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Associations Between Personality Traits, Leisure Activities and Cognitive Levels and Decline Across 12 Years in Older Adults

Gabriel Olaru[1], Erika J. Laukka[2,3], Serhiy Dekhtyar[2], Arian Sarwary[1], & Yvonne Brehmer[1,2]

[1] Developmental Psychology, Tilburg University, Netherlands

[2]Aging Research Center, Karolinska Institutet and Stockholm University, Stockholm, Sweden

[3] Stockholm Gerontology Research Center, Stockholm, Sweden

Author Note

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Correspondence concerning this article should be addressed to

Email: r.g.olaru@tilburguniversity.edu

Abstract

The engagement in cognitively stimulating activities has been found to be associated with slower rates of cognitive decline in old age. In which type of activities people engage in arguably depends partly on their personality traits, which thus might have an impact on later cognitive fitness. To study these potential associations, we examined the associations between Neuroticism, Extraversion and Openness, different types of leisure activities (e.g., social, mental, physical), and cognitive ability levels and decline in older adults. Analyses were based on a sample of young-old (60 to 72 years old; n = 1,609) and old-old (78 years or older; n = 1,085) adults from the Swedish National Study on Aging and Care in Kungsholmen (SNAC-K), who participated in up to five repeated measurements of cognitive abilities spanning 12 years. We used latent growth curve models to estimate cognitive levels and decline, as well as the associations with initial personality trait levels and leisure activity engagement. In both groups, lower Neuroticism, higher Extraversion and higher Openness levels were moderately associated with stronger engagement in all types of activities. Lower Neuroticism, higher Extraversion and a more activity lifestyle were weakly to moderately associated with slower cognitive decline in the old-old age group. There, personality traits and activities explained 9.3% of the variance in cognitive decline after controlling for age, sex, education and chronic diseases (which explained 9.0%). Taken together, this study provides further evidence for the associations of personality traits and activity engagement with later cognitive decline in old age.

Keywords

Cognitive decline; Personality traits; Leisure activities; Ageing; Older adults

The steady increase of the older adult population around the world and its implications for societies has become subject to extensive public and scholarly debate (Uhlenberg, 2009). Age is the strongest predictor for multi-morbidity and dementia, however also healthy aging is characterized by personal and emotional challenges as well as cognitive decline (Salthouse, 2009; Rönnlund et al., 2005). Ageing successfully is often conceptualized as a maximization of gains and minimization of losses (Baltes et al., 1998). Models and theories on successful aging vary on several dimensions, however most of them agree that maintaining cognitive abilities and engagement with life are central aspects (e.g., Rowe & Kahn, 2015; Martin & Kliegel, 2014). A high engagement in social, mental, and physical activities may also be one way to maintain cognitive abilities in old age (Herzog et al., 2008; Köhncke et al., 2017; Lee et al., 2019; Nyberg & Pudas, 2019). Personality traits have been reported to be associated with the rate of cognitive decline (Curtis et al., 2015; Luchetti et al., 2016). A possible explanation is that they affect the degree to which people engage in cognitively stimulating or health behaviors. However, studies linking personality traits, engagement in activities, and cognitive decline in old age are lacking so far. In this study, we examined whether the personality traits Neuroticism, Extraversion, and Openness, as well as engagement in social, mental and physical leisure activities predict rates of cognitive decline.

Cognitive decline in old age

Cognitive abilities such as episodic memory (Head et al., 2008), reasoning (Singh-Manoux et al., 2012), verbal fluency (Albert, et al., 1988), and executive functions (Kennedy & Raz, 2009) generally decline after 60 years of age. This decline is primarily observable in the *mechanics* or *fluid* components of intelligence, related to attention control and basic information processing (e.g., Baltes, 1987; Deary et al., 2010). The *pragmatics* or *crystalized* components of intelligence, representing knowledge, are generally maintained longer or decrease at a slower rate (e.g., Salthouse, 2019). Age-related cognitive decline exhibits significant interindividual variability (Wilson et al., 2020), which can be partly explained by inter-individual differences in genes, education, health behaviors, chronic diseases, and engagement in physical, social, or cognitively stimulating activities (e.g., Deary et al., 2004; Herzog et al., 2008; Lopez et al., 2003; Mangialasche et al., 2012; Nyberg & Pudas, 2019).

Associations Between Activity Engagement and Cognition

An active engagement in various (leisure) activities has been associated with cognitive ability levels and also a reduced subsequent cognitive decline or likelihood of cognitive impairment or dementia (Fallahpour et al., 2016; Hertzog et al., 2008; Köhncke et al., 2017; Newton et al., 2018; Nyberg & Pudas, 2019; Stine-Morrow & Manavbasi, 2022; Yates et al., 2016). While the associations with cognitive ability levels may be primarily driven by cognitively fitter individuals having more resources to maintain an active lifestyle, the effect of activity on cognitive decline is assumed to be, at least partly, due to the activity engagement improving cognitive reserve (i.e., increase neuronal capacity, efficiency, and adaptability; Katzman, 1993; Tucker-Drob et al., 2009). This positive effect of activity engagement on maintaining cognitive abilities has also been referred to as the “use it or lose it” hypothesis (for a review see Stine-Morrow & Manavbasi, 2022), arguing that cognitive resources can be maintained through the engagement in cognitively stimulating activities. In line with this assumption, mentally stimulating activities have been shown to be associated with slower cognitive decline, with some studies also showing benefits of engaging in social and physical activities (Fallahpour et al., 2016; Hertzog et al., 2008; Köhncke et al., 2017; Newton et al., 2018; Nyberg & Pudas, 2019; Stine-Morrow & Manavbasi, 2022; Yates et al., 2016) or in a higher activity diversity (Bielak et al., 2019; Carlson et al., 2012; Rizzuto et al., 2017). However, whereas a positive association between activity and cognitive ability levels were commonly found, some studies could not find significant associations between activity levels and subsequent cognitive decline (e.g., Bielak et al., 2012; Gow et al., 2014; Mitchell et al., 2012; Salthouse et al., 2006).

Engagement in leisure activities is generally measured with scales asking participants to report the frequency with which they engage in a list of activities. To examine whether specific types of activities are more strongly associated with cognitive decline, activities are clustered based on participants' ratings (e.g., Köhncke et al., 2016), based on theoretical considerations (e.g., Friedland et al., 2001; Wang et al., 2002), or data-driven approaches (e.g., principal component analysis on activity engagement frequency; Jopp & Hertzog, 2007; Paillard-Borg et al., 2009). One challenge with clustering activities into different types (e.g., social, mental) is that some activities may represent several such types. For instance, participating in a study circle or playing games may be both social and mentally stimulating (see Köhncke et al., 2016; Stine-Morrow & Manavbasi, 2022). As such, alternatives to these approaches could be to allocated activities to several clusters or examine the effects of individual activities (e.g., only an effect of reading books, computer use and playing games had an effect of later cognition; Shin et al., 2021) Apart from specific types, some studies have argued that the variety or number of activities engaged in is also relevant index for activity engagement (Bielak et al., 2019; Carlson et al., 2012; Rizzuto et al., 2017).

