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Personality change profiles and changes in cognition among middle-aged and older adults

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ABSTRACT

Research on the relationship between personality traits and cognitive abilities has primarily used cross-sectional designs and considered personality traits individually in relation to cognitive dimensions. This study ($N = 2652$) examined the relationship between Big Five personality change profiles and change in cognitive factors, episodic memory and executive functioning. Latent profile analysis was used to capture patterns of change across the Big Five traits. Three profiles of personality change were defined: *Decreasers*, *Maintainers,* and *Increasers*. The *Decreasers* declined more in episodic memory compared to the *Increasers* and *Maintainers*. Also, the *Decreasers* declined more in executive functioning compared to the *Increasers,* but not the *Maintainers*. The findings advance our understanding of the links between patterns of personality change and cognitive aging.

1. Introduction

There is long history of research on personality and cognition, which are two key constructs in the study of individual differences across the lifespan (Baltes, 1987; Cattell, 1971). Although these constructs are often examined in separate literatures, a growing body of research indicates that personality traits and cognitive abilities are related (Graham & Lachman, 2014; Stephan et al., 2020; Sutin et al., 2019) and these associations have been examined across the full lifespan. In the context of childhood and early adulthood, this work has primarily focused on how personality traits or motivation affect school performance or achievement (Sorić et al., 2017). In the context of midlife and old age, the focus has been on whether personality traits are related to differential changes in cognition or the onset of dementia (Terracciano et al., 2014; Terracciano et al., 2017). However, much of this previous work has relied on individual differences in personality traits as antecedents and less work has looked at whether personality *changes* contribute to differences in cognitive change. In part, this is due to long-standing assumptions about the stability of personality traits. Given more recent evidence of personality changes across the entire lifespan into old age (Graham et al., 2020; Roberts & Mroczek, 2008), there is increased interest in exploring *changes* in personality traits as an antecedent of changes in health and behaviors (Stieger et al., 2020). Of particular interest is whether personality changes contribute to differences in the nature and extent of cognitive aging. Yet, much of the previous work linking personality and cognition has been correlational and cross-sectional (e.g., Graham & Lachman, 2014), examined change in only one of the constructs (Luchetti et al., 2016), or focused on individual Big Five traits and their effect on cognitive changes (Stephan et al., 2020; Stephan et al., 2021). The goal of the present study was to take a more holistic approach to consider the combined effects of multiple personality traits on changes in cognitive performance. We did this by identifying personality change profiles using a person-centered approach to focus on the organization of personality trait change within a person (cf. Robins, John, Caspi, Moffitt, & Stouthamer-Loeber, 1996).

1.1. Correlational findings on personality and cognition

There is a rich body of literature demonstrating that personality and cognition are related (Curtis et al., 2015; Rammstedt et al., 2018; Wettstein et al., 2017). Many have used the Big Five framework as a guidepost (Rammstedt et al., 2018), which has facilitated the systematic study of the associations among personality traits and cognitive function. Results of numerous studies have demonstrated that there are robust associations between the Big Five personality traits and measures of cognitive ability. For example, emotional stability and openness are

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both positively related to episodic memory and executive functioning (Graham & Lachman, 2012; Stephan et al., 2020; Sutin et al., 2019; Williams et al., 2010). Longitudinal studies even suggest that these relationships persisted over twenty years (Stephan et al., 2020). Specifically, middle-aged adults who scored higher on openness or emotional stability showed better memory two decades later (Stephan et al., 2020). Interestingly, previous research also suggests differences between Intellect and Openness and their relation with intelligence and cognitive functioning. Specifically, this research stream suggests that mainly the Intellect aspect of the Openness/Intellect domain (represented by the Ideas facet of the NEO PI-R) correlates with working memory (DeYoung et al., 2009). Another study found that Intellect was associated with general intelligence (g) and with verbal and nonverbal intelligence and openness was only associated with verbal intelligence (DeYoung et al., 2014). Correlational findings on conscientiousness and cognitive performance suggest positive associations between conscientiousness and reasoning, speed, and academic performance, but negative associations with verbal ability, reasoning, and divergent thinking (Graham & Lachman, 2012; Moutafi et al., 2006; Schaie et al., 2004). Extraversion and agreeableness are also related to cognitive performance but these associations are less consistent (Curtis et al., 2015; Graham & Lachman, 2014; Stephan et al., 2020). Specifically, extraversion has been associated with better creativity, speed, and long-term memory, but worse divergent thinking, spatial orientation, reasoning, and verbal ability (Chamorro-Premuzic, Furnham, & Ackerman, 2006; Chamorro-Premuzic, Furnham, & Petrides, 2006; Graham & Lachman, 2012). Typically, agreeableness is not related to cognitive ability, but a few studies reported negative associations between agreeableness and inductive reasoning, spatial orientation, and general cognition (Schaie et al., 2004; Willis & Boron, 2008).

1.2. Personality and cognitive change

Although research shows that the Big Five personality traits are associated with cognitive ability when measured concurrently, research on individual differences in personality traits predicting cognitive change has been less conclusive. There are a few studies that examined the relationship of personality trait levels on prospective changes in cognition (Curtis et al., 2015; Luchetti et al., 2016). One recent study found that lower emotional stability was associated with greater cognitive decline, whereas higher conscientiousness, higher openness, and lower extraversion were associated with less cognitive decline in later life (Luchetti et al., 2016). Other studies also found that higher conscientiousness and higher emotional stability are associated with slower cognitive decline (Chapman et al., 2012; Wilson et al., 2007); however, attempts to replicate these findings have failed in some cases (Hock et al., 2014; Williams et al., 2013).

Research has attempted to illuminate these mixed results and to extend the focus beyond normal cognitive aging to cognitive impairment and dementia. This line of research suggests associations between lower conscientiousness and emotional stability and an increased risk of cognitive impairment and dementia (Aschwanden et al., 2021; Terracciano et al., 2017). Low conscientiousness also predicted conversion from cognitive impairment to dementia (Terracciano et al., 2017). In addition, research suggests that individuals with higher conscientiousness and emotional stability show greater cognitive resilience, which refers to less cognitive decline relative to the amount of neuropathology (Graham et al., 2021).

1.3. Personality change and cognition

There are a few studies that have examined the relationship between change in personality traits and individual differences in cognitive functioning (Graham & Lachman, 2012; Mõttus et al., 2012; Mueller et al., 2016; Ziegler et al., 2015). Prior studies found associations between cognitive abilities and changes in emotional stability (Wettstein et al., 2017), extraversion (Wagner et al., 2016; Wettstein et al., 2017), openness (Aschwanden, Martin, & Allemand, 2017; Von Stumm & Deary, 2013; Wettstein et al., 2017), and conscientiousness (Mõttus et al., 2012). Specifically, one study found that greater stability of personality traits was associated with better cognitive functioning. Those who were stable in openness to experience and emotional stability had faster reaction times and better inductive reasoning than those who had more change in these personality traits (Graham & Lachman, 2012). Previous research also suggests that accelerated declines in conscientiousness were associated with lower IQ (Mõttus et al., 2012). Another study suggests that the relationship between cognitive abilities and personality change may be moderated by physical health (Wettstein et al., 2020). Specifically, lower cognitive abilities were associated with a decrease in emotional stability (i.e., increase in neuroticism) in individuals with poor health, but not in those with good health. Lower cognitive abilities were related with an increase in agreeableness in older adults with good health, but with a decrease in agreeableness among those with poor health. Also, better cognitive abilities were associated with stability in conscientiousness, but only among individuals with poorer health. Moreover, prior research found that decreases in emotional stability preceded dementia diagnosis in individuals with mild cognitive impairment, which suggests that decreases in emotional stability may be early indication of dementia (Yoneda et al., 2020).

There are numerous potential mechanisms that may underlie the relationship between personality change and cognitive ability. For example, poor cognitive ability may be associated with decreases in emotional stability and openness due to the cognitive resources required to maintain high levels of those traits (Poon et al., 1992; Ziegler et al., 2012; Ziegler et al., 2015). Conversely, poor cognitive ability may be associated with increases in agreeableness (Baker & Bichsel, 2006) and conscientiousness (Wood & Englert, 2009) to compensate for cognitive limitations and to improve life functioning. In sum, despite the depth of prior research on the relationship between cognitive ability and personality change, results still appear to be inconclusive and conclusions on causality and directionality need further exploration.

1.4. Changes in both personality and cognition

Both personality traits and cognitive performance change as people age. In terms of personality trait change, numerous studies and *meta*-analytic works have provided evidence that personality traits are malleable over longer time periods and across the entire lifespan (e.g., Lucas & Donnellan, 2011; Roberts, Walton, & Viechtbauer, 2006). This line of research suggests that people become – on average – more emotionally stable, more confident, agreeable, and conscientious as they age. However, there are interindividual differences in change in personality traits (e.g., Graham et al., 2020; Roberts et al., 2006). Similarly, cognitive performance tends to decline as people get older (e.g., Hughes et al., 2018; Salthouse, 2010; Schaie, 1996), but the timing and extent of cognitive declines varies across individuals. Although some individuals are better able to maintain their cognitive functioning well into later life, others decline earlier or faster (Mella et al., 2018). As such, individual differences in change in personality traits may be tied to changes in cognitive performance.

Although research has supported the hypothesis that baseline personality measures are associated with the rate of cognitive decline (Wettstein et al., 2019), research has yet to fully explore how personality, considered as dynamic and changing, rather than as a static baseline factor, is associated with cognitive change in older adults. For example, one study found that declines in extraversion and conscientiousness were more evident in multiple sclerosis patients classified as having cognitive decline than those patients whom were cognitively stable over five years (Roy et al., 2018). This result suggests a potential link between personality change and cognitive change. Additionally, one recent study suggests that steeper declines in extraversion,

openness, and conscientiousness are related to greater declines in memory are (Stephan et al., 2021).

1.5. A person-centered approach to personality change

Although personality has been documented as a significant predictor of cognitive function across the adult life span (e.g., Stephan et al., 2020; Wettstein et al., 2019), prior research has solely focused on variable-centered approaches. That is, they have focused on the effect of changes in single Big Five traits on changes in cognitive performance, primarily memory. However, a variable-centered approach misses a key point raised by Allport (1937), that personality traits do not function independently from each other, but they are interconnected and function as a coordinated system and organization within an individual. In contrast to the more traditional variable-centered approach, a person-centered approach to personality change focuses on the individual as the focal unit of analysis and provides information about the person-specific intraindividual pattern and organization of change in multiple personality traits (Asendorpf, 2015; Robins et al., 1996). Specifically, by taking a person-centered approach, individuals can be classified into subgroups that consist of individuals with a similar personality change organization, which then can be used to examine its association with important life outcomes such as cognitive change. The identification of personality change subgroups and understanding the nature and implications of these personality change configurations are important complements to the variable-centered strategies that have been dominant to date. The goal of the present study was to expand prior research by considering the combined effects of personality trait changes in relation to changes in cognitive performance by identifying personality change profiles, using a person-centered approach. To the best of our knowledge, this is the first study to classify people into personality change profiles and consider their relationship to aging-related changes in cognitive performance on two key abilities.

