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Personality and Cognitive Aging
A Population-Based Longitudinal Study

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Abstract. We investigated effects of Extraversion, Neuroticism, and the Lie scale, from the Eysenck Personality Inventory (EPI), on level and change in late life cognition. The data (N=554) were drawn from two birth cohorts (1901/02, 1906/07) as part of the Gothenburg H70 study, where cognition was subsequently measured on five tests at ages 70, 75, and 79. Findings from multilevel models, controlling for sex and education, revealed that high Extraversion, Neuroticism and the Lie scale scores all predicted lower cognitive function at age 70. We found no association with rate of change. In addition, we found that simultaneous high scores on both Extraversion and Neuroticism was associated with poorer cognitive level. Conclusively, personality may affect test performance, but not necessarily cognitive decline.

People generally live longer than they did just half a century ago and aged populations are increasing in many parts of the world. As our bodies age we become more prone to certain types of diseases, and as our brains age, our cognitive abilities decline. As unfair as it may seem, poorer memory, and slower processing speeds, are a part of normal human aging (see e.g. Johansson, Berg & Steen, 2003). Rates of cognitive decline vary widely between individuals, which has inspired a huge amount of research into what factors are associated with faster and slower loss of cognitive function (see Luchetti, Terracciano, Stephan & Sutin, 2015). Physical health has been found to be an important factor; diabetes and cardio-vascular disease, for example, are risk factors for poorer cognitive development (Johansson et al., 2003). Countless newspaper headlines have made common knowledge of the notion that social isolation and loneliness have negative effects on both physical and cognitive health. A varied lifestyle and a solid social network, on the other hand, are said to protect against the ill-effects of aging (Hertzog, Kramer, Wilson & Lindenberger, 2009). As behavioural tendencies are considered by many to play an important role in predicting rates of cognitive decline, it seems reasonable to expect personality traits to be associated in some way also. Research has found evidence of various significant relationships between personality traits and different aspects of cognitive functioning in older adults, but findings differ greatly (Curtis, Windsor & Soubelet, 2015; Luchetti et al., 2015).

Gaining a deeper understanding of this interplay may help in the quest to develop more effective treatments and pre-emptive interventions to decrease the effects of aging on cognitive ability (Curtis et al., 2015). The purpose of the present study was to investigate the potential effects of the personality traits Extraversion and Neuroticism on cognitive function late in life, and rate of cognitive decline during aging, using longitudinal data from The Gerontological and Geriatric Populations Studies in Gothenburg (H70).

The H70 Study

The H70 study started in 1971/72 by collecting physiological, psychological and cognitive data on a representative sample of the 70-year old population of Gothenburg (Johansson et al., 2003). Data were collected again (i.e., longitudinally) when the cohort was 75 and 79 years of age, and additional cohorts of 70-year olds were five years later recruited to follow the same process. The purpose of the H70 study was fourfold: 1) to survey the social and physical status of the population; 2) to collect data to inform planning of geriatric care; 3) to gain insight into the process of human aging; and 4) to offer the participants a medical examination (Rinder, Roupe, Steen & Svanborg, 1975). The large amounts of data collected have been used in many studies to further our understanding of multiple aspects of normal human aging, as well as the occurrence and nature of illness in the aging population. For the purposes of the present study, we have used data on the personalities and levels of cognitive functioning of the first two cohorts, born 1901/02 and 1906/07.

Trait Theory of Personality

According to this theoretical perspective, an individual personality can be described in terms of a number of universal dimensions, or traits (see Larsen & Buss, 2010). Personality traits are seen as a collection of attributes that tend to co-vary, that act as a driving force behind an individual's cognitive and behavioural tendencies, and that tend to remain stable over time. The development of trait taxonomies has been ongoing over many decades, and one of the first to be widely recognised was Eysenck's (1957) hierarchical model of personality (see Larsen & Buss, 2010). Through his extensive research he initially found two dimensions to be central: Extraversion-Introversion and Neuroticism-Stability, and later added Psychoticism-Normality. His model is hierarchical in that each main trait contains a number of subsets of attributes in a descending hierarchy. The trait Extraversion entails at the first level being sociable, lively, active, assertive and sensation-seeking. At the next level, he listed attributes such as carefree, dominant and venturesome. Being more introverted, on the other hand, means being more low-key, preferring the company of a few intimate friends and enjoying quiet activities at a moderate pace, for example. Neuroticism is characterised by high levels of anxiety, feelings of guilt, worrying excessively and having low self-esteem, while Stability entails just the opposite (Larsen & Buss, 2010).

