importance of considering multiple aspects of cognitive abilities when

analyzing the personality-cognition interplay. This is in line with previous research

that has shown that different cognitive domains are differentially related to personality

traits (Ackerman & Heggestad, 1997; Baker & Bichsel, 2006; Ziegler et al., 2015).

This is not the first study reporting rather weak effects of personality on

cognitive changes, particularly in late life (Jelicic et al., 2003; Salthouse, 2014; Sharp

et al., 2010; Waggel et al., 2015). Other factors such as health (or sensory abilities;

Lin et al., 2013) may be more important determinants of late-life cognitive

development than personality characteristics. Indeed, when reporting our results, we

focused on the models adjusted for covariates (gender, education, subjective health,

physician-rated health) which may explain why many of the intervariable cross-

lagged personality-cognition associations (and particularly the ones from baseline

personality to 12-year cognitive change) were not significant: The personality-

cognition interplay may to some extent be spurious and driven by a "common cause".

Among the included covariates, particularly health may be such a common cause as

it was the strongest and most consistent predictor of changes in both personality and cognitive abilities. Importantly, this is only true for physician-rated health, as subjective health was not meaningfully related to change in any cognitive domain and also less consistently associated with personality change than physician-rated health (which is in line with other findings, e.g. Wettstein, Tauber, Wahl, & Frankenberg, in press). The important role of (objective) health and certain diseases for cognitive development has been reported previously (Anstey, 2016; Anstey & Christensen, 2000; Spiro & Brady, 2011). Moreover, some recent studies have shown that health acts as a meaningful predictor of personality change (Jokela, Hakulinen, Singh-Manoux, & Kivimäki, 2014; Mueller et al., 2016; Sutin, Zonderman, Ferrucci, & Terracciano, 2013; Wagner et al., 2015). However, the role of health as a "common cause" of both personality and cognitive changes in midlife and late-life requires further research.

Moreover, personality may play a more important role as predictor of cognitive trajectories in very old age (Chapman et al., 2012; Mõttus, Johnson, Starr, et al., 2012). Wilson et al., (2015), for example, found that terminal decline in cognitive abilities in the last years of life was predicted by conscientiousness, whereas pre-terminal cognitive changes were not. Personality may also be a more important predictor of pathological cognitive changes such as mild cognitive impairment and dementia (Duberstein et al., 2011; Johansson et al., 2014; Kuźma, Sattler, Toro, Schönknecht, & Schröder, 2011; Low, Harrison, & Lackersteen, 2013; Terracciano et al., 2014). Specifically, conscientiousness seems to be a protective factor with regard to late-life cognitive health (Low et al., 2013; Terracciano et al., 2014; Wilson et al., 2015; Wilson, Schneider, Arnold, Bienias, & Bennett, 2007), whereas neuroticism, and particularly its subcomponent distress proneness (Wilson et al., 2003; Wilson,

Schneider, Boyle, et al., 2007), has been found to be risk factor for mild cognitive impairment and Alzheimer disease.

Another possible explanation for the weak effects of personality traits on 12-year cognitive changes is that personality unfolds its effects on cognitive abilities only in combination with other genetic, personal, or contextual factors. Many examples for such interactive effects of personality with other factors on cognitive abilities and cognitive development exist, such as the interaction effect of neuroticism with daily stress on everyday memory failures (Neupert et al., 2008); the interaction effect of the apolipoprotein E (ApoE) e-4 allele with neuroticism (and extraversion) on cognitive functioning and Alzheimer's disease (Dar-Nimrod, Chapman, Franks, et al., 2012; Dar-Nimrod, Chapman, Robbins, et al., 2012); the interaction between neuroticism, openness to experience, and depression regarding older adults' neuropsychological functioning (Ayotte, Potter, Williams, Steffens, & Bosworth, 2009); or the combined effect of neuroticism and sensory impairment on cognitive abilities and cognitive decline (Gaynes et al., 2013; Wettstein et al., 2016). Another moderating factor is lifestyle: neuroticism has been found to be a risk factor for dementia only in individuals with an inactive or socially isolated lifestyle (Wang et al., 2009), and effects of a cognitive enrichment intervention on cognition have been found to be moderated by openness (Stine-Morrow et al., 2014). Further factors that may moderate personality-cognition associations are demographic indicators such as gender (ForsterLee, 2007; Pearman, 2009) or education (Soubelet, 2011; Sutin et al., 2011). Moreover, it may be the specific constellation of certain personality traits, e.g., of neuroticism and extraversion, that is prospectively associated with cognitive outcomes, instead of isolated single personality traits only (Crowe et al., 2006; Johansson et al., 2014; Wang et al., 2009).

Finally, as pointed out before, some of the effects of personality on cognitive development may be nonlinear in nature (Crowe et al., 2006) and may need even more than 12 years to unfold. Following the assumption made by Anstey (2014) that "mid-life is a time when cognitive reserve is built" (p. 5), the contribution of midlife or (even earlier) personality phenotypes for cognitive reserve as well as the beneficial effects of cognitive reserve itself may not be immediately observable, but rather several decades later, when individuals reach old and very old age. Specifically, Crowe et al. (2006) found that neuroticism and extraversion prospectively predicted risk of cognitive impairment 25 years later. Similarly, Johansson et al. (2014) reported that midlife personality in women was significantly related to risk of Alzheimer's disease 38 years later. Substantial long-term relations in the opposite direction have also been found, e.g., with childhood intelligence predicting late-life emotional stability (Gow, Whiteman, Pattie, & Deary, 2005). Therefore, future studies should consider operationalizing even wider time spans than the 12 years investigated in this study and including more than two measurement occasions, because two assessments may not be sufficient to capture and describe meaningful patterns of aging as well as the unfolding of processes and their interrelation over time (Johnson et al., 2012; Kenny, 2005).

Study Limitations

This study has several limitations. Notably, personality is related to study participation, typically resulting in a volunteer/selection bias (Walsh & Nash, 1978), as well as to study dropout and missing data patterns (Jerant, Chapman, Duberstein, & Franks, 2009). This is also true for cognitive abilities, with study participants usually scoring higher on cognitive tests than the general population, particularly in samples of old and very old adults (Vestergaard et al., 2015). However, as the primary goal of

this study was not to describe levels and changes of personality and cognitive abilities in middle adulthood and old age, but rather to investigate the longitudinal personality-cognition interface in both cohorts, we are confident that our findings were not severely biased by sample selectivity and selective study dropout. Rather, selective dropout may have contributed to a restricted range in our target variables of personality and cognitive abilities, so that the longitudinal associations between both domains may actually have been *underestimated* in this study. Moreover, the dropout rate over 12 years was quite low in this study (i.e., 78.7% of the initial sample took part at T3).

Moreover, regarding measurement issues, self-rated health was measured only by one item. However, apart from enabling a "parsimonious" and quick assessment, single-item measures of subjective health have been found to exhibit high validity and to have consistent and meaningful correlates (DeSalvo, Bloser, Reynolds, He, & Muntner, 2006; Idler & Benyamini, 1997; Pinquart, 2001). Another limitation is that the internal consistency of openness to experience was rather low. However, openness was measured using an established assessment instrument, namely the NEO-Five-Factor Inventory (NEO-FFI; Costa & McCrae, 1992b).

Regarding the effect sizes of the intervariable cross-lagged personality-cognition parameters, many of them can indeed be considered small (according to Cohen, 1992). However, they refer to a considerable long-term interval encompassing 12 years. Moreover, we found also several parameter estimates which were < .30 and thus of medium effect size, and two estimates (namely, processing speed → neuroticism change in the late-life cohort, and crystallized abilities → openness in the midlife cohort) were even close to the cutoff value of .50 and can therefore be considered as strong effects. As pointed out, stronger effects of

personality on cognitive development may be observed when considering incidence of cognitive impairments (such as mild cognitive impairment or dementia; Archer et al., 2009; Crowe et al., 2006; Duberstein et al., 2011; Kuźma et al., 2011; Low et al., 2013; Terracciano et al., 2014; Wilson et al., 2015) instead of focusing on "normal"/healthy cognitive aging as we did in this study. However, we focused on healthy cognitive aging because early old age and particularly midlife are characterized by rather low prevalence rates of cognitive impairment. These pathological cognitive developments thus affect a very small minority of these individuals only, whereas many more individuals are affected by non-pathological cognitive changes over 12 years.