Associations Between Personality Traits and Cognitive Ability Levels

Personality traits represent an individual's characteristic way of acting, thinking and feeling, and can have an impact on cognition through the way people experience and interact with their environment (von Stumm & Ackerman, 2013). Studies examining the cross-sectional associations between personality traits and cognitive abilities levels in old age generally found some, albeit weak, correlations. Openness, the tendency to seek out novel and cognitively stimulating experiences, and a higher sensitivity to new ideas or art, has been reported to be positively associated with general cognitive ability (e.g., Austin et al., 2002), fluid intelligence (e.g., Graham & Lachman, 2012), and episodic memory performance (e.g., Aiken-Morgan et al., 2012). Neuroticism, the tendency to experience patterns of negative emotions or thoughts, has been reported to be negatively associated with general cognitive functioning (Wilson et al., 2003), fluid intelligence (Soubelet & Salthouse, 2011) and memory (Gow et al., 2005). Extraversion is generally characterized by having a high reward sensitivity, seeking out social stimulation or excitement, and experiencing more positive affect. The associations of Extraversion and cognitive abilities are mixed and seem to be more domain specific (Baker & Bichsel, 2006; Moutafi, et al., 2003; Soubelet & Salthouse, 2011): Higher extraversion has been linked to better performance on speed-related tasks (Pearman, 2009) but also to weaker performance on reasoning tasks (Graham & Lachman, 2012).

Several potential pathways have been suggested as explanations for the associations between personality traits and cognition (for an overview, see Curtis et al., 2015). For example, Neuroticism may have a negative association with cognitive ability levels because of test anxiety, distraction by worry-related thoughts, or higher experienced stress levels. In particular, the more frequent and intense experience of stress has been suggested to drive the negative association between Neuroticism and cognitive abilities (Lupien et al., 2007; Mangold & Wand, 2006). The positive emotions associated with Extraversion have been suggested as a reason how Extraversion can contribute to a better encoding of information (e.g., better episodic memory;

Allen et al., 2011), but may also lead to a lower performance in other cognitive domains through a higher distractibility or need for stimulation (e.g., Gold & Arbuckle, 1990). For Openness, a stronger tendency to engage in and enjoy thinking (i.e., need for cognition; Cacioppo & Petty, 1982; Sadowski & Cogburn, 1997) may partly explain why highly open individuals also show higher cognitive ability levels.

However, it is also possible that these associations are driven by cognitive abilities affecting personality traits. For instance, people with lower intelligence levels may find novel situations more challenging and thus be less open than more intelligent individuals (Moutafi et al., 2003). In contrast, people with a higher capacity to process novel information may have a stronger enjoyment of thinking or engagement in various cognitively stimulating activities, and thus higher Openness. For example, one study showed that participants participating in a cognitive intervention subsequently also increased in their Openness levels (Jackson et al., 2012). People with higher intelligence levels may also be better able to regulate their emotions (Laborde et al., 2014; Peña-Sarrionandia et al., 2015; Zysberg & Raz, 2019) or feel less overwhelmed by challenging situations in life, which might result in lower Neuroticism levels.

Associations Between Personality Traits and Cognitive Decline

A smaller number of studies examined the associations between personality traits and cognitive decline. Most notably, higher Neuroticism seemed to predict faster rates of decline in cognitive abilities, whereas higher Openness and Conscientiousness predicted slower rates of cognitive decline (Chapman et al., 2012; Luchetti et al., 2016; Terraciano et al., 2017; Ziegler et al., 2015). However, these associations were generally rather weak and did not replicate across all studies (see e.g., Aschwanden et al., 2017; Hock et al., 2014; Wettstein et al., 2017). Previous findings on Extraversion and cognitive decline were mixed, with more recent studies reporting a negative association (i.e., higher Extraversion was associated with faster cognitive decline; Chapman et al., 2012; Luchetti et al., 2016).

The associations between Neuroticism and subsequent cognitive decline or dementia risk have been frequently explained through a higher exposure to stress (see also transactional model of stress and coping; Folkman, 2008; Lazarus, 2006). More neurotic individuals tend to experience potentially stressful situations as more stressful and are also less able to regulate stress by using more maladaptive coping strategies (Lee-Baggley et al., 2005; OBrien & DeLongis, 1996). The higher exposure to stress has been shown to predict increased risks for dementia and faster cognitive decline, arguably due to the chronic exposure to stress hormones resulting in higher neuronal damage over time (Boyle et al., 2010; Chapman et al., 2012; Curtis et al, 2015; Magri et al., 2006). Apart from stress, one of the main pathways of how personality traits are assumed to affect health is through differences in the engagement in various health-related behaviors (e.g., substance use, exercise, diet, or doctoral visits; Atherton et al., 2014; Bogg & Roberts, 2004; see also health behavior model; Smith, 2006). These personality-related differences in health behaviors have shown to partly explain the associations between personality and health outcomes, such as mortality risk (Turiano et al., 2012). A similar effect of personality traits on cognitive abilities have been suggested, as personality traits affect which activities people engage in (e.g., extraverted people being more social) and consequently later cognitive decline (for reviews, see Curtis et al., 2015; Hertzog et al., 2008; Stine-Morrow & Manavbasi, 2022).

Highly open individuals are characterized by the tendency to seek out novel and cognitively stimulating experiences, and this trait has been shown to be positively associated with the engagement in cognitively stimulating activities in older adults (Hultsch et al., 1999;

Soubelet & Salthouse, 2010). Highly extraverted individuals are generally more socially active and seek out social stimulation more often. In line with this, Extraversion has been shown to be positively associated with the likelihood of engaging in social activities in older adults (Newton et al., 2018; Stephan et al., 2014). While the Neuroticism associations have been primarily assumed to be due to stress or mental health, we assume that higher Neuroticism levels in old age may also result in a higher fear of engaging in potentially dangerous or challenging activities, as this trait has also been linked to a lower engagement in physical activities in older adults (Canada et al., 2021). The negative association between Neuroticism and cognitive abilities may thus also partly be due a disengagement from potentially buffering activities. Despite differences in activity engagement being suggested as one of the main pathways by which personality traits can affect cognitive decline in old age, research examining these associations together is still lacking to date.

The present study

The goal of this study was to examine whether personality traits and the engagement in leisure activities are associated with cognitive ability levels and decline across 12 years in a sample of older adults (i.e., 60 years of age and older). We examined the relationship between three personality traits (i.e., Neuroticism, Extraversion, and Openness), a general cognitive ability composite consisting of five specific cognitive abilities (i.e., episodic memory, perceptual speed, semantic memory, letter fluency, and category fluency), and several types of activities based on participants ratings or previous literature (i.e., social; mental; physical; Köhncke et al., 2016; Rizzuto et al., 2017). More specifically, we investigated whether personality traits and activity engagement assessed at the first measurement occasion were associated with cognitive ability levels and decline across 12 years.