1.6. The present study

As both personality traits (e.g., Roberts et al., 2006) as well as cognitive abilities (e.g., Hughes et al., 2018) change throughout adulthood into old age, the goal of the present study was to take a life span developmental approach (e.g., Baltes et al., 2006) and focus on changes in personality traits and cognition among middle-aged and older adults. Our specific research goals were twofold. In a first step, we explored personality change profiles based on patterns of change in Big Five traits across 20 years. In a second step, we used multilevel modeling to examine if the extracted personality change profiles are associated with change in cognitive performance across 10 years. Based on the most consistent findings from the review of cross-sectional and longitudinal studies of personality and cognition, we expected that those who declined in all Big Five traits combined (i.e., decrease in emotional stability, extraversion, openness, agreeableness, and conscientiousness) would be more likely to show greater decreases in cognitive performance. This study was not preregistered.

2. Method

2.1. Participants

Participants were community-dwelling adults from the Midlife in the United States (MIDUS) study, which is a representative longitudinal sample consisting of three measurement occasions. The first wave (M1) was collected in 1994–1995 and included a sample of 7108 adults aged 20–75 years (M = 46.38, SD = 13.00). The second wave (M2) was collected in 2004–2005 and consisted of 4962 adults aged 28–84 years (M = 55.43, SD = 12.45), which is approximately 70% of the original sample, adjusted for mortality (Brim et al., 2004). The third wave (M3) was collected in 2013–2014 and consisted of 3294 adults aged 39–93 (M = 63.64, SD = 11.35), which is 66.4% of the M2 sample. The present study focused on participants who completed both the M1 and M3 personality assessment. Thus, the present study included 2652 participants ranging in age between 20 and 74 years (M = 46.61, SD = 11.26) at M1. Women made up 55% of the sample and 93.3% of the sample were non-Hispanic Whites. Initially, compared to those who dropped out, those who were included in the present study reported higher conscientiousness (survivors: M = 3.47, SD = 0.43; dropouts: M = 3.39, SD = 0.45); $t(5871.06) = -7.31$, $p < .001$), higher emotional stability (survivors: M = 2.78, SD = 0.66; dropouts: M = 2.75, SD = 0.66); $t(6263) = -2.17$, $p = .030$), higher episodic memory (survivors: M = 0.10, SD = 0.91; dropouts: $M = -0.17$, SD = 0.99); $t(3457.99) = -8.76$, $p < .001$), higher executive functioning at M2 (survivors: M = 0.11, SD = 0.64; dropouts: $M = -0.17$, SD = 0.73); $t(3392.99) = -12.51$, $p < .001$), and had more years of education (survivors: M = 14.32, SD = 2.56; dropouts: M = 13.41, SD = 2.61); $t(5655.70) = -14.33$, $p < .001$). There were no significant differences in terms of age, level of extraversion, agreeableness, or openness at M1. The Institutional Review Boards at the University of Wisconsin and BLINDED approved the study and all data were deidentified prior to public release and data analysis. Data are publicly available at https://midus.colectica.org/ or https://www.icpsr.umich.edu/web/ICPSR/search/studies?q=midus.

2.2. Procedures

Personality measures were collected at all measurement waves by mail questionnaire. In this study, the focus was on personality development across 20 years. Thus, we used the personality assessments at M1 and M3 for our analyses. Cognitive data were assessed by telephone and collected twice, at M2 and M3.

2.3. Measures

2.3.1. Personality

The Big Five personality traits were assessed using the MIDI personality scale (Lachman & Weaver, 1997) at the first and third occasion of MIDUS. Participants were asked the degree to which adjectives described them on a 1–4 scale with 1 = *a lot*, 2 = *some*, 3 = *a little*, and 4 = *not at all*. The variables were recoded so that higher scores reflected higher levels of that particular trait and means were calculated for each item set. Alpha coefficients are as follows: emotional stability (moody, worrying, nervous, calm) = 0.75 at M1 and 0.71 at M3; extraversion (outgoing, friendly, lively, active, talkative) = 0.78 at M1 and 0.76 at M3; openness (creative, imaginative, intelligence, curious, broad-minded, sophisticated, adventurous) = 0.78 at M1 and 0.77 at M3; conscientiousness (organized, responsible, hardworking, careless) = 0.56 at M1 and 0.56 at M3; and agreeableness (helpful, warm, caring, softhearted, sympathetic) = 0.81 at M1 and 0.77 at M3.

2.3.2. Cognition

Cognitive performance was assessed using the Brief Test of Adult Cognition by Telephone (BTACT) (Lachman et al., 2014; Tun & Lachman, 2006). The BTACT assesses key cognitive domains that are of theoretical significance for cognitive aging and was designed for telephone administration in the Midlife in the United States national longitudinal study (Tun & Lachman, 2006; Tun & Lachman, 2008). The BTACT is a reliable and valid measure of cognition, despite its brief length (for more information on psychometric properties, see Lachman et al., 2014), which includes seven cognitive subtests. The tests include (1) inductive reasoning (number series; completing a pattern in a series of five numbers), (2) category verbal fluency (the number of words produced from the category of animals in 60 s), (3) working memory span (backward digit span; the highest span achieved in repeating strings of digits in reverse order), (4) processing speed (30 Second And Counting Task, or 30-SACT; the number of digits produced by counting backward from 100 in 30 s), (5) attention switching and inhibitory

control (Stop and Go Switch Task, SGST; Tun and Lachman, 2008) (6) immediate free recall of 15 words, and (7) delayed free recall of 15 words (Rey, 1964).

Studies examining the psychometric properties of the BTACT yielded a good model fit with a two-factor solution consisting of executive functioning and episodic memory (Hughes et al., 2018; Lachman et al., 2010; Lachman et al., 2014) and the two-factor structure was found to be invariant across the two occasions (Hughes et al., 2018). Episodic memory and executive functioning are dimensions that consistently show individual differences in declines associated with cognitive aging, and thus are widely used in aging research (e.g., Reuter-Lorenz et al., 2016; Tromp et al., 2015). Prior research also shows that psychosocial, behavioral, and biological factors are related to these two cognitive factors and individual differences in changes therein (e.g., Agrigoroaei & Lachman, 2011; Chen et al., 2021; Karlamangla et al., 2014; Liu & Lachman, 2019; Robinson & Lachman, 2018). The executive functioning factor score includes the scores for inductive reasoning, category verbal fluency, working memory span, processing speed, as well as attention switching and inhibitory control. The episodic memory factor score includes the scores for immediate and delayed word list recall. Z-scores were computed for all subtests using the M2 means and standard deviations, and the factors were computed as the average of the tests comprising the factor. Both the M2 and M3 factor scores were then standardized using the means and standard deviations from M2 (see Hughes et al., 2018 for further details about the factor score computation). Higher numbers indicate better executive functioning and episodic memory. More information about the derivation of the two factor scores using confirmatory factor analysis and the intercorrelations of the seven subtests at both occasions can be found in one of the original articles (Hughes et al., 2018, p. 809; Table 2). All cognitive tests demonstrated relatively high test–retest correlations across the two occasions.

2.3.3. Covariates

A number of covariates from MIDUS Time 1 were added to the analyses as they are related to personality or cognition and might potentially influence the relationship between personality change and cognitive change. This also enabled examination of the association between personality change and cognitive change above and beyond these variables. Previous studies examining the link between personality and cognition have also included age, sex, education, physical activity and health as control variables (see Curtis et al., (2015) for a review of control factors considered in the field). Specifically, research suggests associations between cognitive declines and age (e.g., Salthouse, 2009), sex (e.g., Levine et al., 2021), and education (e.g., Leibovici et al., 1996; Reas et al., 2017). Intervention studies and longitudinal studies also show positive effects of physical activity on cognition (e.g., Colcombe & Kramer, 2003). In addition, health is associated with cognitive decline (e.g., Bond et al., 2006; Salthouse, 2014) and personality change (e.g., Jokela et al., 2014; Letzring et al., 2014).

2.3.3.1. Demographic variables. Age in years and sex (0 = female, 1 = male) were included.

2.3.3.2. Education. Education was conceptualized as total number of years of formal schooling.

2.3.3.3. Physical activity. Twelve questions assessing the participant's frequency of vigorous (e.g., competitive sports such as running, vigorous swimming, high intensity aerobics, digging in the garden, or lifting heavy objects) and moderate intensity (e.g., leisurely sports such as light tennis, slow or light swimming, low-impact aerobics, or golfing without a power cart, brisk walking, and mowing the lawn with a walking lawnmower) physical activity were used. These questions referred to frequency of physical activities separately for the summer and winter months, in three different settings (i.e., home, work, and leisure), with ratings from 1 = *never*, 2 = *less than once a month*, 3 = *once a week*, 6 = *several times a week*. The mean across summer and winter in all three settings for both moderate and vigorous intensity was computed. The activity intensity and setting with the maximum value to represent the highest frequency of physical activity across all intensity levels and domains was selected. The same approach was used in a previous study (Cotter & Lachman, 2010).

2.3.3.4. Functional health. Ten questions were used to assess participant's functional health (Ware & Sherbourne, 1992): How much does your health limit you in lifting or carrying groceries; bathing or dressing yourself; climbing several flights of stairs; climbing one flight of stairs; bending, kneeling, or stooping; walking more than a mile; walking several blocks; walking one block; vigorous activity (e.g., running, lifting heavy objects); moderate activity (e.g., bowling, vacuuming)? Responses were provided on a 4-point scale: 1 = *a lot*, 2 = *some*, 3 = *a little*, 4 = *not at all*. A mean score across the 10 items was computed with higher values representing better functional health.

2.3.3.5. Self-rated health. Participants rated their physical health on a 5-point scale: In general, would you say your physical health is 1 = *poor*, 2 = *fair*, 3 = *good*, 4 = *very good*, 5 = *excellent*?