Finally, as already pointed out, the personality-cognition interplay may reveal stronger mutual associations in very old age. However, only two adult age cohorts, representing midlife and early-old age, were available in this study. More research focusing on personality-cognition interrelations in multiple cohorts, including also advanced old, age is needed. Moreover, comparing two different age groups in this study, the few personality-cognition associations we found to be different between groups may be either due to cohort or age effects (or both). Assessing and comparing several birth cohorts across long time periods, ideally from childhood/young adulthood into very old age, could be an approach to disentangle cohort and age effects in future investigations.

Conclusion

To summarize, this study is, to our knowledge, the first to compare long-term personality-cognition associations in two different adult cohorts based on all Big Five personality traits and a comprehensive set of cognitive indicators. For neuroticism, extraversion and openness, we found stronger relationships between baseline

cognitive abilities and personality change than vice versa. We also observed that the intervariable cross-lagged associations between personality traits and cognitive abilities were generally very similar in middle-aged and older adults suggesting stability of the longitudinal personality-cognition interplay over the second half of life. Our findings challenge the so far predominant view of personality in middle adulthood and late-life as solely a predictor, rather than as an outcome, of cognitive abilities by demonstrating that cognitive abilities seem to play a particular role for personality change in middle adulthood and late life.

Conflict of Interest

None.

Acknowledgement.

Table 4.1

Publication 3: Sample Description (T1) of the Midlife Cohort (n = 502) and of the Late-Life Cohort (n =500)

Variable	Total	Midlife Cohort	Late-Life Cohort	Statistical Test[a]	Effect Size (Cohen's d/ϕ)
N	1,002	502 (M_{age}: 44.17 years, *SD* =0.91)	500 (M_{age}: 62.87 years, *SD* =0.89)		
Gender (% Male)	520 (51.9%)	260 (51.8%)	260 (52.0%)	*ns*	Φ = .012, *ns*
Education (years) (*M, SD*)	13.48 (2.70)	14.07 (2.50)	12.89 (2.76)	*p < .001*	*d* = .48
Self-rated health[1](*M, SD*)	2.51 (0.86)	2.47 (0.81)	2.55 (0.91)	*ns*	*d* = .07
Physician-rated health[1] (*M, SD*)	2.36 (0.84)	2.26 (0.78)	2.46 (0.88)	*p < .001*	*d* = .24
Number-Connecting 1 (*M, SD*)	22.60 (9.53)	19.71 (6.72)	25.52 (10.96)	*p < .000*	*d* = .64
Number-Connecting 2 (*M, SD*)	21.25 (12.20)	18.54 (6.12)	23.99 (15.70)	*p < .000*	*d* = .46
Digit Symbol Substitution (*M, SD*)	48.17 (11.66)	53.27 (9.74)	43.05 (11.19)	*p < .000*	*d* = .98
Information (*M, SD*)	15.86 (4.47)	16.03 (4.22)	15.69 (4.70)	*ns*	*d* = .08
Similarities (*M, SD*)	25.26 (5.73)	25.58 (5.23)	24.94 (5.50)	*ns*	*d* = .12
Picture Completion (*M, SD*)	12.30 (3.51)	12.84 (3.14)	11.74 (3.90)	*p < .000*	*d* = .31
Block Design (*M, SD*)	28.78 (8.65)	30.61 (9.14)	26.85 (8.14)	*p < .000*	*d* = .46
Spatial Ability (*M, SD*)	22.78 (6.73)	24.19 (6.87)	21.29 (6.57)	*p < .000*	*d* = .43

Table 4.1 – *Continued*

Variable	Total	Midlife Cohort	Late-Life Cohort	Statistical Test[a]	Effect Size (Cohen's d/ϕ)
Neuroticism (*M, SD*)	18.24 (6.98)	17.79 (7.02)	18.71 (6.91)	*p = .040*	*d = .13*
Extraversion (*M, SD*)	27.52 (5.78)	28.51 (5.73)	26.51 (5.65)	*p < .000*	*d = .35*
Openness to Experience (*M, SD*)	26.66 (5.03)	27.31 (5.29)	25.98 (4.66)	*p < .000*	*d = .27*
Agreeableness (*M, SD*)	31.95 (4.82)	31.53 (4.89)	32.40 (4.71)	*p = .005*	*d = .18*
Conscientiousness (*M, SD*)	35.22 (5.34)	35.15 (5.44)	35.30 (5.23)	*ns*	*d = .03*

Note. ns = not significant; *M* = mean; *SD* = standard deviation

[a] t-test for continuous variables and Chi-square-test for categorical variables

[1] Lower values indicate better health.

Table 4.2

Publication 3: Model-Fit Indices of the Multi-Group Bi-Variate Change Regression Models

Personality Domain	Cognitive Domain	Model	χ^2	df	*p*	CFI	RMSEA
Neuro-ticism	Speed	Adjusted [a]	570.965	174	*.00*	.930	.049
		No Covariates	714.228	116	*.00*	.879	.073
	Cryst. Intelligence	Adjusted [a]	410.793	122	*.00*	.939	.049
		No Covariates	219.369	74	*.00*	.961	.045
	Fluid Intelligence	Adjusted [a]	390.282	180	*.00*	.958	.035
		No Covariates	390.914	116	*.00*	.934	.050
Extra-version	Speed	Adjusted [a]	597.525	176	*.00*	.919	.050
		No Covariates	741.494	116	*.00*	.865	.075
	Cryst. Intelligence	Adjusted [a]	446.857	122	*.00*	.925	.052
		No Covariates [b]	320.442	76	*.00*	.927	.058
	Fluid Intelligence	Adjusted [a]	412.201	180	*.00*	.948	.037
		No Covariates	459.509	116	*.00*	.911	.055
Openness	Speed	Adjusted [a]	662.262	176	*.00*	.900	.053
		No Covariates	769.599	116	*.00*	.842	.076
	Cryst. Intelligence	Adjusted [a]	488.828	122	*.00*	.909	.056
		No Covariates	301.675	74	*.00*	.925	.056
	Fluid Intelligence	Adjusted [a]	487.823	180	*.00*	.926	.042
		No Covariates	443.752	116	*.00*	.904	.054
Agree-ableness	Speed	Adjusted [a]	604.921	174	*.00*	.910	.051
		No Covariates	777.536	116	*.00*	.842	.077
	Cryst. Intelligence	Adjusted [a]	380.810	122	*.00*	.932	.047
		No Covariates [b]	253.815	76	*.00*	.938	.049
	Fluid Intelligence	Adjusted [a]	362.079	180	*.00*	.955	.032
		No Covariates	402.855	116	*.00*	.914	.051
Conscien-tiousness	Speed	Adjusted [a]	725.783	178	*.00*	.893	.057
		No Covariates	1083.218	114	*.00*	.770	.094
	Cryst. Intelligence	Adjusted [a]	435.072	122	*.00*	.926	.052
		No Covariates	257.991	74	*.00*	.943	.051
	Fluid Intelligence	Adjusted [a]	400.759	180	*.00*	.950	.036
		No Covariates	411.184	116	*.00*	.921	.051

Note. χ^2 = Chi square, df = degrees of freedom, *p* = significance value, CFI = comparative fit index, RMSEA = root mean squared error of approximation, Cryst. = crystallized.

[a] Adjusted for gender, education, self-rated and physician-rated health.

[b] Model was estimable only with residuals of the indicators Similarities T1 and Similarities T3 constrained as unrelated.