With respect to mean-level change, we expected to find decline in the cognitive abilities with increasing age. For both cognitive levels and decline, we expected negative associations with Neuroticism (Chapman et al., 2012; Luchetti et al., 2016), but positive associations with Openness (DeYoung et al., 2005; Gregory et al., 2010; Luchetti et al., 2016). Previous findings on the association between Extraversion and cognitive abilities were mixed, thus we expected no association with Extraversion. With respect to activities, we expected a negative relationship between Neuroticism and physical activities, as these represent activities that can be perceived as potentially dangerous or challenging by people with higher Neuroticism levels. For Extraversion, we expected a positive association with social activity types. For Openness, we expected a positive association with mentally demanding activities. Finally, for the relationship between cognitive abilities and activities, we expected both cognitive ability levels and decline to be primarily associated with mental activities (Fallahpour et al., 2016; Hertzog et al., 2008; Lee et al., 2019; Wang et al., 2006), but also to a lesser extent to physical and social engagement types (Fallahpour et al., 2016; Hertzog et al., 2008; Köhncke et al., 2017).

Methods

Transparency and Openness

We report how we determined our sample size, and describe all data exclusions, manipulations, and all measures in the study. Analyses code supplementary materials are available in an Open Science Framework (OSF) repository (https://osf.io/sgbk7/). We used data from the Swedish National Study on Aging and Care in Kungsholmen (SNAC-K) (Lagergren et al., 2004). All analyses were run in R version 4.1.3 (R Core Team, 2022) with the R packages ggplot2 (Wickham, 2016), haven (Wickham et al., 2022), lavaan (Rosseel; 2012), and psych (Revelle, 2022). This study's design and its analysis were not pre-registered. All phases of the

SNAC-K data collection were approved by the Karolinska Institutet Ethics Committee and the Regional Ethical Review Board in Stockholm.

Sample and Procedure

This study used data from the Swedish National Study on Aging and Care in Kungsholmen (SNAC-K) (Lagergren et al., 2004). SNAC-K is an ongoing longitudinal study conducted in Stockholm, Sweden. The study sample consists of older adults (i.e., 60 years and older) living on the island of Kungsholmen either at home or in institutions. The participants were gathered using a stratified sampling method based on age and were followed for 12 years with repeated measures every 3 or 6 years (more frequent for older participants). Interviews, clinical examinations, and neuropsychological tests were administered by nurses, physicians, and psychologists.

Of the 3,363 participants who participated in the first assessment in 2001-2003, we selected those who, at the beginning of the study, completed the cognitive test battery, and were not diagnosed with dementia or other neurological diseases. The remaining 2,694 participants represented five age cohorts (i.e., 60, 66, 72, 78, 81+ years at the first measurement occasion), who were followed for up to 12 years. Personality traits and the engagement in leisure activities were measured at baseline for all participants. The number of participants per age cohort and measure used in this study is presented in Table 1.

Table 1

Number of Participants per Age Cohort and Measure

Cohort	Personality traits	Leisure activities	Cognitive abilities				
	Wave 1 2001-03	Wave 1 2001-03	Wave 1 2001-03	Wave 2 2004-06	Wave 3 2007-09	Wave 4 2010-12	Wave 5 2013-15
60 years	596	653	678		546		450
66 years	466	488	504		382		293
72 years	392	410	427		303		175
78 years	351	385	397	287	215	155	89

81+ years	521	650	688	391	253	149	61
Total	2,326	2,586	2,694	678	1,699	535	1,068

Because cognitive abilities were measured every 6 years for the 60, 66 and 72-year cohort, but every three years for the 78- and 81(+)-year cohort (i.e., to account for more rapid change and higher attrition), we ran the analyses separately for the two groups—unless otherwise specified (i.e., unless we mention *total sample*). In the following, we will refer to the younger cohorts as *young-old* group, and the older cohorts as *old-old* group. Of the 1,609 young-old and 1,085 old-old participants, 919 (57.1%) and 751 (69.2%) were female, respectively. Participants' average age at the first measurement occasion was 65.57 (*SD* = 4.83) years in the young-old group, and 83.62 (*SD* = 5.35) years in the old-old group. The average years of education reported were 13.15 (*SD* = 4.16; young-old) and 10.49 (*SD* = 3.82; old-old) years. Participants reported an average of 1.63 (*SD* = 1.63; young-old) and 3.73 (*SD* = 2.39; old-old) chronic diseases at baseline. Descriptive statistics for the demographic variables and all (unstandardized) scales used in this study are presented in OSF Table S1. Ethnicity was not assessed in this study, but 90% of participants reported to be born in Sweden (with remaining participants being predominantly from neighbouring Scandinavian countries). Of the sample, 93% reported that Swedish was their native language. Due to the time frame and geographic location of the data collection, the ethnicity of the sample is likely to be overwhelmingly white Northern European.

Measures

Personality traits

The personality traits Neuroticism, Extraversion, and Openness were assessed at the initial measurement occasion in 2001-2003 using the corresponding 36 items out of the 60-items NEO Five-factor inventory (McCrae & Costa, 2004) translated into Swedish (Källmen et al., 2011). Participants judged the statements using a 3-point Likert scale including “Disagree”, “Neither”, and “Agree”. Each factor was assessed by 12 items. In the total sample, the Cronbach’s alpha/McDonald’s omega of Neuroticism was $\alpha = .82$ / $\omega = .83$, Extraversion $\alpha = .78$ / $\omega = .78$, and Openness $\alpha = .65$ / $\omega = .66$. Agreeableness and Conscientiousness were not measured at baseline in the panel study, which is why we did not include them in the current study.

Cognitive abilities

A cognitive test battery was administered at all measurement occasions by trained psychologists assessing five cognitive domains, namely episodic memory, perceptual speed, semantic memory, letter fluency, and category fluency (Laukka et al., 2020). Each domain except for semantic memory—which was measured with only one test—was measured with two different tests, which are described in detail below.

Episodic Memory. *Word recall* and *word recognition* was assessed with the same task material (Laukka et al., 2013). Participants were presented, orally and visually, with 16 unrelated concrete nouns. Right after encoding, participants were asked to freely recall all words they remembered from the learning list within two minutes. The number of correctly recalled words represented the score for word recall. Afterwards, participants were given a self-paced word recognition task. Participants were presented with 16 target words randomly mixed with 16 distractors and were asked to indicate whether they recognised the word from the previous list. Performance in word recognition was assessed as the number of correctly recognized targets minus falsely recognized lures (hits – false alarms).