2.4. Data analysis

The first step was to identify personality change profiles. To do this, we conducted Latent Profile Analyses (LPA) using Mplus Version 8 (Collins & Lanza, 2009; Muthén & Muthén, 2017). There is some conceptual overlap between LPA and traditional factor analysis, except that whereas factor analysis attempts to identify coherent groups of variables (variable-centered approach), LPA attempts to identify coherent groups of individuals (person-centered approach). That is, the primary function of LPA is to determine whether one or more distinct profiles (i.e., groups) exist within a population. Change scores of the Big Five personality traits were used as indicators to determine the latent profiles. Although there has been some controversy about the use of change scores (Cronbach & Furby, 1970; Lord, 1956), many have shown they are a reliable method for a direct assessment of individual differences in change (e.g., Chiou & Spreng, 1996; Rogosa, 1995; Rogosa & Willett, 1983; Thomas & Zumbo, 2012). Model fit was examined for one through five profile solutions, and, for each model, the AIC, BIC, SABIC, entropy values, and the Lo-Mendell Rubin Adjusted Likelihood Ratio Test (LMR LRT) were examined. A nonsignificant LMR LRT p value suggests that a model with one fewer latent profile is a better model fit. Smaller AIC, BIC, and SABIC values indicate that the model fit is better for the data (Nylund et al., 2007). Entropy values range from 0 to 1, with values closer to 1 indicating greater overall accuracy of the classification. The combination of these fit indices and the size of the profiles were the indicators used to identify the best model (i.e., a profile with less than approximately 5% of the sample size is not ideal) (Collins & Lanza, 2009; Muthén & Muthén, 2017). To explore the extracted profiles, we compared them on a number of characteristics using ANOVA omnibus tests with Tukey post hoc comparisons or Kruskal-Wallis tests in SPSS version 27. Tukey post hoc comparisons can be used to test if two profiles significantly differ from each other on a specific characteristic.

In a second step, longitudinal multilevel models (Bolger & Laurenceau, 2013) and the lme4 package (Pinheiro et al., 2020) in R (R Core Team, 2020) were used to investigate if the extracted profiles are associated with change in episodic memory and executive functioning over time (Bolger & Laurenceau, 2013). The data structure included repeated assessments of episodic memory and executive functioning (Level 1: Time) nested within participants (Level 2: Person). To examine the associations between the extracted profiles and change in episodic memory or executive functioning, linear conditional change models

were fitted to test for differential effects over time. A time by profile probability interaction term was added as a Level 2 predictor to investigate whether change over time in executive functioning or episodic memory differed based on one's probability of being part of a certain profile. Mixed models use all available data and take into account the fact that repeated measures on the same individual are correlated with each other. Also, the mixed models enabled us to control for a number of covariates which might potentially influence the relationship between personality and cognitive change. All models were estimated with maximum likelihood (ML). Data and codes are available on the Open Science Framework (OSF: https://osf.io/r356k/?view_only=b5bfc7e342e64881a20ea47d688bf3b6).

3. Results

3.1. Extracting and describing the personality change profiles

In a first step, we examined if there were significant changes in the Big Five personality traits across the 20 years. On average, participants did not significantly change in conscientiousness ($\beta = -0.00$, $SE = 0.01$, 95% CI $= -0.02; 0.02$, $p = 0.77$, $d = -0.07$). Participants showed a significant increase in emotional stability ($\beta = 0.12$, $SE = 0.01$, 95% CI $= 0.11; 0.14$, $p = < 0.001$, $d = 0.27$). Also, the findings suggest a significant overall decrease in extraversion ($\beta = -0.11$, $SE = 0.01$, 95% CI $= -0.12; -0.09$, $p = < 0.001$, $d = -0.28$), agreeableness ($\beta = -0.05$, $SE = 0.01$, 95% CI $= -0.07; -0.03$, $p = < 0.001$, $d = -0.11$), and openness ($\beta = -0.12$, $SE = 0.01$, 95% CI $= -0.14; -0.11$, $p = < 0.001$, $d = -0.30$).

We used LPA to extract personality change profiles. Table 1 shows the LPA fit statistics for the models with different variance–covariance structures. The LPA fit statistics revealed three contender models: Model 3, Model 8, and Model 17. We selected Model 8 for the final model for the following reasons: (1) Model 8 showed better relative fit indices with lower AIC, BIC, and SABIC values compared to Model 3; (2) Model 8 showed a significant LMR LRT p value, which indicated that the model fit for Model 8 was better than the model fit for Model 7; (3) the three profiles of Model 8 showed good separation in terms of the Big Five change scores (see Fig. 1); (3) the two-profile solution of Model 17 showed a low entropy score which suggest a low overall classification precision of this solution; (4) a three-profile solution is more meaningful than a two-profile solution as it provides the opportunity to examine the link between personality change profiles and cognitive changes in greater detail; and (4) four-profile solutions started to delineate groups with less than 1% of the sample and/or showed convergence problems (i.e., the best log likelihood value did not replicate).

Table 2 shows the descriptive statistics for the entire study sample and Table 3 the descriptive statistics for each profile and comparisons between the latent profiles. The three profiles differed significantly in terms of change in the Big Five personality traits. The *Decreasers* (25.8% of the sample) showed greater declines in extraversion, agreeableness, conscientiousness, and openness compared to the other profiles. Also, they showed less increase in emotional stability compared to the other

Table 2
Descriptive Statistics of Study Sample.

	Range	M1/M2[1] *M (SD)* or %	M3 *M (SD)*	Test-retest correlation
Extraversion	1–4	3.20 (0.56)	2.08 (0.58)	0.68
Conscientiousness	1–4	3.47 (0.43)	3.47 (0.46)	0.56
Agreeableness	1–4	3.48 (0.49)	3.43 (0.50)	0.61
Emotional stability	1–4	2.78 (0.66)	2.95 (0.62)	0.59
Openness	1–4	3.02 (0.51)	2.89 (0.54)	0.64
Episodic memory	−2.94–3.64	0.10 (0.91)	−0.04 (0.97)	0.55
Executive functioning	−5.63–2.34	0.11 (0.64)	−0.15 (0.74)	0.77
Age	20–74	46.61 (11.26)		
Education (years)	6–20	14.32 (2.56)		
Sex (female)		55%		
Physical activity	1–6	4.67 (1.57)		
Functional health	1–4	3.44 (0.71)		
Self-rated health	1–5	3.69 (0.94)		

Note. $N = 2652$.
[1] M1 for personality traits and covariates; M2 for episodic memory and executive functioning.

Table 1
Fit statistics for One- to Five-Profile Solutions – Personality Change Profiles.

Variance-Covariance Structure	Model	Model (K-class)	Best Log-Likelihood	Free Parameters	AIC	BIC	SABIC	Entropy	LMR Test value	LMR p
Diagonal, Class-Invariant	#1	1	−8604.692	10	17229.385	17288.216	17256.443	–	–	–
	#2	2	−8138.387	16	16308.774	16402.904	16352.067	0.642	913.301	<0.001
	#3	3	−7949.337	22	15942.675	16072.102	16002.202	0.762	370.271	<0.01
	#4	4	Smallest class < 1% of sample							
	#5	5	Smallest class < 1% of sample							
Diagonal, Class-Varying	#6	1	−8604.692	10	17229.385	17288.216	17256.443	–	–	–
	#7	2	−8074.836	21	16191.672	16315.216	16248.493	0.619	1047.632	<0.001
	#8	**3**	**−7781.431**	**32**	**15626.862**	**15815.121**	**15713.447**	**0.605**	**580.119**	**<0.001**
	#9	4	Smallest class < 1% of sample							
	#10	5	Smallest class < 1% of sample							
Non-Diagonal, Class-Invariant	#11	1	−7898.989	20	15837.977	15955.639	15892.093	–	–	–
	#12	2	Smallest class < 1% of sample							
	#13	3	Smallest class < 1% of sample							
	#14	4	Smallest class < 1% of sample							
	#15	5	Smallest class < 1% of sample							
Non-Diagonal, Class-Varying	#16	1	−7898.989	20	15837.977	15955.639	15892.093	–	–	–
	#17	2	−7666.907	41	15415.815	15657.021	15526.752	0.329	461.375	<0.05
	#18	3	Best log likelihood value did not replicate							
	#19	4	Best log likelihood value did not replicate							
	#20	5	Best log likelihood value did not replicate							

Note. $N = 2652$; AIC: Akaike Information Criteria; BIC: Bayesian Information Criteria; SABIC: Sample-Size Adjusted BIC; LMR: Lo-Mendell Rubin Adjusted Likelihood Ratio Test.

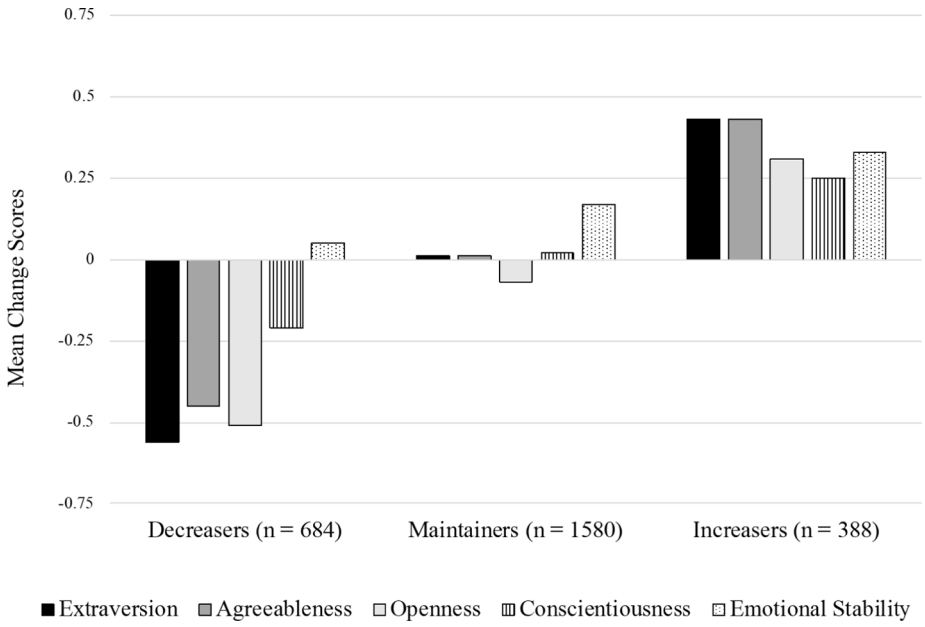

Fig. 1. Latent Profiles of Personality Change Scores.

Table 3
Descriptive Statistics and Comparisons Between Latent Profiles.