Table 4.3

Publication 3: Overview of Standardized Path Coefficients of the Multi-Group Bi-Variate Latent Change Regression Models

Person- ality Domain	Cognitive Domain	Model	Baseline correlation Cognition T1 – Personality T1 LL/ML	Change residual correlation LL/ML	Auto-proportion: Personality T1 → Δ Personality LL/ML	Auto- proportion: Cognition T1 → Δ Cognition LL/ML	Intervariable Cross- Lagged Prediction: Personality T1 → Δ Cognition LL/ML	Intervariable Cross- Lagged Prediction: Cognition T1 → Δ Personality LL/ML
Neuro- ticism	Speed	Adjusted [a]	-.238***/-.181**	-.241/-.224*	-.392***/-.368***	-.138/.262**	.084/.085	-.472***/.009
		No Covariates	-.195***/-.157***	-.039/-.040	-.395***/-.297***	.098/.106	.068 [b] /.059 [b]	-.383*** [b] /-.169*** [b]
	Cryst. Int.	Adjusted [a]	-.416***/-.327***	-.015/-.147	-.379***/-.386***	-.052/-.332*	.084 [b] /.122 [b]	-.178* [b] /-.125* [b]
		No Covariates	-.420***/-.335***	.007/-.181	-.468***/-.349***	-.048/-.113	.110 [b] /.159 [b]	-.320*** [b] /-.236*** [b]
	Fluid Int.	Adjusted [a]	-.406***/-.267***	-.066/.232	-.400***/-.377***	-.077/-.209	.105 [b] /.145 [b]	-.272*** [b] /-.208*** [b]
		No Covariates	-.413***/-.257***	.125/.179	-.462***/-.339***	-.002/-.226*	.019 [b] /.040 [b]	-.323*** [b] /-.263*** [b]
Extra- version	Speed	Adjusted [a]	.169**/.087	.330*/.070	-.219/-.374***	-.159/.273**	-.038 [b] /-.044 [b]	.205* [b] /.094* [b]
		No Covariates	.167**/.066	.420***/-.017	-.168/-.380***	.065/.109	.046 [b] /.040 [b]	.319*** [b] /.123*** [b]
	Cryst. Int.	Adjusted [a]	.020/-.014	.296/.079	-.210/-.363***	-.097/-.372*	-.041 [b] /-.060 [b]	.224* [b] /.142* [b]
		No Covariates [c]	-.006/.006	.098/.016	-.132/-.384***	-.120/-.181	.002 [b] /.003 [b]	.186* [b] /.119* [b]
	Fluid Int.	Adjusted [a]	.009/.022	.147/-.362*	-.193/-.360***	-.088/-.239	.013 [b] /.018 [b]	.211* [b] /.148* [b]
		No Covariates	.013/.023	.379**/-.332*	-.140/-.383***	-.021/-.299*	.067 [b] /.140 [b]	.160* [b] /.114* [b]

Table 4.3 – *Continued*

Person- ality Domain	Cognitive Domain	Model	Baseline correlation Cognition T1 – Personality T1 LL/ML	Change residual correlation LL/ML	Auto-proportion: Personality T1 → Δ Personality LL/ML	Auto- proportion: Cognition T1 → Δ Cognition LL/ML	Intervariable Cross- Lagged Prediction: Personality T1 → Δ Cognition LL/ML	Intervariable Cross- Lagged Prediction: Cognition T1 → Δ Personality LL/ML
Open- ness	Speed	Adjusted [a]	.430***/.243***	-.004/-.139	-.256/-.219*	-.171/.249*	.051 [b] /.072 [b]	.295** [b] /.141** [b]
		No Covariates	.335***/.195**	-.026/-.243**	-.336*/-.236*	.110/.095	.015 [b] /.016 [b]	.302*** [b] /.123** [b]
	Cryst. Int.	Adjusted [a]	.558***/.523***	.468**/.028	-.284/-.313**	-.311*/-.610***	.262*** [b] /.497*** [b]	.374** [b] /.237** [b]
		No Covariates	.596***/.556***	.465***/.071	-.271/-.298**	-.329**/-.492**	.297*** [b] /.566*** [b]	.265** [b] /.180* [b]
	Fluid Int.	Adjusted [a]	.430***/.455***	-.112/.072	-.266/-.261*	-.152/-.324	.165 [b] /.275 [b]	.349*** [b] /.261*** [b]
		No Covariates	.452***/.477***	.018/.124	-.299*/-.270**	-.045/-.407**	.108 [b] /.256 [b]	.260** [b] /.212** [b]
Agree- ableness	Speed	Adjusted [a]	.008/.119	-.095/.197	-.355**/-.252*	-.153/.268**	.200*/-.181	.072/-.193*
		No Covariates	.016/.087	.086/-.148	-.255/-.300**	.098/.106	.020 [b] /.017 [b]	-.016 [b] /-.007 [b]
	Cryst. Int.	Adjusted [a]	-.025/-.009	-.041/.091	-.348**/-.267*	-.063/-.363*	-.106 [b] /-.153 [b]	-.101 [b] /-.075 [b]
		No Covariates [c]	.010/.119*	.019/.039	-.255/-.303**	-.109/-.172	-.134* [b] /-.198* [b]	.039 [b] /.028 [b]
	Fluid Int.	Adjusted [a]	-.043/-.091	.035/-.018	-.352**/-.264*	-.079/-.220	-.205* [b] /-.291* [b]	-.056 [b] /-.046 [b]
		No Covariates	-.059/-.086	-.123/.009	-.241/-.294**	-.021/-.290*	-.143** [b] /-.305** [b]	.026 [b] /.021 [b]

Table 4.3 – *Continued*

Person-ality Domain	Cognitive Domain	Model	Baseline correlation Cognition T1 – Personality T1 LL/ML	Change residual correlation LL/ML	Auto-proportion: Personality T1 → Δ Personality LL/ML	Auto-proportion: Cognition T1 → Δ Cognition LL/ML	Intervariable Cross-Lagged Prediction: Personality T1 → Δ Cognition LL/ML	Intervariable Cross-Lagged Prediction: Cognition T1 → Δ Personality LL/ML
Con-scien-tious-ness	Speed	Adjusted [a]	.020/.026	.200/-.045	-.265**/-.374***	-.136/.227*	-.103/.199*	.113/-.098
		No Covariates	.019/-.017	.390***/-.133	-.399***/-.443***	.096/.108	.002/.222**	.189*/-.141
	Cryst. Int.	Adjusted [a]	-.002/-.127*	.030/.036	-.266**/-.362***	-.131/-.459**	-.204*** [b] /-.312*** [b]	.039 [b] /.040 [b]
		No Covariates	.006/-.110	.105/-.055	-.271**/-.357***	-.127/-.231*	-.228*** [b] /-.346*** [b]	.045 [b] /.045 [b]
	Fluid Int.	Adjusted [a]	.055/-.061	.319*/-.029	-.274**/-.372***	-.110/-.230	-.101 [b] /-.149 [b]	-.017 [b] /-.019 [b]
		No Covariates	.060/-.064	.280*/-.052	-.274**/-.367***	-.026/-.282*	-.043 [b] /-.096 [b]	-.019 [b] /-.021 [b]

Note. LL = Late-Life Cohort born 1930/32, ML = Midlife Cohort born 1950/52, Cryst. = crystallized, Int. = Intelligence, Δ = Change score.

* $p < .05$; ** $p < .01$; *** $p < .001$.

[a] Adjusted for gender, education, self-rated and physician-rated health.

[b] Unstandardized paths set equal between cohorts.

[c] Model was estimable only with residuals of the indicators Similarities T1 and Similarities T3 constrained as unrelated.