Perceptual Speed. Perceptual speed was assessed with two paper-and-pencil tests. In *digit cancellation* (Zazzo, 1974), participants were asked to cross out all 4s encountered in rows of numbers. The score of a participant was equivalent to the amount of 4s he or she had managed to cross out in 30 seconds. In *pattern comparison* (Salthouse & Babcock, 1991), the objective was to compare line-segment patterns and identify whether a pair of line-segments was “same” or “different”. The task consisted of two pages and participants were given 30 seconds per page. The mean number of correct classifications across the two pages represented individuals’ performance.

Semantic Memory. SRB:1 (Dureman, 1960; Nilsson et al., 1997) is a 30-item vocabulary test where, in a set of 5 words, participants were asked to underline the synonym of a target word. The score used was the amount of correctly identified synonyms within seven minutes.

Letter fluency. Within a 60 second timeframe participants were requested to generate as many words as possible starting with the letter F or A, respectively. The number of unrepeated and correct words was registered for each letter.

Category fluency. Within a 60 second timeframe participants were requested to generate as many words as possible belonging to the category of animals or professions. The number of unrepeated and correct words was registered for each category.

A parallel analysis (Auerswald & Moshagen, 2019; Horn, 1965) of the five cognitive domain scores at the first measurement occasion—conducted on the total sample—suggested one principal component with loadings ranging from $\lambda = .64$ (episodic memory) to $\lambda = .83$ (category fluency) and a total explained variance of 56%. When extracting more principal components (or factors with exploratory factor analysis), cross-loadings were high and patterns difficult to interpret. As such, we computed a total cognitive ability score for the subsequent analysis.

Engagement in Activities

In the first wave (i.e., baseline), participants were asked how much they had engaged in 28 activities (e.g., doing car repairs, playing bingo, going hunting or fishing, reading books, light exercise) during the last 12 months using a 4-point Likert scale ranging from 0 = “never” to 3 = “every week”. A group of 78 older adults (60-93 years of age; Köhncke et al., 2016) rated the 28 activities on how “social/interactive”, “mentally demanding”, and “physically demanding” they were on a 4-point Likert scale ranging from 0 = not to 3 = very. Raters were asked to only provide ratings for activities that they had pursued during the last 12 months. Because there is no clear agreement in how leisure activities should be grouped (see Stine-Morrow & Manavbasi, 2022; Yates et al., 2016), we compared three activity clustering approaches (for activity ratings, which activities were allocated to which cluster, and correlations between clusters see OSF Table S2 and OSF Figure S1):

First, we allocated each activity to a (1) social, (2) mental, or (3) physical cluster (see also Köhncke et al., 2016; Rizzuto et al., 2017) if the corresponding average component rating was higher than 1. Because some activities had high scores in several demand types (e.g., study circle was rated to be both social and mentally demanding), activities could be allocated to more than one cluster. All activities except for listening to music and watching TV were assigned to the social, mental and physical cluster. We refer to these clusters as the *rating clusters* in the following.

Second, we used the activity clusters created by Köhncke and colleagues (2016) using a hierarchical cluster analysis on the same activity ratings as used in this study. They found a social, complex (i.e., mentally and socially demanding), physical and low-level activity cluster. The low-level activity cluster generally represented less demanding activities than those allocated to the other clusters (e.g., low-level: reading books vs. mental: study circle). Contrary to our approach, they allocated each activity to only one of the clusters.

Third, we used the social, mental, physical activity scores by Rizzuto and colleagues (2017), which were created based on theoretical considerations regarding the activity demands. In contrast to the other activity scores, these do not represent the average engagement in the activities, but the number of activities the older adults engage in. Rizzuto and colleagues (2017) also computed an index of activity engagement diversity. This index is based on the number of the three activity domains the participants regularly engaged in (i.e., social, mental, physical; ranging from 0 to 3).

Health

Health was included as a covariate in the analyses. It was measured as number of chronic diseases, assessed through self-report, the medical examination, medication lists, blood tests, or diagnosis in the Swedish National Patient Register (Calderon-Larrañaga et al., 2017).

Statistical Analyses

Based on the effect sizes commonly found for individual differences (Gignac & Szodorai, 2016), we considered a correlation of $r \geq .10$ to be small, $r \geq .20$ to be moderate, and $r \geq .30$ to be large. We provide exact p-values for all analyses conducted.

For the analyses in this study, we used standardized scores for cognition. We computed T-scores (i.e., $M = 50$; $SD = 10$) for each measurement occasion based on the mean and standard deviation of the scores at the first measurement occasion of the corresponding age group (i.e., young-old and old-old, separately). We averaged the standardized scores of the two subtasks for each cognitive domain (except semantic memory for which only one measure was available). This resulted in a total of five cognitive scores (i.e., episodic memory, perceptual speed, semantic memory, letter fluency, and category fluency) at five measurement occasions. To form the total cognitive ability scores, we averaged the five cognitive scores at each wave. For the personality traits and activities, we z-standardized the scores from the first wave (i.e., baseline measure) for each age group (i.e., young-old and old-old) separately.

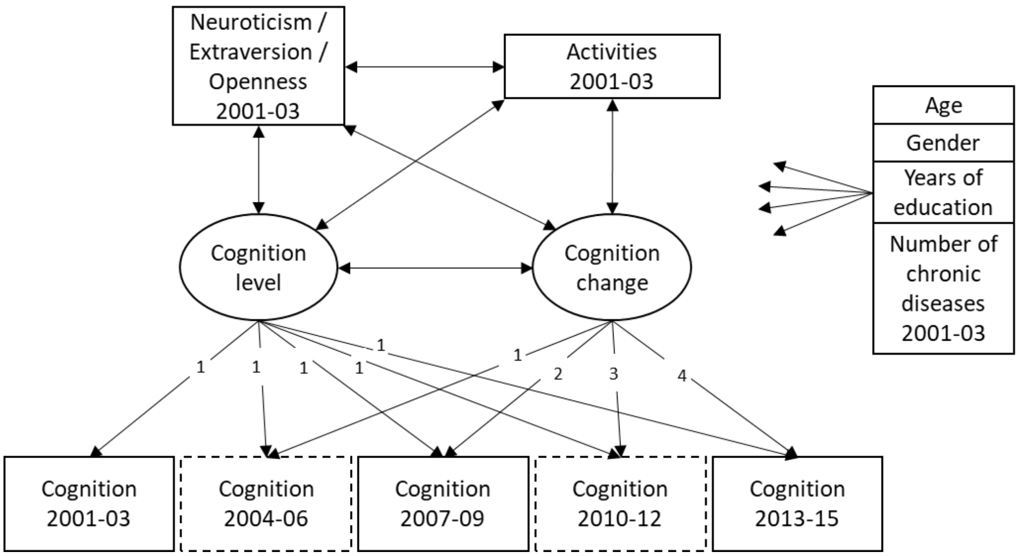
Latent Growth Curve Models

To distinguish between cognitive ability levels and change, we used latent growth curve models (McArdle, 2009). As indicators for each measurement occasion, we used the standardized test scores. The level factor was specified by constraining all loadings on all available measurement occasions to 1. The linear slope (i.e., change) factor was specified by constraining the measurement occasion loadings to an increasing order, ranging from $\lambda = 1$ at the second measurement occasion to $\lambda = 4$ at the fifth. For the young-old group, which was only assessed every six years, the slope only had a loading of $\lambda = 2$ on the third and $\lambda = 4$ on the fifth measurement occasion (to ensure comparability of the results across groups). Indicator intercepts were constrained to 0, and factor means freely estimated. We used full maximum likelihood estimation to account for missing data. We controlled for participants' age, gender, education and number of chronic diseases at baseline by regressing the covariates on the cognitive ability level and change factors, as well as the personality traits and activity indexes. All control variables were z-standardized.