	Decreasers $n = 684$ 25.8% *M* (*SD*)	Maintainers $n = 1580$ 59.6% *M* (*SD*)	Increasers $n = 388$ 14.6% *M* (*SD*)	F	*p*	Decreasers vs. Maintainers p_{tukey}	Decreasers vs. Increasers p_{tukey}	Maintainers vs. Increasers p_{tukey}
Change extraversion	−0.56 (0.95)	0.01 (0.26)	0.43 (0.38)	1117.00	<0.001	<0.001	<0.001	<0.001
Change conscientiousness	−0.21 (0.53)	0.02 (0.29)	0.25 (0.44)	181.92	<0.001	<0.001	<0.001	<0.001
Change agreeableness	−0.45 (0.41)	0.01 (0.26)	0.43 (0.43)	915.41	<0.001	<0.001	<0.001	<0.001
Change emotional stability	0.05 (0.66)	0.17 (0.52)	0.33 (0.65)	28.62	<0.001	<0.001	<0.001	<0.001
Change openness	−0.51 (0.47)	−0.07 (0.29)	0.31 (0.39)	693.23	<0.001	<0.001	<0.001	<0.001
Episodic memory M2	0.03 (0.92)	0.14 (0.91)	0.06 (0.89)	3.480	0.031	0.035	0.884	0.309
Episodic memory M3	−0.20 (0.97)	0.02 (0.97)	0.02 (1.04)	11.20	<0.001	<0.001	0.003	1.00
Executive functioning M2	0.04 (0.66)	0.13 (0.63)	0.10 (0.68)	4.212	0.015	0.010	0.336	0.736
Executive functioning M3	−0.26 (0.75)	−0.12 (0.72)	−0.09 (0.76)	8.879	<0.001	<0.001	0.004	0.887
Change episodic memory	−0.25 (0.88)	−0.11 (0.90)	−0.03 (0.96)	7.33	0.001	0.006	0.001	0.299
Change executive functioning	−0.30 (0.46)	−0.26 (0.49)	−0.21 (0.46)	3.57	0.028	0.158	0.025	0.310
Age M1	46.90 (12.47)	47.07 (11.01)	44.21 (9.62)	10.45	<0.001	0.940	<0.001	<0.001
Education (years)	14.27 (2.64)	14.64 (2.64)	14.25 (2.59)	6.39	<0.001	0.001	0.991	0.021
Sex (female)	52.3%	56.2%	54.9%	2.88◆	0.237	–	–	–
Physical activity	4.46 (1.66)	4.75 (1.52)	4.72 (1.56)	7.60	0.001	<0.001	<0.001	0.947
Functional health	3.36 (0.76)	3.46 (0.69)	3.49 (0.67)	5.88	0.003	0.006	0.013	0.776
Self-rated health	3.59 (0.95)	3.75 (0.92)	3.66 (0.95)	7.35	0.001	0.001	0.415	0.238

Note. ◆Kruskal-Wallis H.

two profiles. The *Maintainers* (59.6%) remained mostly stable in their Big Five traits across the 20 years. The *Increasers* (14.6%) showed greater increases on all Big Five traits compared to the other two profiles. The *Increasers* are significantly younger than the *Maintainers* or the *Decreasers*. The *Decreasers* have significantly fewer years of education than the *Maintainers*, are less physically active and have lower levels of functional health than the *Maintainers* and *Increasers*, and report lower levels of self-rated health than the *Maintainers*. Consistent with the findings from Graham & Lachman (2012), those who had more stable personality profiles were more able, in that they had higher episodic memory and executive functioning performance at the first occasion. At the second occasion, however, those with a decreasing personality profile had the lowest cognitive functioning.

For comparison purposes, we explored whether the results for the profile pattern of Model 3, which was the second three-profile contender model, would be consistent with the selected Model 8 pattern. The descriptive statistics are reported in Supplementary Table 1. Model 3 replicates the pattern of personality *Decreasers*, *Maintainers*, and *Increasers*. In line with the solution of Model 8, the personality *Decreasers* also decrease on all Big Five traits, the *Maintainers* show the least personality changes, and the *Increasers* increase on all Big Five traits. As shown in Supplementary Table 1, Model 3 also replicates the finding that the profiles differ in terms of cognitive changes with the personality *Decreasers* declining significantly more in episodic memory and executive functioning than the personality *Increasers*.

Table 4 shows the correlations of all study variables. The correlation

Table 4
Correlations of Study Variables.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
(1) Extraversion	–	0.27**	0.49**	0.16**	0.52**	0.08**	0.02							
(2) Conscientiousness	0.23**	–	0.27**	0.07**	0.30**	0.14**	0.12**							
(3) Agreeableness	0.50**	0.25**	–	0.07**	0.35**	0.08**	−0.04**							
(4) Emotional stability	0.15**	0.19**	0.04	–	0.18**	0.01	0.08**							
(5) Openness	0.49**	0.25**	0.33**	0.19**	–	0.09**	0.12**							
(6) Episodic memory	0.03	0.09**	0.04*	−0.01	0.06**	–	0.43**							
(7) Executive functioning	−0.02	0.02	−0.11**	0.04*	0.11**	0.37**	–							
(8) Δ Extraversion	−0.36**	−0.05*	−0.16**	0.18**	−0.13**	0.04	0.03	–						
(9) Δ Conscientiousness	−0.07**	−0.41**	−0.09**	−0.04	−0.06**	0.03	0.06**	0.22**	–					
(10) Δ Agreeableness	−0.18**	−0.06**	−0.43**	−0.01	−0.13**	0.04	0.06**	0.41**	0.23**	–				
(11) Δ Emotional stability	−0.04	−0.08**	−0.01	−0.52**	−0.06**	0.04*	0.04	0.10**	0.13**	0.07**	–			
(12) Δ Openness	−0.12**	−0.04*	−0.11**	−0.05*	−0.36**	0.03	0.02	0.42**	0.22**	0.34**	0.13**	–		
(13) Δ Episodic memory	−0.02	−0.03	−0.04	0.01	−0.02	−0.41**	0.02	0.06**	0.08**	0.07**	−0.03	0.06**	–	
(14) Δ Executive functioning	−0.00	−0.03	−0.03	−0.01	−0.03	−0.00	−0.17**	0.04*	0.06*	0.04	−0.00	0.06**	0.18**	–
(15) Age	0.05**	0.06**	0.12**	0.16**	0.01	−0.27**	−0.38**	−0.02	−0.14**	−0.07**	−0.05*	−0.01	−0.16**	−0.22**
(16) Education (years)	−0.06**	0.08**	−0.11**	0.11**	0.19*	0.18**	0.41**	0.03	0.04	0.03	0.03	0.01	0.00	−0.02
(17) Sex	−0.07**	−0.12**	−0.27**	0.12**	0.07**	−0.24**	0.13**	−0.01	0.04*	−0.03	−0.01	−0.04*	−0.02	−0.01
(18) Physical activity	−0.00	0.05*	−0.03	0.01	0.09**	0.13**	0.23**	0.06**	0.08**	0.02	0.00	0.04*	0.05*	0.04
(19) Functional health	0.02	0.08**	−0.09**	0.15**	0.09**	0.11**	0.25**	0.10**	0.10**	0.04*	−0.05*	0.04	0.07**	0.10**
(20) Self-rated health	0.11**	0.18**	0.02	0.18**	0.13**	0.12**	0.23**	0.07**	0.05**	0.02	−0.04*	0.04*	0.03	0.02

	15	16	17	18	19	20
(15) Age	–					
(16) Education (years)	−0.14**	–				
(17) Sex	−0.01	0.11**	–			
(18) Physical activity	−0.27**	0.19**	0.09**	–		
(19) Functional health	−0.34**	0.24**	0.13**	0.26**	–	
(20) Self-rated health	−0.18**	0.26**	0.02	0.19**	0.55**	–

Note. $N = 2{,}130$; M1/M2 (lower part); M3 (upper part); Δ = Change score; * $p < .05$; ** $p < .01$.

matrix shows that, at both occasions, the correlations between the Big Five traits and cognitive performance vary depending on the dimension, which is in line with previous correlational work (e.g., Curtis et al., 2015; Rammstedt et al., 2018; Wettstein et al., 2017). Similarly, consistent with past variable-centered longitudinal studies (e.g., Roy et al., 2018; Stephan et al., 2021), changes in the Big Five traits and changes in episodic memory and executive functioning were correlated, but not consistently across all traits.

3.2. Association between personality change profiles and change in cognitive performance

In a second step, we tested whether the three personality change profiles are associated with change in cognitive performance across 10 years, controlling for age, sex, years of education, physical activity, functional health, and self-rated health. As reported in Hughes and colleagues (2018), on average participants decreased on both episodic memory and executive functioning across the 10 years, although there were individual differences in the extent and direction of cognitive change. The results of the multilevel models show that participants with a higher probability of belonging to the *Decreasers* showed more decline in episodic memory and executive functioning. Also, participants with a higher probability of being an *Increaser* showed less decline in episodic memory and executive functioning. The *Decreasers* declined more in episodic memory compared to the *Increasers* and *Maintainers* (Fig. 2). Also, the *Decreasers* declined more in executive functioning compared to the *Increasers*, but they did not decline more in executive functioning compared to the *Maintainers* (Fig. 3). See Table 5 for the results with episodic memory and Table 6 for the results with executive functioning. The findings of the multilevel models with covariates are mirrored in additional multilevel models conducted without covariates (Supplementary Tables 2 and 3).

As a sensitivity analysis and to test if the association between the personality change profiles and cognitive change differ between those younger and older in the sample, we divided the sample into younger (i.e., middle-aged) and older adults by applying a median split on age at the third wave of the study. At M3, those in the younger group (range: 39–63 years) were on average 55.03 years old ($SD = 5.93$) and the older group (range: 64–93 years) was on average 73.99 years old ($SD = 6.72$). In line with the results of the combined sample, the younger personality *Decreasers* showed significantly greater declines in executive functioning and episodic memory. However, in contrast to the combined sample, the younger personality *Increasers* did not show reduced declines in executive functioning or episodic memory (Supplementary Tables 4 and 5). The older personality *Increasers* showed less declines in executive functioning and episodic memory, which is in line with the findings of the combined sample. Older adults who were personality *Decreasers* showed significantly greater declines in episodic memory, but not in executive functioning (Supplementary Tables 6 and 7) compared to older adults who were *Maintainers* or *Increasers*. Taken together, the findings of this sensitivity analysis suggest that the younger and older subsamples showed significant associations between personality change profiles and cognitive change, with some variations by age and cognitive measure. It is also noteworthy that only the older personality *Increasers*, and not the younger personality *Increasers,* showed reduced cognitive declines.

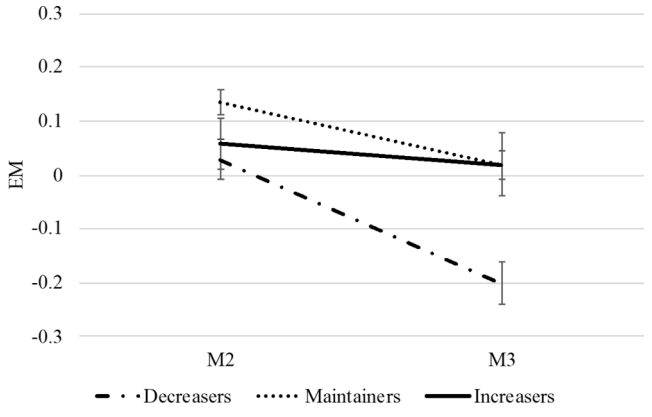

Fig. 2. Change in Episodic Memory by Personality Change Profile, Note. EM: Episodic memory; Error bars represent standard errors of the mean.