The personality measurement used in the H70 study that we were interested in for the purposes of the present study was the Eysenck Personality Inventory (EPI). The model that is most widely used in personality research today is McCrae and Costa's (1987; 2002) Five Factor Model, including five traits: Neuroticism, Extraversion, Openness to Experience, Agreeableness and Conscientiousness. Similar to Eysenck's model, it is hierarchical, in that each trait is made up of six facets. Neuroticism includes Anxiety, Angry Hostility, Depression, Self-Consciousness, Impulsiveness and Vulnerability. The facets included in Extraversion are Warmth, Gregariousness, Assertiveness, Activity, Excitement Seeking and Positive Emotions (McCrae & Costa, 2002). The majority of the studies referenced below have used this model to define and measure the personalities of participants, and we have simply chosen to look at results pertaining to Extraversion and Neuroticism. Although there are differences in definition and measurement between the two models, we would argue that the overlap is large enough to justify comparisons of results.

Neuroticism, Concurrent Cognitive Function and Cognitive Decline

Neuroticism is perhaps the most studied personality trait in relation to public health, as it has been linked to several psychological and physical disorders, as well as to accelerated aging via telomere attrition (van Ockenburg, de Jonge, van der Harst, Ormel & Rosmalen, 2013). It is thought to influence cognitive abilities and cognitive decline through the effects of negative affect and stress sensitivity, both across the life span and during the time of testing. Chronic stress can lead to a derailment of the hypothalamic-pituitary-adrenal axis, causing a hormonal imbalance that has been shown to lead to hippocampal atrophy in animals (see Chapman et al., 2012). This area of the brain is central to memory and sense of location—two cognitive domains that typically deteriorate in Alzheimer's disease. Indeed, there is strong evidence for Neuroticism being a risk factor for developing Alzheimer's disease (Terracciano et al., 2014). The trait has also been linked to decreased brain size in older adults, which is another major indicator of increased cognitive impairment (Jackson, Balota & Head, 2011). Further, Graham et al. (2021) found Neuroticism to be significantly associated with lower levels of cognitive resilience, that is, individuals with a high Neuroticism score were more likely to show higher degree of cognitive impairment than would be expected from their post-mortem neuropathology report.

Another possible link between Neuroticism and cognitive abilities is the effect of state depression, i.e., suffering from temporary depression, as opposed to a lifelong propensity toward depression, or trait depression. State depression is highly correlated with the trait Neuroticism, and is a widely accepted risk factor for developing cognitive dysfunction (e.g., Wilson et al., 2002). It must also be noted, however, that increased cognitive impairment is a risk factor for increased depression (and negative affect in general), and some studies have even found that trait Neuroticism may go up when cognitive abilities decline (Stephan, Sutin, Luchetti & Terracciano, 2020a). The causal direction is therefore not straightforward. Nevertheless, the evidence on hippocampal atrophy and shrinking brains does support the hypothesis that negative affect over the life span may have a causal effect on cognitive impairment.