Table 4.4

Publication 3: Effects of the Covariates on the Change Scores of the Personality Traits and Cognitive Abilities (For Each Cohort Separately)

Personality Domain	Cognitive Domain	Δ Personality LL/ML				Δ Cognition LL/ML			
		Gender	Education	Subj. health	Physician-rated health	Gender	Education	Subj. health	Physician-rated health
Neuroticism	Speed	.015/.105	-.052/-.159***	-.085/.083	.059/.144*	-.001/.082	-.041/-.040	-.072/-.049	-.277**/-.055
	Cryst. Intelligence	-.117/.065	-.059/-.132***	-.076/.062	.165/.127*	.122/-.064	.022/.057	-.005/-.133	-.114/.305**
	Fluid Intelligence	-.116/.046	-.051/-.115**	-.075/.059	.133/.123	-.002/-.122	-.048/-.016	-.170/.002	-.255*/.036
Extraversion	Speed	-.034/-.073	-.014/.029	.160/-.039	-.267*/-.047	.019/.107	-.060/-.050	-.064/-.040	-.264**/-.053
	Cryst. Intelligence	.066/-.015	-.045/.011	.174/-.021	-.292**/-.042	.123/-.046	.015/.057	.001/-.135	-.106/-.301**
	Fluid Intelligence	.042/-.023	-.038/.012	.164/-.029	-.271**/-.042	.017/-.085	-.074/-.038	-.140/.034	-.248*/.034

Table 4.4 – *Continued*

Personality Domain	Cognitive Domain	Δ Personality LL/ML				Δ Cognition LL/ML			
		Gender	Education	Subj. health	Physician-rated health	Gender	Education	Subj. health	Physician-rated health
Openness	Speed	.160/.048	-.015/.000	-.362***/.115	.264*/-.158*	.025/.109	-.068/-.067	-.054/-.020	-.258**/-.047
	Cryst. Intelligence	.321**/.134	-.065/-.014	-.341**/.120	.218*/.146	.068/-.109	.019/.004	.016/-.067	-.105/-.330***
	Fluid Intelligence	.267**/.136	-.052/-.028	-.338***/.119	.247*/-.137	.012/-.099	-.085/-.078	-.119/.083	-.245*/-.047
Agree-ableness	Speed	.314**/-.070	.044/.142***	-.080/-.014	-.026/-.174*	-.023/.148	-.071/-.048	-.052/-.082	-.239**/-.031
	Cryst. Intelligence	.289**/-.105	.072/.126**	-.103/-.008	-.050/-.157	.152/-.016	.010/.053	.012/-.161	-.113/.317***
	Fluid Intelligence	.309**/-.095	.061/.123*	-.090/.001	-.058/-.158	.066/-.017	-.059/-.032	-.147/-.051	-.274*/.074
Conscien-tiousness	Speed	.082/.091	.053/.045	-.139/-.114	-.008/-.027	-.018/.123	-.034/-.026	-.057/-.048	-.304**/-.087
	Cryst. Intelligence	.105/.105	.056/.021	-.142/-.090	-.027/-.021	.079/-.084	.034/.073	.016/-.166	-.141/.315***
	Fluid Intelligence	.088/.085	.070/.036	-.148/-.105	-.042/-.024	-.001/-.088	-.059/-.037	-.138/.018	-.269*/.043

Note. LL = Late-Life Cohort born 1930/32, ML = Midlife Cohort born 1950/52, Cryst. = crystallized, Δ = Change score.

* *p* < .05; ** *p* < .01; *** *p* < .001.

Table 4.5

Publication 3: Overview of Squared Multiple Correlations for the Latent Change Scores of the Personality Traits and Cognitive Domains

Person-ality Domain	Cognitive Domain	SMC Δ Personality (Adjusted Model [a])	SMC Δ Personality (Unadjusted Model)	SMC Δ Cognition (Adjusted Model [a])	SMC Δ Cognition (Unadjusted Model)
		LL/ML	LL/ML	LL/ML	LL/ML
Neuro-ticism	Speed	.317/.153	.244/.101	.100/.089	.012/.013
	Cryst. Intelligence	.157/.169	.195/.122	.044/.200	.019/.050
	Fluid Intelligence	.190/.190	.195/.138	.125/.076	.000/.078
Extra-version	Speed	.145/.148	.112/.153	.098/.095	.007/.014
	Cryst. Intelligence	.146/.156	.052/.161	.043/.191	.014/.033
	Fluid Intelligence	.145/.153	.044/.158	.117/.071	.005/.107
Openness	Speed	.206/.080	.136/.059	.093/.088	.013/.010
	Cryst. Intelligence	.210/.098	.058/.062	.098/.381	.080/.253
	Fluid Intelligence	.226/.095	.087/.064	.119/.123	.009/.132
Agree-ableness	Speed	.196/.159	.065/.090	.126/.112	.010/.012
	Cryst. Intelligence	.186/.129	.066/.091	.049/.211	.030/.077
	Fluid Intelligence	.182/.127	.060/.088	.169/.131	.021/.162
Conscien-tiousness	Speed	.116/.172	.192/.214	.109/.132	.009/.060
	Cryst. Intelligence	.109/.155	.075/.133	.079/.298	.069/.155
	Fluid Intelligence	.110/.158	.076/.134	.125/.082	.003/.085

Note. LL = Late-Life Cohort born 1930/32, ML = Midlife Cohort born 1950/52, Δ = Change score, SMC = Squared multiple correlation.

[a] Adjusted for gender, education, self-rated and physician-rated health.
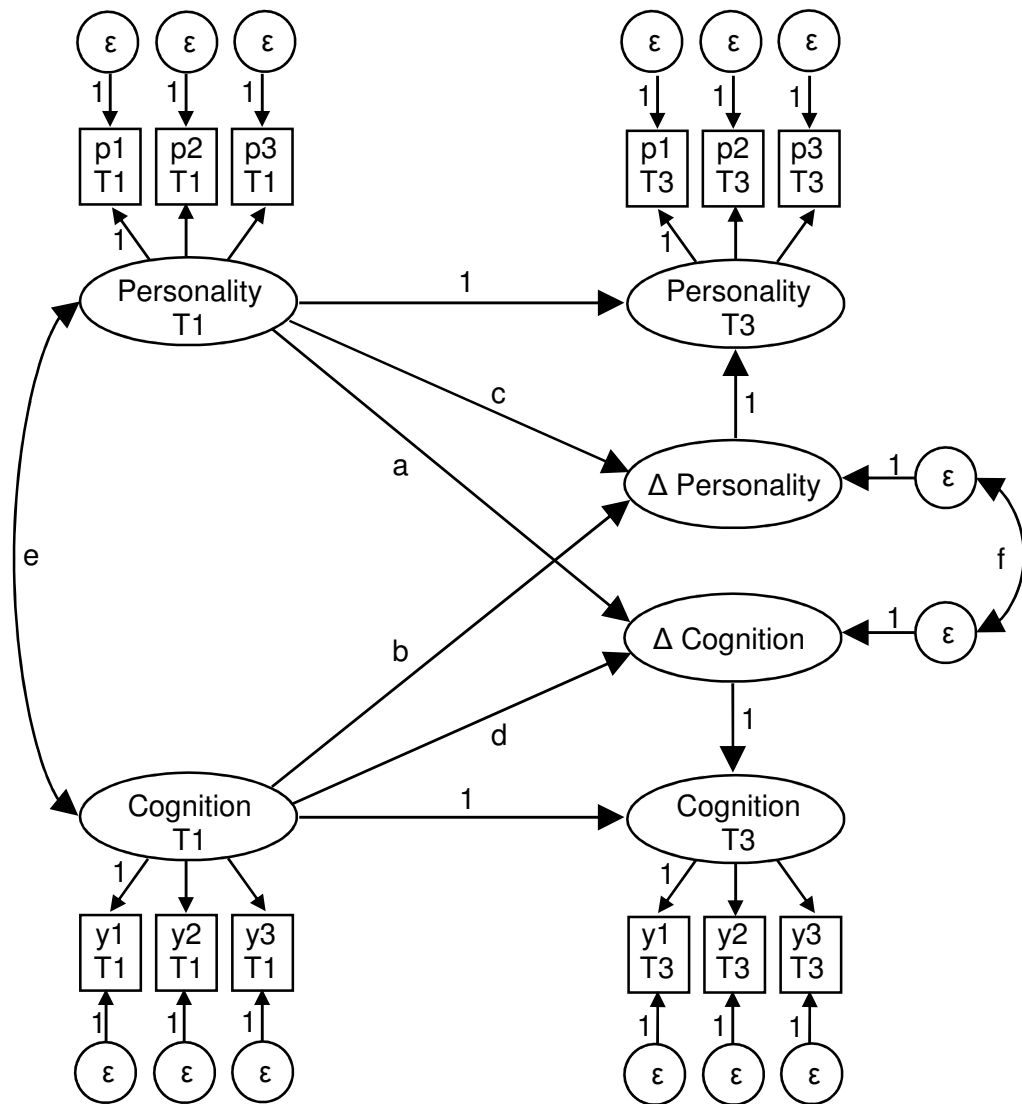
Figure 4.1. Illustration of a bi-variate latent change regression model of one personality trait and one cognitive ability domain at two measurement occasions.