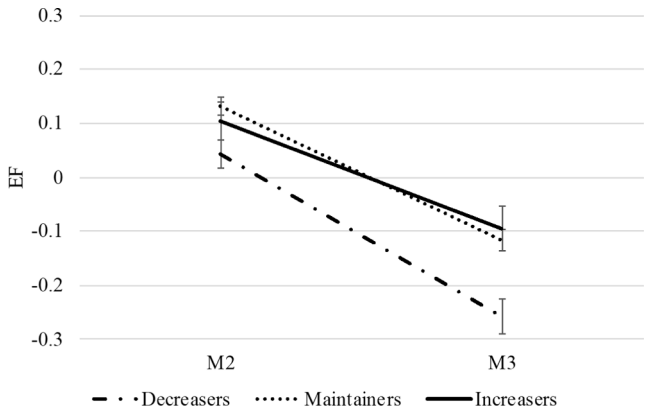

Fig. 3. Change in Executive Functioning by Personality Change Profile. Note. EF: Executive functioning; Error bars represent standard errors of the mean.

Table 5
Personality Change Profiles and Change in Episodic Memory.

	Decreasers		Maintainers		Increasers	
	β (SE)	P value	β (SE)	P value	β (SE)	P value
Intercept	0.25 (0.14)	0.076	0.28 (0.14)	0.05	0.31 (0.14)	0.029
Time	−0.04 (0.01)	<0.001	−0.09 (0.02)	<0.001	−0.10 (0.03)	<0.001
Age	−0.28 (0.02)	<0.001	−0.29 (0.02)	<0.001	−0.29 (0.02)	<0.001
Sex	−0.27 (0.02)	<0.001	−0.27 (0.02)	<0.001	−0.27 (0.02)	<0.001
Education	0.15 (0.02)	<0.001	0.15 (0.02)	<0.001	0.16 (0.02)	<0.001
Physical Activity	0.05 (0.02)	0.002	0.05 (0.02)	0.002	0.05 (0.02)	<0.001
Functional Health	0.03 (0.02)	0.085	0.03 (0.02)	0.073	0.04 (0.02)	0.063
Self-rated Health	0.05 (0.02)	0.008	0.05 (0.02)	0.011	0.05 (0.02)	0.005
Profile Probability	0.05 (0.03)	0.134	0.03 (0.03)	0.420	−0.10 (0.03)	0.004
Time × Profile Probability	−0.12 (0.03)	<0.001	0.05 (0.04)	0.146	0.09 (0.03)	0.005

Note. Number of observations = 4563; predictors are profile probabilities.

As another sensitivity analysis, we also tested whether initial levels on the Big Five traits affect our findings. The results of the models with M1 Big Five traits as additional covariates are largely the same as those without controlling for the M1 Big Five traits. The results of these multilevel models are shown in Supplementary Tables 8 and 9.

4. Discussion

The current study extends existing research and advances our understanding of the association between personality and cognition by exploring how 20-year personality change profiles and change in cognitive performance across 10 years are related in middle-aged and older adults. On average, participants showed significant increases in

Table 6
Personality Change Profiles and Change in Executive Functioning.

	Decreasers		Maintainers		Increasers	
	β (SE)	P value	β (SE)	P value	β (SE)	P value
Intercept	−0.22 (0.10)	0.025	−0.23 (0.10)	0.022	−0.22 (0.10)	0.030
Time	−0.17 (0.01)	<0.001	−0.20 (0.01)	<0.001	−0.20 (0.01)	<0.001
Age	−0.36 (0.02)	<0.001	−0.37 (0.02)	<0.001	−0.36 (0.02)	<0.001
Sex	0.06 (0.02)	<0.001	0.06 (0.02)	<0.001	0.06 (0.02)	<0.001
Education	0.28 (0.02)	<0.001	0.28 (0.02)	<0.001	0.29 (0.02)	<0.001
Physical Activity	0.06 (0.02)	<0.001	0.06 (0.02)	<0.001	0.06 (0.02)	<0.001
Functional Health	0.02 (0.02)	0.332	0.02 (0.02)	0.306	0.02 (0.02)	0.283
Self-rated Health	0.11 (0.02)	<0.001	0.11 (0.02)	<0.001	0.11 (0.02)	<0.001
Profile Probability	0.02 (0.03)	0.504	0.03 (0.03)	0.276	−0.06 (0.03)	0.026
Time × Profile Probability	−0.07 (0.02)	0.003	0.02 (0.03)	0.346	0.06 (0.02)	0.011

Note. Number of observations = 4559; predictors are profile probabilities.

emotional stability, and significant decreases in extraversion, agreeableness, and openness across the 20 years. These findings are largely in line with previous research on personality trait development among middle-aged and older adults (Graham et al., 2020; Roberts et al., 2006). The results of the LPA advance the picture of personality change as characterized by three personality change subgroups: 1) *Decreasers*, 2) *Maintainers,* 3) and *Increasers*. The *Decreasers* showed greater decline in extraversion, agreeableness, conscientiousness, and openness compared to the other two profiles. Also, they showed less increase in emotional stability compared to the other two profiles. The *Maintainers* remained mostly stable in their Big Five traits across the 20 years. The *Increasers* showed greater increases on all Big Five traits compared to the other two profiles. Although the person-centered analysis was exploratory and there were no a priori predictions about the profiles we would find, the results are coherent and interpretable. From a personality development perspective, it is meaningful that the three types that were found show consistent patterns of change or stability across all five traits, with some increasing, and others decreasing or maintaining their personality characteristics over 20 years.

The multilevel analyses that link the personality profiles with changes in cognition show that participants with a higher probability of being in the *Decreasers* profile showed greater decline in episodic memory and executive functioning. In addition, participants with a higher probability of being part of the *Increasers* showed less decline in episodic memory and executive functioning. The results for stability of personality over 20 years are consistent with previous research showing that those whose personalities were more stable over 10 years had the highest levels of cognitive performance at the first occasion (Graham & Lachman, 2012). Moreover, although Stephan and colleagues (2021) also found that those who declined more in emotional stability, extraversion, openness, or conscientiousness showed greater decreases in memory, their variable-centered approach cannot provide information about how the traits work together within persons. In other words, it is not clear from their approach if those who declined in extraversion are also the same people who declined in openness or conscientiousness. The present results expand our understanding of personality and cognition linkages in presenting a more complex multivariate conception of personality change that includes multiple traits and includes two key dimensions for cognitive aging, episodic memory and executive functioning. This person-centered approach shows that there are different types of personality change constellations across traits, which have implications for changes in another psychological domain, that is, cognition.

The relationship between personality change profiles and cognitive changes showed some differences by age. For the younger (middle-aged) group, cognitive changes were only related for those who were classified as personality *Decreasers*. Given that the personality *Decreasers* had less education and worse health than the *Maintainers*, it is possible that the Decreaser group is especially vulnerable to cognitive declines at an earlier age than the other profiles. For the older group, there were differences in the relationship of personality change to episodic memory and executive functioning in that the *Decreasers* showed greater cognitive declines in episodic memory, but not executive functioning. Although both cognitive dimensions showed average declines, previous studies have found that memory abilities are consistently related to conscientiousness, extraversion, and openness to experience (Stephan et al., 2020; Stephan et al., 2021). Those older adults who show decreases in these personality traits, for example, are likely to be less engaged in intellectual or social activities (Segel-Karpas & Lachman, 2018), which may put them at greater risk for declines in memory abilities.

The present findings suggest that when controlling for age, both middle-aged and older adults who increase their Big Five personality trait levels during adulthood are able to mitigate cognitive declines associated with aging. In contrast, those who show personality decreases, also experienced greater declines in cognitive functioning. Although further work is needed to explore the potential mechanisms involved, based on previous work (e.g., Segel-Karpas & Lachman, 2018) it is possible that the personality increasers are better able to maintain their cognitive functioning because they are more socially engaged (extraversion, agreeableness), work longer and harder (conscientiousness), are involved in more intellectually stimulating activities (openness), and experience less stress, anxiety and depression (emotional stability). Also, the personality increasers may increase their engagement in healthy behaviors which may help protect them from many aging-related diseases, including cognitive decline (Stieger, Robinson, et al., 2020). For example, individuals who increase their levels of openness and conscientiousness over time may become more motivated to engage in stimulating cognitive, physical, and social activities, which can attenuate their rate of cognitive decline. Put differently, the personality increasers may increase their cognitive reserve (Stern, 2009).

Although the personality changes in the present study were small in magnitude across the 20 years, they are in line with personality changes across two decades found in prior research (e.g., Roberts et al., 2006). Given the known effects of personality traits on such significant life outcomes as occupational success, longevity, and health (Bogg & Roberts, 2004; Friedman, 2000; Judge et al., 1999), any change in personality traits may reap benefits and pitfalls for those individuals who do change and even small changes in personality traits can have profound effects on successful development across the life course.

4.1. Limitations

There are limitations to this study that should be considered. First, as is typically the case, the longitudinal sample in MIDUS is positively biased relative to the original sample on a number of variables, thereby limiting the generalizability of the present findings (Radler & Ryff, 2010). Due to selective attrition, compared to the original sample, the longitudinal participants in the present study reported higher conscientiousness, emotional stability, episodic memory, executive functioning, and had more years of education than those who are no longer in the sample. It is possible, for example, that the nature of aging-related cognitive changes was underestimated given that the dropouts had lower cognitive functioning at the initial occasions and might have shown greater declines than the longitudinal sample.

Second, there was limited racial and ethnic diversity in the MIDUS sample; the vast majority of participants were non-Hispanic Whites.

Thus, additional research is needed to examine the generalizability of the findings in more ethnically and racially diverse samples. Also, because the MIDUS data were collected in the United States, it is unknown whether similar associations between changes in personality and cognition would be observed in other countries. Third, as this is the first study which takes a person-centered approach to personality change in the Big Five using latent profile analysis in a national sample, future studies are needed to test if the three subgroups (i.e., Increasers, Decreasers, and Maintainers) can be replicated in other samples. Morin et al. (2016) suggest a sequential set of analytic procedures to guide future investigations of the similarity of latent profile solutions across different samples. For example, future cross-national comparisons can be useful to systematically and quantitatively assess the extent to which our three-profile solution generalizes across diverse samples and can help to provide a richer interpretation of our findings.

Also, although the initial personality assessments (M1) were prior to the first cognitive assessment, the assessments of personality and cognitive change overlapped between M2 and M3. As such, it is not possible to determine directionality of the relationship between personality and cognitive change. That is, cognitive change may also lead to changes in personality traits (e.g., Jackson et al., 2012). For example, decreased cognitive functioning may generate anxiety and daily stress (decreases in emotional stability), impair an individual's efficiency and organizational skills (decreased conscientiousness), restrict one's preference for variety (decreased openness), or limit one's tendency to engage in social interactions (decreased extraversion and agreeableness). Health-related and behavioral pathways may also explain some of this relationship. Decreased cognitive functioning may increase the likelihood of frailty (Gale et al., 2017) and depressive symptoms (Jajodia & Borders, 2011) resulting in decreases in personality traits such as neuroticism (Hakulinen et al., 2015). Furthermore, it is likely that individuals with greater cognitive decline may be less active or more anxious, which may lead to decreases in personality traits such as extraversion, emotional stability, or conscientiousness (Stephan et al., 2014). Longitudinal data with three or more measurement occasions would be ideal for examining the relationship of change processes in personality and cognition in future work. Also, future research is needed to examine potential underlying mechanisms of this relationship.