We first estimated the model only including the overall cognitive ability scores and control variables to examine factor mean-levels (i.e., initial levels and decline in cognitive abilities) and the effect of the covariates on them (young-old: $df = 5$; $\chi^2 = 68$; CFI = .981; RMSEA = .088; SRM*R* = .017; old-old: $df = 22$; $\chi^2 = 93$; CFI = .970; RMSEA = .055; SRM*R* = .034). In the next step, we added the personality traits and activity clusters as correlates of the cognitive level and change factor (see Figure 1). We ran the model separately for the three activity clustering approaches. Model fit was acceptable (young-old: *df* = 11-12; χ^2 = 77-84; CFI = .988-.992; RMSEA = .058-.064; SRM*R* = .010-.011; old-old: *df* = 40-43; χ^2 = 117-127; CFI = .982-.989; RMSEA = .040-.042; SRM*R* = .024-.028).

Figure 1

Latent Growth Curve Model with Personality Traits and Activities as Correlates



Note. Cognition at the second and fourth wave (dashed boxes) were only included in the model for the old-old age group.

Power Analysis

To estimate the ability to detect a significant correlation between the baseline variables and the cognitive ability level and slope factors, we ran a power analysis. More specifically, we simulated 1000 datasets for both the young-old and old-old cohort, using the same models (excluding control variables), sample sizes, and missing data structures as in the original analyses. We simulated true underlying correlations of .10 / .20 / .30 between a baseline variable and the latent growth curve model level and change factor. The results are presented in Table 2. In the young-old cohort, the power to detect correlations of .10 was adequate (> .80) for the chosen significance level of α = .05. In the older cohort, power was only adequate for correlations of approximately .13 and higher.

Table 2
Power to Detect Correlations in the Latent Growth Curve Model

Cohort	Parameter	Effect size r = .10	r = .20	r = .30
Young-old	Level cor.	.84 / .61	> .99 / > .99	> .99 / > .99
(*N* = 1,609)	Change cor.	.92 / .77	> .99 / > .99	>.99 / > .99
Old-old	Level cor.	.65 / .40	.99 / .97	>.99 / >.99
(*N* = 1,085)	Change cor.	.59 / .35	>.99 / .98	>.99 / >.99

Note. Cor. = correlation. Values before the slash (/) indicate the power to detect an effect at the α = .05 level, values after the slash for α = .01.

Results

Because the results were very similar across the three different activity clustering approaches, we only present the results for the *rating*-based clusters here. Results for all three approaches are presented in the OSF.

Age Group Differences and Attrition

We first examined differences between the two age groups in the variables of interest. Participants in the old-old age group were more neurotic (d = 0.26; p < .001), less extraverted (d = −0.25; p < .001) and less open (d = −0.56; p < .001) than the young-old age group. Furthermore, they had much lower cognitive ability levels at baseline assessment (d = −1.15; p < .001), and were also much less active (social: d = −1.04; mental d = −0.95; physical d = −1.05; all p < .001). With respect to demographic variables, the old-old age group was more likely to be female (69.2% vs. 57.1%; p < .001), less educated (d = −0.66; p < .001) and have a higher number of chronic diseases (d = 1.06; p < .001).

On average, participants from the young-old age group responded to 2.3 out of 3 waves, and participants from the old-old age group to 2.5 out of 5 waves. In both groups, the number of waves individuals participated in was associated with age (young-old/old-old: $r = -.18/-.32$), education (young-old/old-old: $r = .17/.12$), chronic diseases (young-old/old-old: $r = -.18/-.21$), the initial cognitive ability levels (young-old/old-old: $r = .28/.39$), the activity engagement level (young-old/old-old: average $r = .23/.37$), and personality traits (young-old/old-old: Neuroticism: $r = -.10/-.15$; Extraversion: $r = .10/.17$; Openness: $r = .13/.11$) (all associations $p < .001$). This suggests that older participants, or those more likely to experience health or cognitive problems, dropped out of the study earlier. The consequence for the current analysis is that the associations might be underestimated, as those participants likely to experience the strongest cognitive decline are also most likely to provide the least measures of cognitive abilities. We tried to alleviate this issue by using full information maximum likelihood estimation (including age, gender, education and chronic diseases as covariates) to estimate missing cognitive ability data based on the existing cognitive ability data and covariates.