Note. T1 = baseline measurement occasion, T3 = 3rd measurement occasion, p = parcel, Δ = latent change variable, ε = error term, a/b = intervariable cross-lagged parameter, c/d = auto-proportion parameter, e = personality-cognition correlation at baseline, f = correlation of change score residuals.

Chapter 5: General Discussion

The overarching goal of this dissertation has been to add long-term evidence to the growing body of psychological research on personality development across adulthood. For this reason, the predictor dynamics of personality were investigated. Specifically, how personality predicts and is predicted by important and impactful constructs of different psychological life domains (i.e. life satisfaction, subjective/objective health, cognitive abilities) was analyzed. This work, when compared to current research on personality development across the life span, uniquely features investigations that all (1) are based on the same data set (ILSE, Sattler et al., 2015), (2) amount up to 12 years of longitudinal research interval (long-term), (3) focus on mutual cross predictor dynamics of the Big Five personality factors (Costa & McCrae, 1992a, 1992b), and (4) investigate this predictor dynamics more precisely in explicitly comparing the dynamics in mid adulthood and old age with each other. With the previous presentation of the manuscripts, the below section condenses the findings, addressing the combined strengths and weaknesses of the research practice, outlines possible future research directions and evaluates its impact for practitioners.

Main Findings

The discussion of main findings is organized in four sections. First, the results of cross-sectional correlations are presented to give a general estimation on the relationship patterns across measurement times. Second, the results regarding longitudinal stability are considered. Third, the main findings, namely the cross-predictions and intervariable cross-lagged predictions are discussed and, fourth and lastly, the results regarding the age group differentiation are critically examined.

Results of cross-sectional correlations of personality with domains of individual functioning. In line with previous meta-analyses (DeNeve & Cooper, 1998; Steel et al., 2008), life satisfaction and personality demonstrated mild-to-moderate cross-sectional correlations in both cohorts at baseline, 4-years, and 12-years later. Both subjective and objective health surprisingly revealed only small correlations at baseline and 12-years later with the Big Five personality traits. These relations, moreover, were of equal magnitude, despite previous research indicating that especially neuroticism and conscientiousness are most closely related to individuals' health (Reiss, Eccles, & Nielsen, 2014; Shanahan, Hill, Roberts, Eccles, & Friedman, 2014; Sutin et al., 2013). More importantly, the correlations lost statistical significance and their respective standardized path coefficients values were substantially reduced when control variables were added into the analyses, highlighting the importance and impact of the covariates of depression and cognitive abilities in particular. Previous research on the cognition and personality interplay indicates that there are small-to-moderate relationships between these domains with openness and conscientiousness being the closest related to cognitive abilities (Schaie, Willis, & Caskie, 2004; Soubelet & Salthouse, 2011; von Stumm & Ackerman, 2013; Ackerman & Heggestad, 1997; DeYoung, 2014; DeYoung, Peterson, & Higgins, 2005; Curtis, Windsor, & Soubelet, 2015). The analyses in manuscript 3 show small-to-moderate cross-sectional relationships of openness and neuroticism with the different cognitive abilities. Even though the relations with openness were replicated, the expected cross-sectional-relationships with the other personality traits, except neuroticism, were not. It was especially surprising that conscientiousness showed almost no cross-sectional correlations with cognitive abilities like other studies suggest (e.g., Curtis, Windsor, & Soubelet, 2015).

Results regarding longitudinal stability of personality and domains of individual functioning. In the light of the discussion whether personality changes or remains stable across the life span (chapter 1; e.g. McCrae & Costa, 2003; Specht et al., 2014), the results of the present studies add to the view that personality development across adulthood is a coupled process of stability that goes hand in hand with small-in-magnitude but remarkable changes (Mroczek & Spiro, III., 2003; Ryff, Kwan, & Singer, 2001). The present analyses in manuscripts 1-2 indicate moderate-to-high rank-order stability coefficients of all five personality traits of the Big Five across 12 years in mid and in late adulthood alike. Taken together, it is acknowledged that personality development in mid adulthood and early old age as brought forward by the ILSE-Study (Sattler et al., 2015) is generally in line with current key empirical investigations and meta-analytic compilations on life span personality development (e.g., Roberts & Del Vecchio, 2000; Specht et al., 2011) regarding rank order consistency and mean value development. Considering the three domains of individual functioning, stability coefficients across 12 years were lower as compared to the stability coefficients of the personality traits, but still of considerable magnitude. Life satisfaction showed small-to-moderate, health moderate and cognitive functioning almost equally high, stability when compared to the personality factors.

Results of longitudinal cross predictions and inter-variable cross-lagged predictions. Main research interest in all three manuscripts are the longitudinal predictions of personality to subsequent domains of individual functioning and vice versa. Despite prior research by Specht et al. (2013) and Soto (2015), who found meaningful effects of well-being for personality later in life, life satisfaction in manuscript 1 indicated only very small effects of limited practical value for later life

personality (i.e. neuroticism, extraversion) regardless of the study interval. Personality, on the other hand, showed small and significant predictions for 4-year later life satisfaction in both cohorts. Across 12-years, only in the younger cohort and only neuroticism was predictive for subsequent life satisfaction. All in all, the analyses in manuscript 1 indicate life satisfaction to be less of a predictor of personality than a developmental outcome of personality development.

The analyses in manuscript 2 indicate that the longitudinal interrelationship of personality and health is indeed reciprocal in nature. It is important to state that the effects found are rather small. On the other hand, observed effects should be seen in the light of the long observational interval spanning an interval of up to 12-years. Moreover, the found results might underestimate the true longitudinal relationships, because the cross-paths in this analyses might be, due to the use of manifest modeling only, contaminated by measurement error (Allemand et al., 2007).

Despite this critique, the results suggest a couple of promising perspectives. First, physician-rated health apparently challenges personality stability stronger than self-rated health, while self-rated health is more strongly indicated to be longitudinally shaped by prior personality traits. Second, observed effects highly depend on the specific personality factor and health domain considered. In particular, the physician-based "objective" health rating was predictive only for later life neuroticism, agreeableness and extraversion (the latter only in the model without covariate control). Subjective health predicts later life conscientiousness, but only in the uncontrolled model. Regarding the opposing paths from personality to health, neuroticism (only uncontrolled model), extraversion and conscientiousness predicted later life subjective health. Moreover, openness and conscientiousness (but both only in the uncontrolled model) predicted later life physician rated health. Third, as to be

expected, the consideration of relevant control variables weakened the cross-lagged effects, which was especially true for depression. This is not a surprising finding, because both the subjective and the objective health measures are closely related to depressive symptoms on a conceptual as well as the empirical level (e.g. Moussavi, Chatterji, Verdes, Tandon, Patel, & Ustun, 2007; Matthews et al., 2009; World Health Organization, 1992). Taken together, although longitudinal results support the assumption that personality and subjective as well as objective health are reciprocally interrelated, a highly differentially framed interpretation is needed to do justice to the data.