4.2. Implications and future directions

Some researchers propose a General Factor of Personality (GFP) as the apex of personality trait hierarchy and argue that this underlying GFP reflects a mixture of positively valued personality characteristics (Musek, 2007), an individual's degree of social desirability (e.g., Hofstee & Hendriks, 1998), or an individual's social intelligence (e.g., van der Linden et al., 2017). As the personality *Increasers* of the present study tend to show personality changes in a more socially desirable direction and the *Decreasers* in a more socially undesirable direction, it might be that these extracted personality change profiles would show associations with a GFP. Future research is needed to test if there is an association between the extracted personality change profiles and changes in a GFP and if changes in a GFP are related to changes on cognitive abilities.

An alternative analytic approach, Growth Mixture Modeling (Jung & Wickrama, 2008), could be used in the future to estimate person-centered trajectories with more than two occasions for each Big Five trait separately. Growth Mixture Modeling provides the opportunity to classify individuals into subgroups which show similar trajectories over time in a particular outcome. When doing this, one can output the likely trajectory membership for each individual and for each personality trait and describe how trajectory memberships overlap across the five personality traits. Previous studies have used this approach to describe trajectories in different outcomes such as resilience (see Infurna & Luthar, 2017b, 2017a).

To the extent that personality traits are modifiable, personality change interventions could be used to potentially attenuate the rate of cognitive decline among individuals who show decreases on their Big Five traits combined. Recent research has shown that adults can actively change their personality traits in desired directions with the help of interventions that directly target personality trait change (Stieger et al., 2021; Stieger, Wepfer, et al., 2020). These intervention studies found that participants could change their Big Five traits in the desired direction with medium- to large size effects over time and changes happened relatively quickly (i.e., within a few weeks), at least by standards typically considered in personality development (Roberts et al., 2006). There is increasing evidence for the malleability of personality and effective use of personality change interventions (Roberts et al., 2017). Yet, previous personality interventions typically have targeted change in only one personality trait at a time (Allemand et al., 2020; Stieger, Allemand, et al., 2021; Stieger, Flückiger, et al., 2021) These effective interventions were delivered using a smartphone app and provided participants with a set of micro-interventions to teach them how to increase their engagement in new behaviors and how to systematically reflect their own thoughts, feelings and behaviors (Stieger et al., 2018). The person-centered approach adopted for the present study can potentially inform interventions that are tailored to the person's whole constellation of personality traits and change patterns (Chapman et al., 2014). Preventive measures could be taken for those who are at risk for a pattern of personality decline across the Big Five traits combined. For instance, personality change interventions for personality *Decreasers*, which target all Big Five traits at the same time, might be more effective for minimizing cognitive declines or other changes associated with aging than an intervention which only targets one trait at a time. Future research is needed to test whether a targeted increase on personality traits can help middle-aged and older adults as a prevention tool to slow down the rate of cognitive decline. As mentioned above, directionality of the relationship between personality and cognitive change cannot be determined based on the present findings. As such, interventions that target cognitive changes might also lead to changes in personality traits. For example, a prior study found that cognitive training can increase openness to experiences in older adults (Jackson et al., 2012). Further intervention research is needed to take a closer look at the directionality of the personality-cognition link.

As the present study used a sample of adults between 20 and 75 years at M1 to examine the link between personality and cognitive change across the adult lifespan, it is important to note that the personality *Increasers* were significantly younger than the personality *Maintainers* or *Decreasers*. And age is a significant predictor of both personality and cognitive change. Specifically, in the present sample, those younger in age (i.e., the middle-aged) showed greater changes in personality traits compared to those who were older, and the older adults showed greater decline in cognition compared to middle-aged adults. Moreover, we found that the older personality *Increasers*, and not the middle-aged personality *Increasers,* showed reduced cognitive declines. This suggests that the pattern of increases in the Big Five traits combined is particularly beneficial for cognition among older adults. More research is needed to shed light on the question of what age groups could be targeted most effectively with personality interventions or cognitive training.

Whereas previous research on personality has typically examined individual differences separately by trait, the present approach takes a more holistic approach that captures the person across traits. Moreover, the current focus is on patterns of change over 20 years rather than static differences in variables or persons. Although it is now widely accepted that personality is not necessarily stable throughout adulthood, past work has focused on which traits increase and which decrease over the life course, a variable-centered approach (e.g., Roberts, Walton, & Viechtbauer, 2006). In contrast, the person-centered approach applied in this study characterizes and classifies people with regard to how they change across all Big Five aspects of personality in relation to changes in cognition. This approach can supplement other work that has examined, for example, whether extraversion or conscientiousness show average

increases over time, and whether individual differences in change in either or both of these dimensions are predictive of cognition.

The personality change patterns we found show consistency in the direction and extent of change across traits, which adds to our understanding of how people change across adulthood. It was not a given that people would be classified as either decreasing, maintaining, or increasing across all Big Five traits. This consistent change pattern is worth examining in the future in other samples to see if it is replicated. To the extent that personality traits change in a homogenous way, it may shed light on the adaptive value of different patterns of personality stability and change.

The present study adds to theories of personality development by showing that there are individual differences in *patterns* of personality change. We find evidence for a coherent pattern of change across all Big Five traits, with some people who are stable, and others who increase or decrease across all traits. These person types provide a more parsimonious way to examine how personality is related to a wide range of other important dimensions than looking separately at each trait. In the present study we examined personality change profiles in relation to cognitive changes. In future work it will be of interest to examine personality change profiles in relation to other outcomes such as changes in physical health.

4.3. Conclusion

The present study extends previous findings and provides novel information on the link between changes in personality traits and cognition by using a person-centered approach to personality change. Investigating the association between personality change profiles and cognitive change can help to elucidate person-specific intraindividual patterns of personality change among middle-aged and older adults that might be protective or a source of vulnerability to cognitive functioning. This is important given the need to address individual differences in the nature of cognitive aging. Assessment of personality change patterns could be useful in identifying and targeting those who may be at risk for cognitive declines. To the extent that personality traits are modifiable, the present findings may provide valuable information for tailoring interventions based on constellations of individual differences in personality, especially for those who are experiencing personality decreases.

5. Notes

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This study was not preregistered.

M.S. analyzed the data. M.S., Y.L., E.K.G., J.D., and M.E.L. wrote the manuscript. All authors provided critical feedback on earlier versions of the manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jrp.2021.104157.

References

Agrigoroaei, S., & Lachman, M. E. (2011). Cognitive functioning in midlife and old age: Combined effects of psychosocial and behavioral factors. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 66*, i130–i140.

Allemand, M., Keller, L., Gmür, B., Gehriger, V., Oberholzer, T., & Stieger, M. (2020). MindHike, a digital coaching application to promote self-control: Rationale, content, and study protocol. *Frontiers in Psychiatry*.

Allport, G. (1937). *Personality: A psychological interpretation*. Holt.

Aschwanden, D., Martin, M., & Allemand, M. (2017). Cognitive abilities and personality traits in old age across four years: More stability than change. *Journal of Research in Personality, 70*, 202–213. https://doi.org/10.1016/j.jrp.2017.08.002

Aschwanden, D., Strickhouser, J. E., Luchetti, M., Stephan, Y., Sutin, A. R., & Terracciano, A. (2021). Is personality associated with dementia risk? A meta-analytic investigation. *Ageing Research Reviews, 67*, 101269. https://doi.org/10.1016/j.arr.2021.101269

Asendorpf, J. B. (2015). Person-centered approaches to personality. In M. L. Cooper, & R. Larsen (Eds.), *Handbook of personality processes and individual differences*. American Psychological Association.

Baker, T. J., & Bichsel, J. (2006). Personality predictors of intelligence: Differences between young and cognitively healthy older adults. *Personality and Individual Differences, 41*(5), 861–871.

Baltes, P. B., Lindenberger, U., & Staudinger, U. (2006). Life span theory in developmental psychology. In W. Damon & R. Lerner (Eds.), Handbook of child psychology theoretical models of human development (pp. 569–595).

Baltes, P. B. (1987). Theoretical propositions of life-span developmental psychology: On the dynamics between growth and decline. *Developmental Psychology, 23*(5), 611–626. https://doi.org/10.1037/0012-1649.23.5.611

Bogg, T., & Roberts, B. W. (2004). Conscientiousness and health-related behaviors: A meta-analysis of the leading behavioral contributors to mortality. *Psychological Bulletin, 130*(6), 887–919. https://doi.org/10.1037/0033-2909.130.6.887

Bolger, N., & Laurenceau, J. P. (2013). *Intensive longitudinal methods*. Guilford.

Bond, J., Dickinson, H. O., Matthews, F., Jagger, C., & Brayne, C. (2006). Self-rated health status as a predictor of death, functional and cognitive impairment: A longitudinal cohort study. *European Journal of Ageing, 3*(4), 193–206.

Brim, O. G., Ryff, C. D., & Kessler, R. C. (2004). The MIDUS national survey: An overview. In O. G. Brim, C. D. Ryff, & R. C. Kessler (Eds.), *How healthy are we?: A national study of well-being at midlife* (pp. 1–30). University of Chicago Press.

Cattell, R. B. (1971). *Abilities: Their structure, growth, andaction*. Houghton Mifflin.

Chamorro-Premuzic, T., Furnham, A., & Ackerman, P. L. (2006). Ability and personality correlates of general knowledge. *Personality and Individual Differences, 41*(3), 419–429.

Chamorro-Premuzic, T., Furnham, A., & Petrides, K. (2006). Personality and intelligence: The relationship of Eysenck's Giant Three with verbal and numerical ability. *Journal of Individual Differences, 27*(3), 147–150.

Chapman, B., Duberstein, P., Tindle, H. A., Sink, K. M., Robbins, J., Tancredi, D. J., … Franks, P. (2012). Personality predicts cognitive function over 7 years in older persons. *The American Journal of Geriatric Psychiatry, 20*(7), 612–621.

Chapman, B. P., Hampson, S., & Clarkin, J. (2014). Personality-informed interventions for healthy aging: Conclusions from a National Institute on Aging workshop. *Developmental Psychology, 50*(5), 1426–1441. https://doi.org/10.1038/jid.2014.371

Chen, R., Weuve, J., Misra, S., Cuevas, A., Kubzansky, L. D., & Williams, D. R. (2021). Racial disparities in cognitive function among middle-aged and older adults: The roles of cumulative stress exposures across the life course. *The Journals of Gerontology: Series A*.