With regard to non-clinical populations, the research lends a good deal of support to the supposition that Neuroticism is associated with poorer performance on cognitive tests, as well as increased cognitive decline in aging. As for concurrent test performance, the leading explanation seems to be Eysenck and Calvo's processing efficiency theory (1992; see Eysenck, Derakshan, Santos & Calvo, 2007), which purports that individuals high on the Neuroticism scale are more likely to be occupied with anxious and intrusive thoughts and ruminations, which may simply distract them from the cognitive task, and/or take up precious space in their working memory. Neuroticism has been found to be negatively associated with concurrent performance on working memory and verbal learning tests (Aiken-Morgan et al., 2012), with scores on screening instruments (Boyle et al., 2007; Chapman et al., 2012), episodic memory (Meier, Perrig-Chiello & Perrig, 2002), verbal fluency (Sutin et al., 2011) and executive functions (Williams, Suchy & Kraybill, 2010).

Longitudinal studies have found similar effects. Neuroticism at baseline was negatively associated with episodic memory twenty years later (Stephan, Sutin, Luchetti & Terracciano, 2020b) and with rate of decline in global cognitive function over a seven year follow up period (Chapman et al., 2012). Jelicic et al. (2003), however, found no significant association with concurrent performance, nor with cognitive decline. The authors explain their null finding by the fact that participants showing signs of cognitive impairment at baseline were excluded from the study, implying that the potential influence of Neuroticism may be only relevant in a clinical population. Similarly, Wetherell, Reynolds, Gatz & Pedersen (2002) found no significant associations with cognitive decline among their cognitively healthy participants.

Given the evidence of the effects of long term stress and anxiety on neurological health, and the number of previous studies showing significant associations between Neuroticism and concurrent test performance as well as cognitive decline in aging, we expect to find similar results, albeit with modest effect sizes at best. We expect effect sizes to be relatively small as there are other factors contributing to cognitive deterioration during aging that have proven to have a greater effect than personality traits, such as cardio-vascular disease and genetic risk factors.

Extraversion, Concurrent Cognitive Function and Cognitive Decline

The literature contains various theories as to how and why Extraversion may impact cognitive ability in aging. Some argue that certain aspects of Extraversion can improve an individual’s ability to perform in a cognitive testing situation, while others argue that other aspects may impede performance. With regard to cognitive decline, researchers tend to expect behaviours associated with Extraversion to have a protective effect.

Extraverts tend to be more assertive and optimistic than introverts, which may mean that they have a level of confidence, enjoyment of the challenge and faster response rate that leads to a better performance on cognitive tests (Luchetti et al., 2016). The facet Assertiveness has been found to be correlated with performance on working memory and a verbal learning tests (Aiken-Morgan et al., 2012), as well as a verbal fluency test (Sutin et al., 2011). The facet most strongly related to verbal fluency was Positive Emotion (Sutin et al., 2011). The authors propose that a tendency toward positive mood may enhance an individual’s cognitive flexibility and creative thinking. They also suggest that more sociable people tend to talk more, and can therefore think of more words, and that people living more fast-paced lives may also be quicker at coming up with words under time pressure.

It has also been suggested that the higher degree of positive affect that characterises Extraversion can benefit performance on episodic memory tests specifically (Stephan et al., 2020b; Allen, Kaut, Baena, Lien & Ruthruff, 2011). Some cross-sectional studies lend support to this idea; Meier et al. (2002) found a positive association between Extraversion and performance on a test of episodic memory, and Stephan et al. (2020b) concluded in the meta-analytical section of their study that extraverts perform better on memory tests over time than do introverts.

A number of cross-sectional studies have found no significant associations between Extraversion and concurrent test performance, however, Williams et al. (2010) reported no association between Extraversion and executive functioning in older adults, and Booth, Schinka, Brown & Borenstein (2006) found no correlation with any of the several cognitive domains they tested among community dwelling women. While Aiken-Morgan (2012) found some significant associations on the facet level, they report none on the trait level. In fact, their initial hypothesis was that more extraverted individuals would perform worse on tasks involving working memory and verbal learning, as their sociability would interfere with focused attention on the task at hand. Others have suggested that extraverts may get bored with repetitive tasks more quickly than introverts, and spend less time solving problems (see Curtis et al., 2015). It is possible that some aspects of Extraversion indeed do impede performance, while others tend to improve it, which may mask any significant association on the trait level.