The analyses in manuscript 3, demonstrated mild to moderate effects for all three cognitive domains (speed, crystallized intelligence, fluid intelligence) as 12-year longitudinal predictors for change in neuroticism, extraversion and openness. Only the cross-relationship of speed to neuroticism change was not predictive in the mid adulthood cohort. These findings are in line with recent research with regard to neuroticism and openness (e.g. Waggel et al., 2015; Wettstein et al.; 2016, von Stumm & Deary, 2013). The cognitive domains failed to predict agreeableness and conscientiousness changes in the present analyses, which is in line with previous research regarding agreeableness (Ackerman & Heggestad, 1997; Curtis et al., 2015), but in contrast to findings by Mõttus et al. (2012). Considering the path from personality to changes in cognitive ability, there were no intervariable cross-lagged predictions for neuroticism and extraversion, which is in line with previous findings (e.g. Salthouse, 2014). However, openness and conscientiousness were predictive for changes in crystallized intelligence; furthermore, the path coefficients of both of these personality factors also suggest a predictive role regarding other cognitive domain changes. Agreeableness, on the other hand, showed a somewhat surprising

pattern in that it was, as expected, positively related to changes in processing speed, but only in the old cohort; but it was negatively related to changes in fluid intelligence in both cohorts. The negative relation may be explainable in the light of Baker and Bichsel (2006)'s reasoning stating that high agreeableness might precede decline in fluid abilities due to being an adaptive coping strategy for cognitive decline by activating social resources as compensation. Taken together, manuscript 3 supports the view that the relationship of personality and cognition is to some extent reciprocal, but that such reciprocity highly depends on the specific factor and domain considered (e.g., Ackerman & Heggestad, 1997; Baker & Bichsel, 2006; Soubelet & Salthouse, 2011). Moreover, the intervariable cross-lagged predictions were clearly higher in number and overall more consistent from cognitive functioning to 12-year personality change than vice versa.

In summary, the three manuscripts indicate significant and mostly meaningfully interpretable reciprocal intervariable cross-lagged predictions of the Big Five personality factors and the domains of health (subjective/objective) and cognitive abilities. Especially in the domain of cognitive abilities but also in the health domain were demonstrated rather strong cross-predictions for personality change across the 12-year observational period. In some contrast, life satisfaction as an indicator for long-term (12-years) personality changes appeared to be nearly negligible. Therefore, it may be concluded that life satisfaction works less as a change initiating entity, but should better be looked at as a developmental outcome.

Results regarding the need to differentiate between mid adulthood and old age. Another goal of the present manuscripts was to examine the role of developmental phase (midlife versus old age) for observed predictor dynamics by utilizing multi-group analyses based on the two ILSE cohorts. This should be seen

against the background that previous research has not seriously addressed this issue so far. A number of reasons have been brought forward to support the overall assumption that predictor / cross-lagged effects might be stronger in the old age realm.

However, results of all three manuscripts tell another story. Overall, there were almost no meaningful differences between the cross predictor paths regarding the life phase differentiation with only limited need for further specification. In manuscript 3, processing speed was demonstrated to be a significant and notable predictor for later neuroticism changes in the older cohort only, while processing speed significantly predicted changes in agreeableness in the midlife cohort only. The almost complete absence of age effects was unexpected, because prior investigations lend emerging data to the assumption that age may be a moderating factor (e.g. Baker & Bichsel, 2006; Graham & Lachman, 2014). One possible explanation could be that assumed differences might unfold when comparing mid adulthood with very old age, rather than with old age, only. This issue is further discussed in the section on future research needs. Nonetheless, the research of the present manuscripts, as it stands, support that the two age cohorts are more alike than different, highlighting the overarching importance of health and cognitive ability for personality change across all of adulthood.

Strengths and limitations

The present study is based on data from the "Interdisciplinary Longitudinal Study of Adult Development (ILSE)" (Sattler et al., 2015). Besides all its strengths exploited in the 3 papers, ILSE comes with a number of limitations regarding the data analyses conducted in the present manuscripts.

First, regarding ILSE's strengths, the German long-term longitudinal cohort study covers a research interval of up-to 12-years. The specific cohort design of the ILSE enabled the investigation and comparison of the two specific age cohorts of mid adulthood and old age. Its intense multidisciplinary data gathering and large bandwidth of different psychological and medical constructs at each measurement time allowed for a broad theory-driven selection of constructs as well as control variables. The ILSE sample amounted to 1002 participants at baseline and retention rate at the third measurement occasion was still high with 789 participants (retention rate = 78.74%). Furthermore, participants at T3 still distributed nearly equally across age cohorts, gender, and center (Heidelberg, Leipzig) and thus a key design criterion of the study was maintained across 12 years. In relation to the requirements of data analyses, the given sample size allowed for the reliable detection of strong, moderate, and even small effects. Indeed, some very small effects were detected as significant, like for example, the effects targeting the health with personality linkage. It needs to be acknowledged, however, that this should not lead to devaluation of the results at large. Even very small effects might accumulate over time (e.g., Soto, 2015) and initiate larger-scale changes that might be visible only many years later, thus being of importance for the understanding of long-term developmental trajectories.

Although far from unusual in longitudinal research, data analyses were bound to existing time distances of measurement time points which may or may not fit to important developmental phases in participants' life history. While acknowledging that 12-years of cross-development is a very long time span, one can assume that the development initiating changes might have happened before, in between or even after the rather distant measurement time points used in ILSE. In other words, the

present analyses are, despite their longitudinal nature, a selective snapshot of "real" life span development and the underlying assumption of steady, long-term change processes is subject to debate.

Linked with this reasoning, the impacts of specific critical life events on personality trajectories is assessed in numerous studies (e.g. Hutteman, et al., 2014; Jackson, Thoemmes, Jonkmann, Lüdtke, & Trautwein, 2012; Lüdtke, Roberts, Trautwein, & Nagy, 2011; Specht, Egloff, & Schmukle, 2011; Zimmermann & Neyer, 2013). Although this approach is promising, it has its own limitations (Luhmann, Orth, Specht, Kandler, & Lucas, 2014). For instance, the precise definition of a critical life event is problematic and may lead to hard to justify inclusion or exclusion decisions. Changes can be perceived as slow and steady or even as continuous, and some changes might arise without the occurrence of a specific event at all. For example, a mental sickness like depression might occur gradually through the stepwise experience of more and more depressive symptoms and, more importantly, lacking a specific event like the date of diagnosis or a specific time period in hospital that might qualify it as a distinct critical life event. Therefore, instead of investigating the influences of certain specific life events, the present manuscripts targeted the predictability of personality development by three major life domains of adult development that all represent various dimensions of individual functioning.

Going further, the ILSE sample suffers together with most other longitudinal studies from positive selection bias, systematic study dropout, and not "missing-at-random" missing data patterns (Walsh & Nash, 1978; Jerant, Chapman, Duberstein, & Franks, 2009). On the positive side, ILSE's drop-out/attrition rate across 12 years is below what one would expect based on other longitudinal studies (Sattler et al., 2015). Therefore, sample selectivity which reduces inter-individual variability in the

target variables which may lead to the underestimation of "true" cross-lagged relationships is likely acceptable in ILSE.