Chiou, J. S., & Spreng, R. A. (1996). The reliability of difference scores: A re-examination. *Journal of Consumer Satisfaction Dissatisfaction and Complaining Behavior, 9*, 158–167.

Colcombe, S., & Kramer, A. F. (2003). Fitness effects on the cognitive function of older adults: A meta-analytic study. *Psychological Science, 14*(2), 125–130.

Collins, L. M., & Lanza, S. T. (2009). *Latent class and latent transition analysis: With applications in the social, behavioral, and health sciences*. John Wiley & Sons.

Cotter, K. A., & Lachman, M. E. (2010). No strain, no gain: Psychosocial predictors of physical activity across the adult lifespan. *Journal of Physical Activity and Health, 7*(5), 584–594.

Cronbach, L. J., & Furby, L. (1970). How we should measure "change": Or should we? *Psychological Bulletin, 74*(1), 68–80.

Curtis, R. G., Windsor, T. D., & Soubelet, A. (2015). The relationship between Big-5 personality traits and cognitive ability in older adults – A review. *Aging, Neuropsychology, and Cognition, 22*(1), 42–71.

DeYoung, C. G., Quilty, L. C., Peterson, J. B., & Gray, J. R. (2014). Openness to experience, intellect, and cognitive ability. *Journal of Personality Assessment, 96*(1), 46–52.

DeYoung, C. G., Shamosh, N. A., Green, A. E., Braver, T. S., & Gray, J. R. (2009). Intellect as distinct from Openness: Differences revealed by fMRI of working memory. *Journal of Personality and Social Psychology, 97*(5), 883–892.

Friedman, H. S. (2000). Long-term relations of personality and health: Dynamisms, mechanisms, tropisms. *Journal of Personality, 68*(6), 1089–1107.

Gale, C. R., Mõttus, R., Deary, I. J., Cooper, C., & Sayer, A. A. (2017). Personality and risk of frailty: The English Longitudinal Study of Ageing. *Annals of Behavioral Medicine, 51*(1), 128–136.

Graham, E. K., James, B. D., Jackson, K. L., Willroth, E. C., Boyle, P., Wilson, R., … Mroczek, D. K. (2021). Associations between personality traits and cognitive resilience in older adults. *The Journals of Gerontology: Series B, 76*(1), 6–19.

Graham, E. K., & Lachman, M. E. (2012). Personality stability is associated with better cognitive performance in adulthood: Are the stable more able? *The Journals of Gerontology: Psychological Sciences and Social Sciences, 67*(5), 545–554.

Graham, E. K., & Lachman, M. E. (2014). Personality traits, facets and cognitive performance: Age differences in their relations. *Personality and Individual Differences, 59*, 89–95.

Graham, E. K., Weston, S. J., Gerstorf, D., Yoneda, T. B., Booth, T., Beam, C. R., … Mroczek, D. K. (2020). Trajectories of Big Five Personality Traits: A coordinated analysis of 16 longitudinal samples. *European Journal of Personality., 34*(3), 301–321.
Hakulinen, C., Elovainio, M., Pulkki-Råback, L., Virtanen, M., Kivimäki, M., & Jokela, M. (2015). Personality and depressive symptoms: Individual participant meta-analysis of 10 cohort studies. *Depression and Anxiety, 32*(7), 461–470.
Hock, R. S., Lee, H. B., Bienvenu, O. J., Nestadt, G., Samuels, J. F., Parisi, J. M., … Spira, A. P. (2014). Personality and cognitive decline in the Baltimore Epidemiologic Catchment Area follow-up study. *The American Journal of Geriatric Psychiatry, 22*(9), 917–925.
Hofstee, W. K. B., & Hendriks, A. A. J. (1998). The use of scores anchored at the scale midpoint in reporting individuals' traits. *European Journal of Personality, 12*(3), 219–228.
Hughes, M. L., Agrigoroaei, S., Jeon, M., Bruzzese, M., & Lachman, M. E. (2018). Change in Cognitive Performance From Midlife Into Old Age: Findings from the Midlife in the United States (MIDUS) Study. *Journal of the International Neuropsychological Society, 24*(8), 805–820. https://doi.org/10.1017/S1355617718000425
Infurna, F. J., & Luthar, S. S. (2017a). Parents' adjustment following the death of their child: Resilience is multidimensional and differs across outcomes examined. *Journal of Research in Personality, 68*, 38–53.
Infurna, F. J., & Luthar, S. S. (2017b). The multidimensional nature of resilience to spousal loss. *Journal of Personality and Social Psychology, 112*(6), 926–947.
Jackson, J. J., Hill, P. L., Payne, B. R., Roberts, B. W., & Stine-Morrow, E. A. L. (2012). Can an old dog learn (and want to experience) new tricks? Cognitive training increases openness to experience in older adults. *Psychology and Aging, 27*(2), 286–292.
Jajodia, A., & Borders, A. (2011). Memory predicts changes in depressive symptoms in older adults: A bidirectional longitudinal analysis. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 66B*(5), 571–581.
Jokela, M., Hakulinen, C., Singh-Manoux, A., & Kivimäki, M. (2014). Personality change associated with chronic diseases: Pooled analysis of four prospective cohort studies. *Psychological Medicine, 44*(12), 2629–2640.
Judge, T. A., Higgins, C. A., Thoresen, C. J., & Barrick, M. R. (1999). The big five personality traits, general mental ability, and career success across the life span. *Personnel Psychology, 52*(3), 621–652.
Jung, T., & Wickrama, K. A. (2008). An introduction to latent class growth analysis and growth mixture modeling. *Social and Personality Psychology Compass, 2*(1), 302–317.
Karlamangla, A. S., Miller-Martinez, D., Lachman, M. E., Tun, P. A., Koretz, B. K., & Seeman, T. E. (2014). Biological correlates of adult cognition: Midlife in the United States (MIDUS). *Neurobiology of Aging, 35*(2), 387–394.
Lachman, M. E., Agrigoroaei, S., Murphy, C., & Tun, P. A. (2010). Frequent cognitive activity compensates for education differences in episodic memory. *American Journal of Geriatric Psychiatry, 18*(1), 4–10. https://doi.org/10.1097/JGP.0b013e3181ab8b62
Lachman, M. E., Agrigoroaei, S., Tun, P. A., & Weaver, S. L. (2014). Monitoring cognitive functioning: Psychometric properties of the Brief Test of Adult Cognition by Telephone. *Assessment, 21*(4), 404–417. https://doi.org/10.1177/1073191113508807
Lachman, M. E., & Weaver, S. L. (1997). *The Midlife Development Inventory (MIDI) personality scales*. Scale construction and scoring.
Leibovici, D., Ritchie, K., Ledésert, B., & Touchon, J. (1996). Does education level determine the course of cognitive decline? *Age and Ageing, 25*(5), 392–397. https://doi.org/10.1093/ageing/25.5.392
Letzring, T. D., Edmonds, G. W., & Hampson, S. E. (2014). Personality change at mid-life is associated with changes in self-rated health: Evidence from the Hawaii Personality and Health Cohort. *Personality and Individual Differences, 58*, 60–64.
Levine, D. A., Gross, A. L., Briceño, E. M., Tilton, N., Giordani, B. J., Sussman, J. B., … Galecki, A. T. (2021). Sex differences in cognitive decline among US adults. *JAMA Network Open, 4*(2), e210169. https://doi.org/10.1001/jamanetworkopen.2021.0169
Liu, Y., & Lachman, M. E. (2019). Socioeconomic status and parenting style from childhood: Long-term effects on cognitive function in middle and later adulthood. *The Journals of Gerontology: Series B, 74*(6), e13–e24.
Lord, F. M. (1956). The measurement of growth. *Educational and Psychological Measurement, 16*(4), 421–437.
Lucas, R. E., & Donnellan, M. B. (2011). Personality development across the life span: Longitudinal analyses with a national sample from Germany. *Journal of Personality and Social Psychology, 101*(4), 847–861. https://doi.org/10.1037/a0024298
Luchetti, M., Terracciano, A., Stephan, Y., & Sutin, A. R. (2016). Personality and cognitive decline in older adults: Data from a longitudinal sample and meta-analysis. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 71*(4), 591–601.
Mella, N., Fagot, D., Renaud, O., Kliegel, M., & De Ribaupierre, A. (2018). Individual differences in developmental change: Quantifying the amplitude and heterogeneity in cognitive change across old age. *Journal of Intelligence, 6*(1), 10.
Morin, A. J. S., Meyer, J. P., Creusier, J., & Biétry, F. (2016). Multiple-group analysis of similarity in latent profile solutions. *Organizational Research Methods, 19*(2), 231–254.
Mõttus, R., Johnson, W., Starr, J. M., & Deary, I. J. (2012). Correlates of personality trait levels and their changes in very old age: The Lothian Birth Cohort 1921. *Journal of Research in Personality, 46*(3), 271–278.
Moutafi, J., Furnham, A., & Crump, J. (2006). What facets of openness and conscientiousness predict fluid intelligence score? *Learning and Individual Differences, 16*(1), 31–42.
Mueller, S., Wagner, J., Drewelies, J., Duezel, S., Eibich, P., Specht, J., … Gerstorf, D. (2016). Personality development in old age relates to physical health and cognitive performance: Evidence from the Berlin Aging Study II. *Journal of Research in Personality, 65*, 94–108.
Musek, J. (2007). A general factor of personality: Evidence for the Big One in the five-factor model. *Journal of Research in Personality, 41*(6), 1213–1233.
Muthén, L., & Muthén, B. (2017). *Mplus User's Guide* (8th ed.). Muthén & Muthén.
Nylund, K. L., Asparouhov, T., & Muthén, B. O. (2007). Deciding on the number of classes in latent class analysis and growth mixture modeling: A Monte Carlo simulation study. *Structural Equation Modeling: A Multidisciplinary Journal, 14*(4), 535–569.
Pinheiro, J., Bates, D., DebRoy, S., Sarkar, D., & Team, R. C. (2020). nlme: Linear and Nonlinear Mixed Effects Models. R package version 3.1-148, https://CRAN.R-project.org/package=nlme.
Poon, L. W., Martin, P., Clayton, G. M., Messner, S., Noble, C. A., & Johnson, M. A. (1992). The influences of cognitive resources on adaptation and old age. *International Journal of Aging & Human Development, 34*(1), 31–46.
R Core Team. (2020). *A Language and Environment for Statistical Computing*. Vienna: Austria. Available at: https://www.R-project.org/.
Radler, B. T., & Ryff, C. D. (2010). Who participates? Accounting for longitudinal retention in the MIDUS national study of health and well-being. *Journal of Aging and Health, 22*(3), 307–331. https://doi.org/10.1177/0898264309358617
Rammstedt, B., Lechner, C., & Danner, D. (2018). Relationships between personality and cognitive ability: A facet-level analysis. *Journal of Intelligence, 6*(2), 28–41.
Reas, E. T., Laughlin, G. A., Bergstrom, J., Kritz-Silverstein, D., Barrett-Connor, E., & McEvoy, L. K. (2017). Effects of sex and education on cognitive change over a 27-year period in older adults: The Rancho Bernardo Study. *The American Journal of Geriatric Psychiatry, 25*(8), 889–899.
Reuter-Lorenz, P. A., Festini, S. B., & Jantz, T. K. (2016). Executive functions and neurocognitive aging. In *Handbook of the Psychology of Aging* (pp. 245–262). Academic Press.
Rey, A. (1964). *The clinical examination in psychology*. Presses Universitaries De France.
Roberts, B. W., Luo, J., Briley, D. A., Chow, P. I., Su, R., & Hill, P. L. (2017). A systematic review of personality trait change through intervention. *Psychological Bulletin, 143*(2), 117–141. https://doi.org/10.1037/bul0000088
Roberts, B. W., & Mroczek, D. (2008). Personality trait change in adulthood. *Current Directions in Psychological Science, 17*(1), 31–35.
Roberts, B. W., Walton, K. E., & Viechtbauer, W. (2006). Patterns of mean-level change in personality traits across the life course: A meta-analysis of longitudinal studies. *Psychological Bulletin, 132*(1), 1–25. https://doi.org/10.1037/0033-2909.132.1.1
Robins, R. W., John, O. P., Caspi, A., Moffitt, T. E., & Stouthamer-Loeber, M. (1996). Resilient, overcontrolled, and undercontrolled boys: Three replicable personality types. *Journal of Personality and Social Psychology, 70*(1), 157–171.
Robinson, S. A., & Lachman, M. E. (2018). Perceived control and cognition in adulthood: The mediating role of physical activity. *Psychology and Aging, 33*(5), 769–781.
Rogosa, D. (1995). Myths and methods: "Myths about longitudinal research" plus supplemental questions. In J. M. Gottman (Ed.), *The analysis of change*. Erlbaum.
Rogosa, D. R., & Willett, J. B. (1983). Demonstrating the reliability of the difference score in the measurement of change. *Journal of Educational Measurement*, 335–343.
Roy, S., Drake, A., Fuchs, T., Dwyer, M. G., Zivadinov, R., Chapman, B. P., … Benedict, R. HB. (2018). Longitudinal personality change associated with cognitive decline in multiple sclerosis. *Multiple Sclerosis Journal, 24*(14), 1909–1912.
Salthouse, T. A. (2009). Decomposing age correlations on neuropsychological and cognitive variables. *Journal of the International Neuropsychological Society, 15*(5), 650–661.
Salthouse, T. A. (2010). Selective review of cognitive aging. *Journal of the International Neuropsychological Society, 16*(5), 754–760.
Salthouse, T. A. (2014). Correlates of cognitive change. *Journal of Experimental Psychology: General, 143*(3), 1026–1048.
Schaie, K. W. (1996). *Intellectual development in adulthood: The Seattle longitudinal study*. Cambridge University Press.
Schaie, K. W., Willis, S. L., & Caskie, G. I. L. (2004). The Seattle longitudinal study: Relationship between personality and cognition. *Aging Neuropsychology and Cognition, 11*(2-3), 304–324.
Segel-Karpas, D., & Lachman, M. E. (2018). Social contact and cognitive functioning: The role of personality. *The Journals of Gerontology: Series B, 73*(6), 974–984.
Sorić, I., Penezić, Z., & Burić, I. (2017). The Big Five personality traits, goal orientations, and academic achievement. *Learning and Individual Differences, 54*, 126–134.
Stephan, Y., Sutin, A. R., Luchetti, M., & Terracciano, A. (2020). Personality and memory performance over twenty years: Findings from three prospective studies. *Journal of Psychosomatic Research, 128*, 109885. https://doi.org/10.1016/j.jpsychores.2019.109885
Stephan, Y., Sutin, A. R., Luchetti, M., & Terracciano, A. (2021). Memory and personality development in adulthood: Evidence from four longitudinal studies. *The Journals of Gerontology: Series B, 76*(1), 88–97.
Stephan, Y., Sutin, A. R., & Terracciano, A. (2014). Physical activity and personality development across adulthood and old age: Evidence from two longitudinal studies. *Journal of Research in Personality, 49*, 1–7.
Stern, Y. (2009). Cognitive reserve. *Neuropsychologia, 47*(10), 2015–2028. https://doi.org/10.1016/j.neuropsychologia.2009.03.004
Stieger, M., Allemand, M., & Lachman, M. E. (2021). Targeting self-control as a behavior change mechanism to increase physical activity: Study protocol of a randomized controlled trial. *Contemporary Clinical Trials, 100*, 106236. https://doi.org/10.1016/j.cct.2020.106236
Stieger, M., Flückiger, C., Rüegger, D., Kowatsch, T., Roberts, B. W., & Allemand, M. (2021). Changing personality traits with the help of a digital personality change intervention. *Proceedings of the National Academy of Sciences, 118*(8).
Stieger, M., Nißen, M., Rüegger, D., Kowatsch, T., Flückiger, C., & Allemand, M. (2018). PEACH, a smartphone- and conversational agent-based coaching intervention for