Cognitive Ability Mean Levels and Change

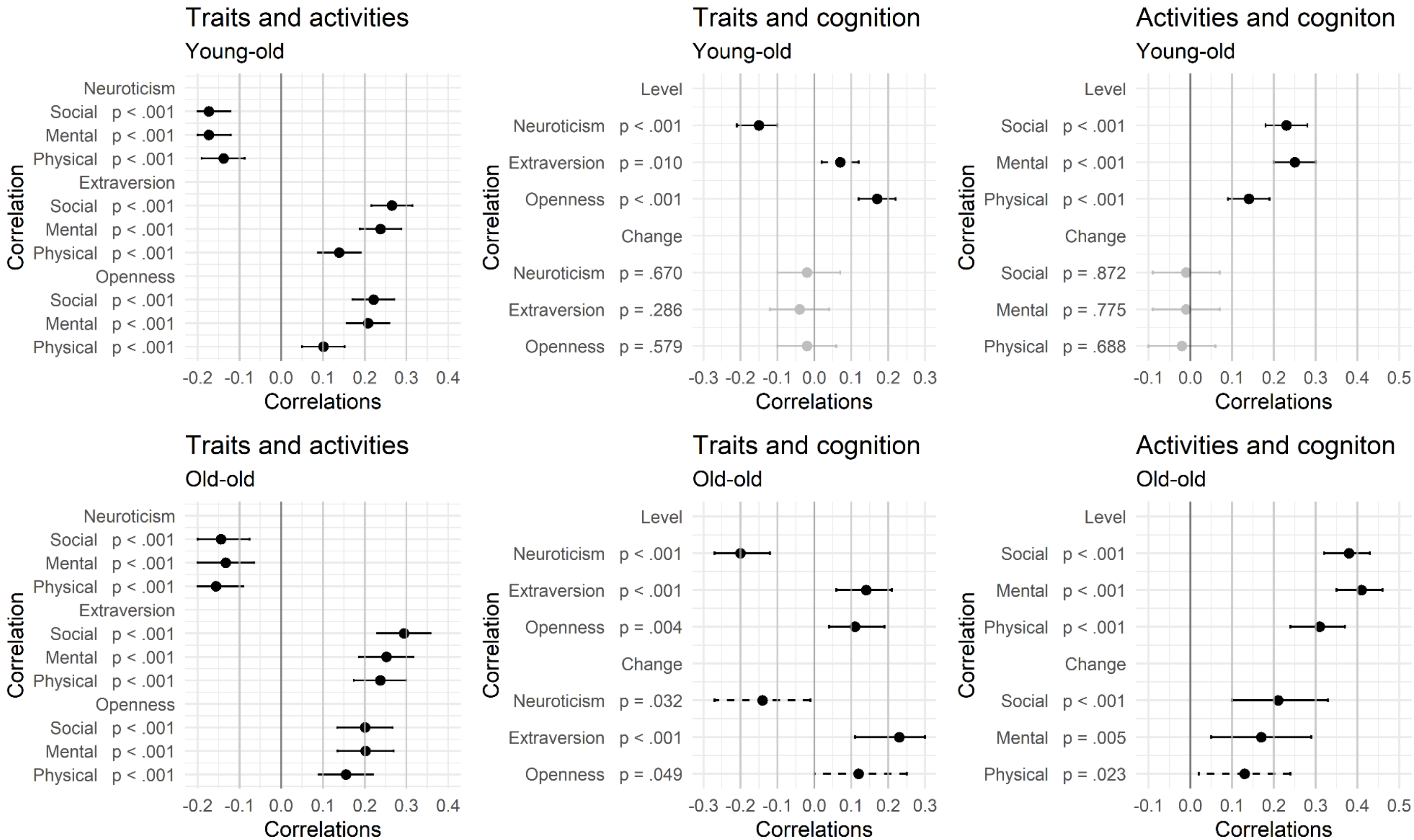
Cognitive ability levels, change across time, and associations with the control variables are presented in OSF Table S2. Across the 12 years covered in this study, the cognitive ability score decreased on average by 4.08 (young-old) and 10.80 (old-old) T-scores (both $p < .001$). Age at the first measurement occasion was negatively associated to cognitive ability levels (young-old: std. $\beta = -.17$; old-old: std.$\beta = -.31$; both $p < .001$) and change (young-old: std. $\beta = -.29$; old-old: std. $\beta = -.29$; both $p < .001$; indicating faster decline with higher age). Age, gender, education and number of chronic diseases explained a total of 26.8% / 30.2% (young-old / old-old) of the variance in cognitive ability levels, and 10.5% / 9.0% (young-old / old-old) of the variance in cognitive decline. The remaining individual differences in 12-year cognitive decline were significant (young-old: $SD = 3.62$; old-old: $SD = 5.99$; both $p < .001$) and similar to the initial differences in cognitive ability levels (young-old: *SD* = 5.36; old-old: *SD* = 5.48; both $p < .001$).

Correlations Between Personality Traits and Activities

We then estimated the model including the personality traits and activity clusters as correlates of the cognitive ability level and change factor, controlling for the covariates (see Figure 1). The correlations between personality traits and activities are presented in the first column of Figure 2 (see OSF Fig. S1 for all clustering approaches). Overall, the personality traits were associated with all activity clusters, with similar associations in both age groups. As such, we only refer to the average correlations across both age groups. Neuroticism was negatively associated with all activity engagement indexes with an average $r = -.15$. Differences in the associations with the different activity types (e.g., social, mental, physical) were negligible. Extraversion correlated positively with engagement in all activities (average $r = .24$), most notably with social activities (average $r = .28$), followed by mental activities (average $r = .25$) and physical activities (average $r = .19$). Openness was also positively associated with all activity indices (average $r = .18$), most notably with social and mental activities (average $r = .21$), followed by physical activities (average $r = .13$).

Figure 2

Correlations Between Personality Traits, Activity Engagement and Cognitive Levels or Decline



Note. Young-old = 60, 66 and 72-year cohort; old-old = 78 and 81(+)-year cohort. Error bars represent 95% confidence intervals. Grey lines indicate $p > .05$; dashed black lines $p \leq .05$; solid black lines $p \leq .01$. Exact significance values are presented next to the variable names.

We also examined how much variance the personality traits and activity engagement shared by running a model in which the three activity clusters were regressed on the three personality traits and vice versa (also including the control variables). We did this for both directions as the activity clusters shared some activities, which resulted in different estimates between directions. The personality traits explained around 7.2% of the variance in activity engagement in the young-old group (social: 9.9%; mental: 8.5%; physical: 3.1%), and 7.1% in the old-old group (social: 8.3%; mental: 6.9%; physical: 6.0%). Vice versa, activities explained around 5.2% of the variance in personality traits in the young-old group (Neuroticism: 2.9%; Extraversion: 7.8%; Openness: 5.0%), and 4.8% in the old-old group (Neuroticism: 2.1%; Extraversion: 8.6%; Openness: 3.6%).

Correlations of Personality Traits and Activities with Cognitive Levels and Decline

The second and third columns of Figure 2 show the correlations between baseline personality traits and cognitive ability levels / change, or activity engagement and cognitive ability levels / change, respectively (see OSF Figure S2 for all activity clustering approaches). The initial cognitive ability level was negatively correlated with Neuroticism (young-old: $r = -.15$; $p < .001$; old-old: $r = -.19$; $p < .001$), as well as positively associated with Extraversion (young-old: $r = .07$; $p = .015$; old-old: $r = .12$; $p = .002$) and Openness (young-old: $r = .17$; $p < .001$; old-old: $r = .10$; $p = .010$). We only found associations between cognitive decline and the personality traits in the old-old age group (Neuroticism: $r = -.14$; $p = .032$; Extraversion: $r = .24$; $p < .001$; Openness: r = .12; $p = .049$).

In both age groups, participants with higher cognitive ability levels were more engaged in all types of activities, with the associations being stronger in the old-old age group (correlations young-old / old-old: social $r = .23$ / .38; mental $r = .25$ / .41; physical $r = .14$ / .31; all $p < .001$).

Stronger activity engagement was also associated with slower cognitive decline in the old-old age group (social r = .21; p < .001; mental r = .17; p = .005; physical r = .13; p = .023), but not the younger cohorts.