Extraversion is thought to be associated with cognitive decline over time primarily through a higher degree of positive affect and having a more active lifestyle. The 'use it or lose it' hypothesis proposes that brains, like muscles, need to be exercised in order to prevent deterioration (Bielak, 2009). Engaging in social and intellectually stimulating activities would thereby slow cognitive decline in aging, and a good deal of research supports this claim (Hertzog et al., 2009). Further, Extraversion is thought to be associated with a lower reactivity to stress, better sleep and better physical health, all of which have been found to potentially protect against cognitive aging (Stephan et al., 2020b; Hertzog et al., 2009).

Experiencing a greater intensity of positive affect could also enhance memory encoding and retrieval across the life span (Stephan et al., 2020b; Allen et al., 2011). Inspired by Damasio's (1994) somatic marker hypothesis, which posits that bodily sensations are instrumental in the encoding of memories around life events, Allen et al. (2011) hypothesised that intensity of positive affect would predict rate of decline of episodic memory in an aging population. Using Extraversion scores as a proxy for positive affect, they found that highly extraverted older adults performed better on a delayed recall task than those with lower Extraversion scores. Moreover, extraverted older adults performed as well as younger adults, suggesting that Extraversion can protect against decline in episodic memory in aging. Of additional interest is their finding that Extraversion was correlated with delayed recall (episodic long-term memory), but not with instant recall (short-term memory or working memory).

However, the longitudinal research into this topic tends to show either no significant associations between Extraversion and cognitive decline in aging, or negative associations. Stephan et al. (2020b) found no association between Extraversion at baseline and episodic memory twenty years later, nor with measures of cognitive impairment. An investigation into resilience to cognitive decline, conducted by Graham et al. (2021), tentatively hypothesised that Extraversion would show a positive association, but found none. Chapman et al. (2012) measured global cognitive functioning using a screening instrument every six months for a period of seven years and found that higher Extraversion was associated with lower average scores during follow up, but not with the rate of decline. They explain this finding with the idea that extraverts' focus on external stimulation may make it harder for them to concentrate on the test.

Given the mixed bag of results derived from previous research we expect to find both positive and negative effects of Extraversion on concurrent cognitive ability and on cognitive decline. As with Neuroticism, we expect effect sizes to be small, considering the multitude of other factors involved.

Interaction between Extraversion and Neuroticism

In addition to the isolated effects of personality traits on cognitive aging, it is possible there may be ways in which Extraversion and Neuroticism interact to produce different outcomes. Wang et al. (2009) found no significant associations between dementia risk and level of Neuroticism or Extraversion, but did find that those with low Neuroticism and high Extraversion had a decreased risk compared to other combinations of the two traits. They propose that this may be due to a more socially active lifestyle protecting against cognitive aging when stress and anxiety has been low over the lifespan. Chapman et al. (2012) expected to replicate this finding, but found no interaction.

In line with Wang et al.'s (2009) findings, we expect the positive effects of an active lifestyle and a higher degree of positive mood, in combination with emotional stability, to make for a slightly slower rate of decline among those high on Extraversion and low on Neuroticism, compared to other trait combinations.

With regard to concurrent cognitive function, being highly extraverted may counteract the internal anxiety during cognitive testing otherwise attributable to being highly neurotic. It could also be the case the extraverted neurotics are likely to be doubly distracted, both by ruminations and by the social aspects of the situation. We therefore expect to see some significant interactions, but it is unclear which combination will stand out in relation to the others.

The Lie Scale

In addition to the scales measuring the two personality dimensions, The Eysenck Personality Inventory (EPI) contains a so called Lie scale, designed to measure the extent to which the respondent is answering the questionnaire truthfully. It is made up of questions such as 'Are all your habits good and desirable ones?', and 'Do you occasionally have thoughts and ideas you would not like other people to know about?', where it is presumed that there is only one fully truthful answer, regardless of personality. Giving the opposite response likely indicates that the individual is responding in a socially desirable way.