intentional personality change: Study protocol of a randomized, wait-list controlled trial. *BMC Psychology, 6*(1), 1–15. https://doi.org/10.1186/s40359-018-0257-9

Stieger, M., Robinson, S. A., Bisson, A. N., & Lachman, M. E. (2020). The relationship of personality and behavior change in a physical activity intervention: The role of conscientiousness and healthy neuroticism. *Personality and Individual Differences, 166* (March), Article 110224. https://doi.org/10.1016/j.paid.2020.110224

Stieger, M., Wepfer, S., Rüegger, D., Kowatsch, T., Roberts, B. W., & Allemand, M. (2020). Becoming more conscientious or more open to experience? Effects of a two-week smartphone-based intervention for personality change. *European Journal of Personality, 34*(3), 345–366.

Sutin, A. R., Stephan, Y., Damian, R. I., Luchetti, M., Strickhouser, J. E., & Terracciano, A. (2019). Five-factor model personality traits and verbal fluency in 10 cohorts. *Psychology and Aging, 34*(3), 362–373.

Terracciano, A., Stephan, Y., Luchetti, M., Albanese, E., & Sutin, A. R. (2017). Personality traits and risk of cognitive impairment and dementia. *Journal of Psychiatric Research, 89*, 22–27.

Terracciano, A., Sutin, A. R., An, Y., O'Brien, R. J., Ferrucci, L., Zonderman, A. B., & Resnick, S. M. (2014). Personality and risk of Alzheimer's disease: New data and meta-analysis. *Alzheimer's & Dementia, 10*(2), 179–186.

Thomas, D. R., & Zumbo, B. D. (2012). Difference scores from the point of view of reliability and repeated-measures ANOVA: In defense of difference scores for data analysis. *Educational and Psychological Measurement, 72*(1), 37–43.

Tromp, D., Dufour, A., Lithfous, S., Pebayle, T., & Després, O. (2015). Episodic memory in normal aging and Alzheimer disease: Insights from imaging and behavioral studies. *Ageing Research Reviews, 24*, 232–262.

Tun, P. A., & Lachman, M. E. (2006). Telephone assessment of cognitive function in adulthood: The Brief Test of Adult Cognition by Telephone. *Age and Ageing, 35*(6), 629–632.

Tun, P. A., & Lachman, M. E. (2008). Age differences in reaction time and attention in a national telephone sample of adults: Education, sex, and task complexity matter. *Developmental Psychology, 44*(5), 1421–1429. https://doi.org/10.1037/a0012845

van der Linden, D., Pekaar, K. A., Bakker, A. B., Schermer, J. A., Vernon, P. A., Dunkel, C. S., & Petrides, K. V. (2017). Overlap between the general factor of personality and emotional intelligence: A meta-analysis. *Psychological Bulletin, 143* (1), 36–52.

Von Stumm, S., & Deary, I. J. (2013). Intellect and cognitive performance in the Lothian Birth Cohort 1936. *Psychology and Aging, 28*(3), 680–684.

Wagner, J., Ram, N., Smith, J., & Gerstorf, D. (2016). Personality trait development at the end of life: Antecedents and correlates of mean-level trajectories. *Journal of Personality and Social Psychology, 111*(3), 411–429.

Ware, J. E., Jr, & Sherbourne, C. D. (1992). The MOS 36-item short-form health survey (SF-36): I. Conceptual framework and item selection. *Medical Care*, 473–483.

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, 32*(3), 259–277.

Wettstein, M., Tauber, B., & Wahl, H.-W. (2020). Associations between cognitive abilities and 20-year personality changes in older adults in the ILSE study: Does health matter? *The Journals of Gerontology: Series B, 75*, 1206–1218.

Wettstein, M., Wahl, H. W., Siebert, J., & Schröder, J. (2019). Still more to learn about late-life cognitive development: How personality and health predict 20-year cognitive trajectories. *Psychology and Aging, 34*(5), 714–728.

Williams, P. G., Suchy, Y., & Kraybill, M. L. (2010). Five-factor model personality traits and executive functioning among older adults. *Journal of Research in Personality, 44* (4), 485–491.

Williams, P. G., Suchy, Y., & Kraybill, M. L. (2013). Preliminary evidence for low openness to experience as a pre-clinical marker of incipient cognitive decline in older adults. *Journal of Research in Personality, 47*(6), 945–951.

Willis, S. L., & Boron, J. B. (2008). Midlife cognition: The association of personality with cognition and risk of cognitive impairment. In Handbook of cognitive aging: Interdisciplinary perspectives (pp. 647–660).

Wilson, R. S., Scherr, P. A., Schneider, J. A., Tang, Y., & Bennett, D. A. (2007). Relation of cognitive activity to risk of developing Alzheimer disease. *Neurology, 69*(20), 1911–1920. https://doi.org/10.1212/01.wnl.0000271087.67782.cb

Wood, P., & Englert, P. (2009). Intelligence Compensation Theory: A critical examination of the negative relationship between conscientiousness and fluid and crystallised intelligence. *Australian and New Zealand Journal of Organisational Psychology, 2*, 19–29.

Yoneda, T., Rush, J., Graham, E. K., Berg, A. I., Comijs, H., Katz, M., … Piccinin, A. M. (2020). Increases in neuroticism may be an early indicator of dementia: A coordinated analysis. *The Journals of Gerontology Series B, 75*(2), 251–262.

Ziegler, M., Cengia, A., Mussel, P., & Gerstorf, D. (2015). Openness as a buffer against cognitive decline: The Openness-Fluid-Crystallized-Intelligence (OFCI) model applied to late adulthood. *Psychology and Aging, 30*(3), 573–588.

Ziegler, M., Danay, E., Heene, M., Asendorpf, J., & Bühner, M. (2012). Openness, fluid intelligence, and crystallized intelligence: Toward an integrative model. *Journal of Research in Personality, 46*(2), 173–183.