We also examined how much variance in cognitive decline the activity engagement and personality traits would explain by running the model with regressions instead of correlations. As a reference, the covariates (i.e., age, gender, years of education, chronic diseases) explained 10.5% and 9.0% of variance in cognitive decline in the young-old and old-old age group, respectively. In the younger cohort, adding personality traits and activity engagement as predictors did not increase the explained variance noticeably (i.e., 0.4%). In the older cohort, traits explained 6.2%, activity engagement 5.2%, and both together 9.3% of the variance in cognitive decline beyond the control variables. Thus 2.1% (6.2% + 5.2% − 9.3%) of the variance in cognitive decline was explained by the shared variance between traits and activity engagement.

Discussion

In this study, we examined the associations between personality traits, engagement in leisure activities, and cognitive ability levels and decline in two age groups of older adults followed across 12 years. This study expands on previous research by examining these associations in a common study, as well as comparing young-old and old-old age groups and different activity clustering approaches. We were able to show that older adults with lower Neuroticism, higher Openness or higher Extraversion levels also had a more active lifestyle. Higher cognitive ability levels were associated with being less neurotic, more extraverted and more open (small effects), as well as a higher engagement in all types of activities (small to moderate effects in the young-old group; moderate to strong effects in the old-old group).

One of the main findings of this study was that activity engagement and personality traits were associated with cognitive decline in the older (i.e., 78+ years of age), but not younger age groups. More specifically, lower Neuroticism, and higher Extraversion, Openness and engagement in all activity clusters were associated with slower cognitive decline in the older age group after controlling for age, gender, years of education, and number of chronic diseases. Together they explained 9.3% of the variance in cognitive decline in addition to the 9.0% explained by the control variables. In the younger cohort, they only explained 0.4% whereas the control variables accounted for 10.5% of decline. One potential explanation for these results is that the effects of activity engagement and personality traits on cognitive decline might have had more time to accumulate in the older group. Leisure activities might have played a more central role in the life of the older cohorts as they were retired for a much longer time than the younger cohorts. However, the personality traits and activity engagement might have already been affected by an ongoing cognitive decline in the older age group. Those participants who showed the strongest cognitive decline in the following years might thus have already shown higher Neuroticism levels, and lower Extraversion, Openness and activity engagement levels at the first measurement occasion (but note that the studies on correlated change between cognitive decline and personality change found only weak or no effects; e.g., Aschwanden et al., 2017; Hock et al., 2014; Wettstein et al., 2017).

Associations Between Activities and Cognitive Ability Levels and Decline

Replicating previous research on this topic, we found stronger activity engagement to be positively associated with slower cognitive decline (Fallahpour et al., 2016; Hertzog et al., 2008; Köhncke et al., 2017; Newton et al., 2018; Nyberg & Pudas, 2019; Stine-Morrow & Manavbasi, 2022; Yates et al., 2016)—albeit only in the older age group. While the associations with cognitive ability levels may also be driven by activity engagement being dependent on the cognitive fitness of the older adults, the associations with cognitive decline should primarily be caused by activity engagement improving cognitive reserve (i.e., "use it or lose it"-hypothesis; Stine-Morrow & Manavbasi, 2022). Generally, the associations with decline were smaller than the associations with cognitive ability levels, and even exhaustive sets of possible contributing factors generally fall short of meaningfully accounting for inter-individual differences in cognitive decline (e.g., Lövdén et al., 2020; Ritchie et al., 2016), as was also shown by the control variables only explaining 9.0% of cognitive decline, but 30.2% of the cognitive level variance (old-old age group). As such, it is rather noteworthy that the self-report baseline activity measures were able to explain 5.2% of the differences in cognitive decline in the old-old age group. Furthermore, the way the activities were clustered had little effect on the found associations.

Contrary to our assumptions, mental activities did not emerge as the strongest correlate of cognitive decline but had similarly strong associations as the other activity types. The participant ratings (see OSF Table S2) and correlations between the various clusters show that these clusters, in particular social and mental components, were difficult to disentangle (see also complex cluster in Köhncke et al., 2016). The interaction with other people through social activities thus also seem to provide the cognitive stimulation needed to maintain cognitive ability levels in old age.

Neuroticism

In line with previous findings (e.g., Gow et al., 2005; Soubelet & Salthouse, 2011; Terraciano et al., 2013; Wilson et al., 2003), Neuroticism had a small negative association with cognitive ability levels and decline in the older age group. Neuroticism describes the tendency to experience negative emotions or thought patterns, as well as having a higher emotional instability. The negative association with cognitive ability levels have primarily been attributed to experienced stress, mental health issues or test anxiety (Curtis et al., 2015), but could also be caused by cognitive ability levels. For instance, higher cognitive abilities or intelligence can be beneficial in dealing with stressful circumstances (Perking & Corr, 2006). Some studies also reported that participants who developed dementia (Waggel et al., 2015; Robins Wahlin & Byrne, 2010) also reported higher Neuroticism levels, suggesting another possible pathway for the association (i.e., increased anxiety due to already experienced cognitive decline).

With respect to the association with cognitive decline, the prolonged exposure to stress or higher risk for mental health issues has been argued to drive the effect (Abdellaoui et al., 2019; Boyle et al., 2010; Chapman et al., 2012; Curtis et al, 2015; Magri et al., 2006). In addition to this, we were able to show that Neuroticism was also negatively associated with activity engagement in our study. Higher fear or anxiety due to higher Neuroticism levels may result in people not engaging in activities that they may deem potentially dangerous or challenging, thus decreasing the likelihood to engage in potentially buffering activities. However, this association may also be driven by third variables (e.g., physical limitations; death of the partner or friends), which may result both in increased Neuroticism levels and lower activity engagement. Another potential pathway for this association is that a disengagement from life activities may result in older adults become more fearful or depressed, which could be observed as increased Neuroticism levels.

Extraversion and Openness

Both Extraversion and Openness were associated with higher engagement in all activity types. These traits are characterized by a need for overall or cognitive stimulation (see also

Extraversion and reward sensitivity; Lucas et al., 2000; Openness and need for cognition; Fleischhauer et al., 2009), which might explain why people with higher levels on these traits reported a more active leisure engagement overall. One surprising finding in this study was that Openness was associated with social activity engagement to a similar degree as with mental activity engagement. This might also be explained by open older adults seeking cognitive stimulation through social interactions as well. For example, one study showed that Openness levels of older (but not younger) adults were associated with the time spent with friends (Wrzus et al., 2015). Similarly, extraverted older adults might also engage in mental activities that provide an opportunity for social interactions—as nearly all mental activities were rated as social by older adults to some degree (see OSF Table S2). Apart from the aforementioned difficulties in distinguishing between pure social and mental activities, these associations may also be explained by third variables (e.g., health), as maintaining an active lifestyle and high trait levels might be affected by these third variables simultaneously. Studies on personality development in old age found decreases for Openness and Extraversion (e.g., Allemand et al., 2007; Graham et al., 2020; Lucas & Donnellan, 2011; Mõttus et al., 2012), with some studies showing that these declines were associated with decreases in health (Chereches et al., 2022; Jokela et al., 2014; Wagner et al., 2016). While we controlled for differences in the number of chronic diseases, the associations between overall activity engagement and these personality traits might be affected by health differences not accounted for (e.g., severity of the chronic diseases).