Since its development as simply a lie detector, it has been argued that the Lie scale in fact measures some distinct aspect of personality that can be described as conformity or social acquiescence (Jackson & Francis, 1999). We have not been able to find studies that have looked at this as a predictor of cognitive function, but it is not unreasonable to imagine that it may have an effect. Individuals who are very eager to show themselves in the best possible light might feel undue pressure in a cognitive test situation, which may in turn impede their performance.

Further, it stands to reason that a high Lie score effectively hides a higher score on Neuroticism, presuming that this is the least socially desirable personality trait. Indeed, an inverse relationship between Lie score and Neuroticism has been found (see Jackson & Francis, 1999). If Neuroticism is associated with poorer cognitive outcomes, then the Lie scale could carry a similar association. We therefore expect a high score on the Lie scale to predict a lower concurrent test performance and a steeper rate of cognitive decline.

Summary

The aim of the present study was to investigate the possible associations between the personality variables Extraversion, Neuroticism and the Lie scale, and a) cognitive function at age 70, and b) the rate of cognitive decline between the ages of 70 and 79. Additionally, we proposed to investigate whether different combinations of Extraversion and Neuroticism may predict different outcomes.

We hypothesise that:

1. Neuroticism will be negatively associated with concurrent cognitive function, and will predict a steeper rate of cognitive decline.
2. Extraversion will be positively associated with concurrent cognitive function, and will predict a more gradual rate of cognitive decline.
3. The Lie scale will be negatively associated with concurrent cognitive function, and will predict a steeper rate of cognitive decline.
4. A high score on Extraversion in combination with a low score on Neuroticism will predict a more gradual rate of cognitive decline, as compared to other combinations of these traits.
5. Extraversion and Neuroticism will show some significant interaction with regard to concurrent cognitive function, but it is in unclear which trait combination(s) will stand out in comparison to the others.

Method

Participants and Procedure

For the present study we drew data from the first two cohorts to take part in The Gerontological and Geriatric Populations Studies in Gothenburg (H70). Participants were recruited using an official census register. For the first cohort, all registered individuals born between 1 July 1901 and 30 June 1902, on dates ending in 2, 5 or 8, were contacted by post in the first instance, and later by telephone. The initial response rate was 85%, which after analysis was deemed a representative sample (Rinder et al., 1975). Subsampling was done by randomly dividing participants into five groups, where groups 1 and 2 took part in examinations of personality, cognitive function, as well as a psychiatric examination. The participation rate in this subsample was 80% (see Thorvaldsson, Karlsson, Skoog, Skoog & Johansson, 2017). The same sampling procedure was carried out in 1976/77 for the second cohort.

Cognitive test data was available for 786 participants in total, and three of these were excluded due to zero points scored on all tests at age 70, indicating severe cognitive impairment. Of these 783 participants, 56.8% were women and 43.2% were men. Among them, the most common highest level of completed academic education was grade school (79.7%), and 31.2 % had some form of formal vocational training.

Personality data measured with the EPI was available for 554 of these participants, of which 57.2% were women and 42.8% were men. In this subsample, 80.5% had completed grade school as their highest level of academic education, and 29.8% had formal vocational training. The psychological examination took place at the out-patient clinic of a local geriatric hospital. One hour was spent on cognitive testing and one hour on questionnaires pertaining to personality and adjustment to old age.

Cognitive Measures

All but one of the cognitive tests used in the H70 study were selected from the Dureman & Sälde (1959) test battery, which was based on Thurstone's (1938) theory of primary mental abilities (Berg, 1980). The following tests were selected:

1) Synonyms (maximum score 30). This test measures verbal ability by asking participants to go through a list of words and select the correct synonym for each among five options.

2) Figure Logic (maximum score 30), a non-verbal test measuring problem solving and logic ability. The test consists of several rows of geometric figures, and participants are asked to quickly identify the figure that differs from the others on each row.

3) Block Design (maximum score 42), measuring visual-spatial ability. Participants are given blocks with different colours and asked to use them to quickly replicate a series of figures, with increasing complexity.