Considering the measures used in the current research, mostly established devices have been included. Personality was assessed by the NEO-FFI inventory (Costa & McCrae, 1992b), which is widely recognized as an excellent, state-of-the-art personality questionnaire proving good internal consistency and temporal reliability as well as robust and valid measuring of the Big Five personality factors (e.g., Murray, Rawlings, Allen, & Trinder, 2003; Lang & Lüdtke, 2005). It should be noted that there are personality conceptualizations beyond the Big Five architecture, but in line with a large part of the current personality research community the Big Five is the most influential and best established framework (e.g. Matthews et al., 2009). The measurement of life satisfaction and subjective health was conducted based on established single-item measures. Despite the classic critique of limited reliability due to their non-scale character, single-item measures of self-rated health and life satisfaction are commonly used, exhibit meaningful correlates with objective health parameters and demonstrate sufficient validity as well as variability (DeSalvo et al., 2006; Idler & Benyamini, 1997; Pinquart, 2001). Single-item measurements of life satisfaction prove good longitudinal convergent validity and moderate-to-good discriminant validity (Lucas, Diener, & Suh, 1996). Furthermore, they exhibit at least acceptable reliability (Lucas & Donnellan, 2012). In summary, the general critique on single-item measurements remains an issue of the data analyses of the present manuscripts, but there are also arguments in the literature strengthening the used models. The variable of objective health was based on a set of components containing key medical and gero-psychiatric assessments. Concretely, the rating consisted of an anamnesis, a gero-psychiatric assessment, a blood analysis and a

medical check-up, which were conducted by trained study geriatricians. All these elements were then condensed based on a spelled-out coding scheme into one 6-point global rating (Miche et al., 2014). Thus, the Likert scaled categories were explicitly circumscribed to make the ratings as reliable and objective as possible. Note that utilizing information of various different sources and condensing them into one single scale is a strength and weakness at the same time. This procedure provides a broad construct that is more valid than relying on a single indicator; at the same time an interpretation going beyond a global notion is not possible. Nevertheless, having a high quality proxy for objective health is clearly more than most other longitudinal studies—typically solely relying on self-ratings or disease lists—have.

Further, the papers of this dissertation did not only contain self- and professional ratings, but also internationally established reliable, valid, and objective testing procedures of a broad range of cognitive abilities. Based on a prior empirically done dimensionality by Zimprich and colleagues (e.g. Zimprich, Allemand, & Dellenbach, 2009; Zimprich & Mascherek, 2010) as well as additional factor analyses by the author, the papers build on three fundamental cognitive domains, namely information processing speed, crystalline and fluid intelligence, each measured by several well-established markers.

In terms of co-variates included, the assessment of depressive symptoms by the scale suggested by Zung (SDS; Zung, 1965) is worth mentioning. Depression is an important control variable considering the second manuscript, but, unfortunately, the SDS showed only weak internal consistency in ILSE data space. Therefore, it is highly recommended to replicate the present findings and include a depression measure with better psychometric properties. Generally spoken, measuring

constructs exclusively by self-report questionnaires may indeed be regarded as a problem, because answers are influenced by individuals' possibly biased self-perception as well as by social desirability. Therefore, results might only to some extent capture the "true" score on a specific item. To counteract this challenge, participants of the ILSE were, prior to filling out their questionnaires, carefully reminded of the anonymous nature of analyses and evaluations. Moreover, participants were instructed to take their time and stay as true to themselves as possible while answering. Despite this effort, analyses should be replicated and enhanced using different measurement approaches in the spirit of a multi-method approach (Campbell & Fiske, 1959).

Statistical modeling was conducted following the work of McArdle (2009). Manuscripts 1 and 2 utilize multi-group dual cross-lagged autoregressive models with two measurement times, while manuscript 3 utilizes multi-group dual latent change regression models at two measurement points with cross-change predictions. Overall, the models suit the needed statistical complexity to answer the research questions of the present manuscripts and are straight-forward regarding interpretation of results. The conceptualization as multi-group models adequately offered the possibility to differentiate the cohorts from another and to precondition measurement invariance across the groups. There are two major critical issues that need to be addressed. First, the models used in manuscript 1 partly, and the models used in manuscript 2 completely, abstained from using latent modeling to control for measurement error contamination in the cross-predictor paths (e.g. Allemand et al., 2007). Caution is recommended until future research replicates the findings using latent constructs for well-being and subjective as well as objective health. Second, the present statistical analyses are incapable of detecting non-linear trends, because

only two measurement times were implemented into each model. Theoretically, the interrelationships of personality with life satisfaction, health or cognition could be quadratic, cubic, or even more complex.

Another critical point worth mentioning is the present study's sole focus on normal aging. Pathological processes might, indeed, reveal stronger and practically more important effects with personality development. The rationale behind the present investigations was to find long-term predictors in the ordinary population. This rationale was based on a practical and a theoretical reason. Practically, a comparison of the two cohorts with the focus on pathological processes and their influence on personality development was discarded because the sample would have been restricted by the low prevalence rates of cognitive disability in the younger cohort, limiting means of statistical analyses. Theoretically, a selection on pathological processes was not intended, because it was desired to investigate normal aging processes.

In summary and despite the critiques and methical issues raised, ILSE provided a well-fitting data set for treating the research questions of this dissertation in terms of its specific cohort design and richness in available measures.

Future directions in research on personality development across adulthood

Although substantial longitudinal research based on state-of-the-art data-analytic tools have substantially increased in recent years, personality development across adulthood and its inter-systemic relations to other domains (health, cognition, social relations, emotions) is still far from being understood. This section discusses future research needs and directions on two levels: (1) It targets issues directly derived from the present analyses to replicate and strengthen the results, and (2) it

addresses more general future research needs in the field of personality development across adulthood at large.

As mentioned before, modeling in all analyses was restricted to two measurement occasions per model only, because the models suite the needed statistical complexity to answer the research questions and promote straight-forward interpretation of results. As Kenny (2005) and Johnson et al. (2012) argue, two assessments have their limits to properly investigate developmental patterns and processes. A study having more measurement occasions at its disposal would allow investigation of not only non-linear trends (as argued by Crowe et al., 2006), but also capture the underlying developmental dynamics in more depth. Additionally, the present analyses focused on long term predictor dynamics and investigated change across 12 years, but, nonetheless, personality change might unfold even across far longer time intervals than covered in the present analyses. Taken together, more measurement points would be needed to improve knowledge in life span developmental research on personality development. It is important to keep in mind that more research design complexity would also call for still more sophisticated modeling, which is, arguably, a double-edged sword, because psychological models of development try to fulfill two requirements at the same time, namely: (1) to describe as precisely as possible, and (2) to simplify the developmental processes to ease understanding and practical application. The models chosen in the present analyses were of limited complexity although state-of-the-art approaches, allowing a high degree of straightforwardness in their interpretation.

To strengthen and replicate the results of this dissertation, future research should add more age groups to the research plan and analyses. Two age groups might, in analogy to the discussion on the sole use of two measurement points, not

be sufficient to capture the "true" age differences in the longitudinal dynamics of personality and the predictor domains. The present analyses did, as mentioned before, and very surprisingly, only detect very limited age group differences in the predictor paths, which could be explained as follows. First, it is questionable whether a mid adulthood sample was compared to a true old age sample in terms of the theoretical conceptions presented in chapter 1. The present analyses might have compared mid agers with young-olds, rather than with old-olds. This is crucial, because the categorization of individuals by age is not fixed, but socially defined. Differentiations by age are changing as a consequence of demographic and cultural change and issues of health and frailty that would have been important considering individuals aged 65 and older might be challenged by progress in healthcare and longevity, ultimately shifting the age group conceptualizations. Today's 80s might in fact be yesterday's 60s. Second, the age groups could be more similar than theoretically presumed, meaning that the theoretical considerations highlighting age group differences do overestimate the true empirical variation between mid adulthood and old age. It is possible that the investigated processes are indeed independent from, rather than susceptible to, age group effects. For these reasons, future studies on more than two age groups or investigations featuring even longer time intervals are needed to replicate the results and clarify theoretical reflections on age group differences.