Higher Extraversion and Openness levels were associated with higher cognitive ability levels in both groups. Associations between Openness and cognitive ability levels are commonly found (e.g., Aiken-Morgan et al., 2012; Austin et al., 2002; Graham & Lachman, 2012), as this trait is most strongly characterized by cognitive components (e.g., curiosity; creativity; intellect;

appreciation for art). This association might thus be explained through a combination of open individuals engaging in more cognitively stimulating activities, as well as cognitively fitter individuals seeking more cognitive stimulation. Associations between cognitive ability levels and Extraversion are generally mixed in the literature (e.g., Baker & Bichsel, 2006; Graham & Lachman, 2012; Moutafi, et al., 2003; Soubelet & Salthouse, 2011), and not well understood. We assume that the associations between Extraversion and cognitive ability levels found in this study were primarily caused by cognitively fitter older adults being able to engage more strongly in Extraversion-related behaviors (e.g., social interactions).

Extraversion and Openness were also associated with slower cognitive decline in the older age group. One potential explanation for this effect might be the stronger engagement in social and mental activities found for older adults with higher Openness and Extraversion levels (see also Curtis, 2015; Salthouse, 2006; Stine-Morrow & Manavbasi, 2022). This is partly supported by the finding that 2.1% of the cognitive decline variance was explained by the shared variance of personality traits and activity engagement. However, this shared variance can also reflect an effect of activity engagement on both personality traits and cognitive decline. For example, older adults who engage more in social activities may do so because they are extraverted but may also perceive themselves as more extraverted because they engage in social activities. Acquiring new behaviors or habits has been suggested to lead to personality trait change (e.g., Allemand & Flückiger, 2017; Hudson et al., 2019; Roberts et al., 2017), and similarly a disengagement from trait-related activities (e.g., mental activities for Openness) may lead to subsequent trait changes as well.

The 9.3% of the cognitive decline variance explained uniquely by traits or activity engagement may point to effects of personality traits not covered by the activity measure, such as other trait-related activities or cognitive or emotional processes associated with the traits (e.g., stress reactivity; mental health; coping strategies; e.g., Ozer & Benet-Martinez, 2006; Soto, 2019). Vice versa, the three broad trait domains only explained a small proportion of the activity engagement, likely because they represent very broad decontextualized aggregates of the personality trait space (Mõttus et al., 2020), and are only one of many factors that may explain what activities older adults engage in (e.g., life circumstances; health; education; interests; motivation/goals; see e.g., Hooker & McAdams, 2003).

Limitations and Future Research

Despite the strengths of the study, such as large sample size, modeling of change across several objectively assessed cognitive abilities and up to five measurement occasions, and the comparison of different approaches to cluster activities, there are some limitations that may affect the interpretation of the findings and guide future research. First, we focused only on broad dispositional traits, which only represent one component of individual differences in personality, alongside for instance personal action constructs (e.g., goals, personal strivings) and life stories (e.g., identity) (Hooker & McAdams, 2003; McAdams, 1995). These aspects of personality might be more directly linked to the activities older adults engage in and might also explain individual differences in cognitive decline (e.g., Miller & Lachman, 1999). Furthermore, we only included the Big Five personality trait domains Neuroticism, Extraversion, and Openness, as Agreeableness and Conscientiousness were not covered by the baseline measurement in this study. While generally no effects of Agreeableness on cognitive decline are reported (Curtis et al., 2015), higher Conscientiousness levels have been shown to predict slower rates of cognitive decline (Chapman et al., 2012; Luchetti et al., 2016; Wilson et al., 2007). Conscientiousness is particularly interesting as it has been linked to health through the engagement in health-related activities (e.g., Lodi-Smith et al., 2010), which may also explain the association with cognitive decline.

Secondly, the personality traits and engagement in activities were measured with self-reports, which may underlie subjective interpretations or response biases to some degree. While the number of items for each personality trait (12) was relatively high for such a panel study, the use of a 3-Point Likert scale might have restricted the ability of the scales to differentiate between people's trait levels, thus reducing the potential to find effects. A similar limitation applies to measuring the frequency of engagement in the leisure activities with a 4-Point Likert scale ranging from *never* to *every week*. A more detailed assessment of the frequency (e.g., time spent on activities) and potentially also the intensity thereof might have provided a more differentiated picture of the effects.

Thirdly, most activity clusters were highly correlated with each other and might not have been able to differentiate between the different demand types well, as all activities were rated as social and mentally demanding to some degree. However, this issue applies to all attempts to classify leisure activities into a predominantly social, mental and physical cluster, as the ratings have shown that the differences are not as clear cut. Especially for older participants, many activities may become increasingly physically and mentally demanding, further exacerbating this problem.

Fourthly, the number of measurement occasions for the cognitive abilities differed across age cohorts, with only three occasions for the younger age group across the 12 years. Fifthly, while the cognitive test battery was rather broad with five abilities and two subtasks each (except for semantic memory), the principal component analysis suggested a common cognitive ability factor. Future studies with a broader measure of crystallized abilities could further investigate whether the effects are similar for fluid and crystalized abilities.

And finally, both personality traits and activities are likely to change during the covered time span (e.g., Bleidorn et al., 2022). While the goal of the current study was to examine the associations of personality traits and activity engagement with subsequent cognitive decline, it is also relevant to examine whether traits and activity engagement change due to cognitive decline. For example, studies on personality development in old age reported increases in Neuroticism and decreases in Extraversion and Openness (Graham et al., 2020; Kandler et al., 2015; Mõttus et al., 2012; Wortman et al., 2012). Future studies should investigate whether these patterns of change co-occur with a simultaneous decline in cognitive abilities (e.g., Ashwanden et al., 2017; Wettstein et al., 2017). The literature on intentional personality change also suggests that learning new behaviors or habits may lead to personality trait change (e.g., Allemand & Flückiger, 2017; Hudson et al., 2019; Roberts et al., 2017). In the context of aging research, it might thus be interesting to examine whether individual differences in personality change can be explained by the activities older adults choose to engage in (e.g., Baltes & Baltes, 1990).

Conclusion

This study found that Neuroticism, Extraversion and Openness were associated with cognitive ability levels, but only explained differences in cognitive decline in the old-old age group. Older adults with higher cognitive ability levels, lower Neuroticism or higher Extraversion or Openness levels also showed a stronger engagement in various leisure activities. The engagement in leisure activities was associated with slower cognitive decline, but again only in the older age group. Taken together, these findings can provide some support for the association of personality traits and activity engagement with later cognitive decline. Future research should expand upon this study using broader and repeated measures of personality traits and activity engagement (including objective measures) to also study reciprocal effects of cognitive abilities, personality traits, and activity engagement.

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