4) Identical Forms (maximum score 60) measures perceptual speed by asking participants to identify matching figures, as quickly as they can.

5) To test auditory working memory, the Digit Span test (maximum total score 17) from the Wechsler-Bellevue Scale was included. The test administrator reads out a series of numbers that the participant then tries to reproduce in the same order. During the second part of the test, the participant is required to reproduce the numbers in the reverse order.

Due to time constraints at the 1971 measurement, half of the participants in the first cohort were randomly selected to only complete the first two tests (see Berg, 1980). Cognitive testing was carried out at three points in time for each cohort: at age 70, 75 and 79.

Personality Measure

The personality measurement chosen at the start of the study was the Maudsley Personality Inventory (MPI; see Jensen, 1958), based on Eysenck's (1957) hierarchical model of personality. For the second cohort an updated version was used, namely the Eysenck Personality Inventory (EPI; see Howarth, 1976). The first cohort completed the EPI during the next round of tests, when they were 75 years of age. To avoid using two different personality scales in the analysis, we used the available EPI scores at age 75 for the 1901/02 cohort and at age 70 for the 1906/07 cohort. This should make minor difference to the results, as the personality dimensions measured are presumed to remain relatively stable from age 70 to age 75.

The EPI consists of 48 'yes/no' questions formulated to measure the two personality dimensions Extraversion-Introversion and Neuroticism-Stability, each on a scale of 0 to 24. According to Eysenck's theory, Extraversion entails being sociable, lively, active, assertive and sensation-seeking, while introverts are more low-key, prefer the company of a few intimate friends and enjoy quiet activities at a moderate pace (Larsen & Buss, 2010). Neuroticism is characterised by high levels of anxiety, feelings of guilt, worrying excessively and having low self-esteem, while Stability entails just the opposite (Larsen & Buss, 2010). The questionnaire also contains nine questions that comprise a Lie scale, measuring the degree of social desirability, or truthfulness, in each participant's responses (Howarth, 1976). An example of such a question is 'Are all your habits good and desirable ones', where it is presumed that the only truthful answer is 'no'.

Covariates

We used the available demographic information, sex and level of education, as covariates. In the original dataset, education level was divided into an ordinal scale of academic education, in terms of level achieved, and a categorical scale of vocational education, with no inherent order of value. See Appendix A for details of categories and their frequencies in the entire sample (i.e., including those where personality data is missing).

Data Analysis

The study design had a hierarchical nature, in that the dataset contains a certain number of individuals (at level 2), and repeated measures (at level 1) of cognitive function nested within each individual. In other words, there is a nested hierarchy built into the study design, whereby the measures nested within a given individual are highly likely to be correlated, rather than being independent data points. Thus, both fixed (between person) effects and random (within person) effects will ideally be included in the analysis of the between person variance in cognitive function and rate of change. We therefore used multilevel modelling (Heck, Thomas & Tabata, 2011) to analyse the data. This type of modelling not only reduces the risk of Type-I errors, but also has the added advantage of dealing effectively with missing data (Graham, 2009).

In building the level-1 and level-2 part of the models, the intercept (i.e., estimated cognitive function at baseline), age, personality measures, and interaction terms between personality and age, were specified as fixed effects. The intercept and linear age slope were included as random effects. An unstructured covariance matrix was chosen for the random effects, which means that both variances and the co-variance were estimated as free parameters. This is common when modelling repeated measures data, as there is no reason to assume that variances will be constant or follow any discernible pattern over the study period (Heck, Thomas & Tabata, 2011). We used maximum likelihood to estimate the parameters.

Data analysis proceeded as follows: In the first instance, descriptive statistics were calculated for outcomes, predictors and control variables. In the next step, an unconditional growth curve model was built, to estimate the randomly varying intercepts and randomly varying slopes for each cognitive test and for the composite measure (Model 1). To build the conditional growth curve model, predictor variables were added to estimate the associations with test score at baseline (intercept), as well as interaction terms between each predictor and age to model the association with rate of cognitive decline (i.e., linear change slope; Model 2). Finally, to control for sex and education, these variables were added to the level-2 part of the model as fixed effects (Model 3).