In summary, future research on personality development across the adult life span is a vivid field: We are now beginning to understand confounding variables and conditions regarding longitudinal predictor dynamics of personality traits with different domains of individual functioning. The present analyses do indeed stress the importance of health and cognitive abilities for changes in personality. Moving

forward, future research endeavors should replicate and solidify the importance of health and cognitive abilities, as well as of other important confounding variables as predictors of personality change. Specifically, the use of time varying covariates and change-susceptible predictors might offer new and important insights. The second important and promising research direction following the present analyzes would be to investigate the age group differences more precisely. It is unclear why there were no significant differences in the cross-predictor paths or intervariable cross-lagged predictions between the two groups despite strong theoretical assumptions to the contrary. The integration of more than two different age groups, specifically integrating very old participants (i.e. aged 80 years and older), and different modeling approaches (e.g. growth curve modeling; Curran, Obeidat, & Losardo, 2010; McArdle, 2009) seems promising. Third and last, the mechanisms driving longitudinal predictor dynamics between personality traits and the domains of individual functioning need to be identified. Promising candidates that might influence the relationship are health behaviors, coping strategies, stress, sensory impairment, environmental enrichment factors, and more (e.g. Booth-Kewley & Vickers, 1994; Gunthert, Cohen, & Armeli, 1999; Neupert et al., 2008; Gaynes et al., 2013; Wettstein et al. 2016; Ziegler et al., 2015; Ziegler et al., 2012).

Emerging practical implications

The present work promotes the individual's ability to proactively change the one's self for the better, acknowledging that individuals are active agents of their lives (e.g. McAdams & Olson, 2010). Admittedly, the change processes described in the present manuscripts are very difficult to effect, because of their long-term oriented nature, but the optimization of developmental conditions might one small single step

at a time alter one's personality to be better suited facing challenges of old age. There is first promising evidence for interventions to change personality trait configuration to the better, i.e. increases in neuroticism and decreases in extraversion and openness (Chapman, Hampson, & Clarkin, 2014; Magidson, Roberts, Collado-Rodriguez, & Lejuez, 2014), and, as the present work demonstrates, health and cognitive abilities are important influencing factors. Health changes and changes in cognitive abilities might indicate that adaptive personality development in old age is in jeopardy, which could be used by health care practitioners to assess the need for special support, especially when individuals begin to suffer from severe health conditions or chronic diseases.

People in general long for optimal, so-called "successful", aging (Rowe & Kahn, 1997; Wahl, Siebert, & Tauber, 2015), which is a well-established and often taught model in applied medical practice regarding old age. Being "successfully aging" theoretically means that an individual is (1) healthy, (2) cognitively and physically functioning and (3) actively engaged in life. Having a positive and adaptive personality configuration is one important, additional tile in the puzzle of achieving high life satisfaction and quality of life in old age (e.g. Charles et al., 2001; Isaacowitz & Smith, 2003; Mroczek & Spiro, III., 2005). Therefore, the results of the present investigations underline the importance of incorporating personality traits in models of aging applied by practitioners, especially when optimal trajectories are desired.

Taken together, the present analyses inform physicians and health care practitioners of the importance of personality in health care and their daily practice. Future medical and developmental concepts are recommended to incorporate personality more prominently.

Overall conclusion

It is well established that personality develops throughout the lifespan, but less is known about the sources, opportunities and constraints of personality development, specifically when it comes to adulthood. Much needed long-term research in this important area of life-span developmental and aging psychology is still scarce. The present dissertation added a set of new empirical results to this field that help to better understand long-term personality change as well as to better frame future research priorities. In particular, health and cognitive abilities were successfully detected as relevant predictors for 12-year longitudinal personality development. Moreover, the results were nearly independent from effects of age group (midlife, old age), suggesting that the "wiredness" of personality with well-being, health, and cognitive function may be more stable than previously assumed in the conceptually driven life-span developmental literature. Lastly, the current work clearly supports the need for a highly differential approach regarding the personality traits considered, indicating that future research should put much emphasis on better understanding of the potentially different role of established personality subdomains.

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List of Abbreviations

ApoE   Apolipoprotein E

BRD   Federal Republic of Germany

CFI   Comparative Fit Index

DDR   German Democratic Republic

ILSE   Interdisciplinary Longitudinal Study on Adult Development and Aging

NAR   Network Aging Research (Institution in Heidelberg)

RMSEA   Root Mean Squared Error of Approximation

SAVI   Strength and Vulnerability Model

SDS   Self-rated depression scale by Zung

SRMR   Standardized Root Mean Squared Residual

WAIS-R   Wechsler Adult Intelligence Scale – Revised

WWII   The second World War

Description of Personal Contribution for the Publications of this Thesis

I. Publication

Tauber, B., Wahl, H.-W., & Schröder, J. (2016). Personality and life satisfaction over 12 years: Contrasting mid- and late life. *GeroPsych: The Journal of Gerontopsychology and Geriatric Psychiatry*, *29*, 37-48. doi:10.1024/1662-9647/a000141

B. Tauber conducted the data analyzes and wrote the article.

II. Publication

Wettstein*, M., **Tauber*, B.**, Wahl, H.-W., & Frankenberg, C. (2017). 12-Year associations of health with personality in the second half of life – Being versus feeling healthy. *GeroPsych: The Journal of Gerontopsychology and Geriatric Psychiatry, 30*, 5-17. doi:10.1024/1662-9647/a000162

B. Tauber, together with Dr. M. Wettstein, conducted the data analyzes and wrote the article. Please note that both authors had equal share on their contribution to this manuscript and should be considered *co-first-authors*.

III. Publication

Wettstein, M., **Tauber, B.**, Kuźma, E., & Wahl, H.-W. (2017). The interplay between personality and cognitive ability across 12 years in middle and late adulthood: Evidence for reciprocal associations. *Psychology and Aging*. Advance online publication. doi:http://dx.doi.org/10.1037/pag0000166

B. Tauber, together with Dr. M. Wettstein, conducted the data analyzes. B. Tauber contributed to the article by writing the methods section, statistical analyses and results section. Furthermore, B. Tauber compiled the tables and figures, helped writing the theory and discussion section and was strongly involved in the revision of the article.

Acknowledgments

professionality, as well as her light and single hearted personality brightened my days and kept me on track.

Further and very sincere thanks are addressed at the co-authors of the different publications included in this dissertation. Particularly the cooperative work with Dr. Markus Wettstein was especially pleasant, joyful, motivating and productive. I profited enormously from his industriousness, idea generation skills and theoretical knowledge in the field. Thanks are also directed to Ela Kúzma for her critical input on the cognition-personality manuscript.

Moreover, I want to thank my working group, i.e. the Department of Psychological Aging Research of Heidelberg University of the years 2013-2016. To make a long story short, all of you do great work and are lovely colleagues and I am proud of having been one of you. Special thanks to Anja Schilling, our secretary, for all her help and advice regarding organization of work and life.

Additionally, I thank my colleagues of the Section of Personality Research of Heidelberg University (2013-2016). Anna-Lena Schubert and Gidon Frischkorn always provided me with a place to stay when I travelled to the main part of the Psychological Institute. I profoundly thank you for your help, motivation and every shared laugh. Further thanks go to Andreas Neubauer and Amanda Bligh, who helped me immensely by proofreading the manuscript in cooperation with previously named Anna-Lena Schubert, thank you. Moreover, I thank all thus far unnamed colleagues of the Psychological Institute I had the honor of working with.

Deep and wholehearted thanks are addressed at my family, in particular to my parents, Sylvia and Harald Tauber, and my elder brother Tobias Tauber. Thank you for all your support and encouragement throughout all these years, especially in the bleak times. I address special thanks to my partner, Lea Fuchs, who supported me throughout all this time. You calmed me in times of trouble and motivated me to keep working. I took a lot of strength from your love to face the daily challenges.

Lastly, I want to give a shout-out to all my friends in and out of the region of Heidelberg. Despite not being named in this text, I am grateful to have such lively, nice, helpful and motivational friends. Thanks for having me in your lives.

Declaration in accordance to § 8 (1) c) and d) of the doctoral degree regulation

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