To aid interpretation of the models, we chose to centre the three personality variables at their respective mean values. For the same reason, the time variable (i.e. the age at which outcomes were measured) was coded as age = 0, 5, 9.

Raw scores were used for each of the five cognitive tests. In an effort to present a more coherent and concise result, we created a composite variable out of these five outcome variables. This variable gave something akin to a measure of global cognitive function for each participant at each time point. The computation was done by first standardising (using a z-score transformation) each cognitive measure at age 70, then using the mean and standard deviation at baseline to standardise the scores at age 75 and 79. Simply z-standardising at each time point would effectively strip the data of its longitudinal value, so we used this method as a way to avoid this error. Finally, a composite variable was computed by adding together the standardised measures at each time point and dividing by the number of tests completed by each individual.

With regard to the covariates, sex was coded as man = 0 and woman = 1. We had two variables describing level of education, and rather than attempting to perform analyses with these two variables, we chose to create a composite variable to summarise each participant's relative level of education. Given that the different categories of vocational training themselves were of limited interest, we reduced it to a dichotomous variable, where no = 0 and yes = 1. This was then simply added to the value for academic education. The result is an imperfect measure, but in the very least it gave us a reasonable indication of the relative level of education of each participant, ranging from 0 to 9. This variable was then centred at the mean.

To investigate interactions between Extraversion and Neuroticism, we created a categorical personality variable (i.e., a factor) and contrasted the four personality categories against each other. We split the personality dimensions into High (12-24 points) and Low (0-11 points), dividing the participants into four categories: Low Extraversion and Low Neuroticism (Low E / Low N; n = 327), Low Extraversion and High Neuroticism (Low E / High N; n = 90), High Extraversion and Low Neuroticism (High E / Low N; n = 106), and High Extraversion and High Neuroticism (High E / High N; n = 31). The contrast analysis was done by dummy coding the personality factor, using High E / Low N as reference category, and retaining the Lie scale as part of the analyses (Model 4). We then added the covariates to this model, to control for sex and level of education (Model 5).

Results

Given the similar pattern of findings across the cognitive measures, we have chosen to present the analyses using the composite measure of cognitive function as primary findings, and analyses using each cognitive test as secondary findings. Table 1 shows the mean and standard deviation of the outcomes and predictors, and Table 2 shows a summary of the relevant fixed and random effects.

Overall, the results showed a small, yet significant, negative association between all personality variables and cognitive function at baseline, and no associations whatsoever with rate of decline. The coefficients for Neuroticism and the Lie scale were both highly significant ($p < .001$), while that for Extraversion was only just significant at $p = .022$. Standardised parameter estimates for the three personality variables were: Extraversion -0.090, Neuroticism -0.157 and Lie scale -0.205. Thereby we can determine that the Lie scale was the predictor with the greatest effect on cognitive function at baseline.

Sex had no significant association with cognitive function at baseline. Level of education showed a significant positive association, whereby a higher score on level of education predicted a slightly higher average level of cognitive function at age 70. Significant associations among predictors remained after adding control variables, so neither sex nor level of education appeared to bear any influence on the relationship between personality and cognitive function.

Proportion explained variance, in terms of effect size reporting, is not as straight forward when using multilevel modelling as with single level modelling. However, we can determine that the difference between the intercept variance in Model 1 and Model 2 showed that adding the chosen predictors led to a decrease in the variance in cognitive function at baseline by 21.4%. This gives us some indication as to the combined importance of the personality variables for level of cognitive functioning.

The results for each individual cognitive test followed roughly the same pattern as those for the composite measure (see Appendix B for estimates produced by Model 2). The most reliable association was that between the Lie scale and concurrent test score; this variable also consistently had a greater effect on average estimated test score than did Extraversion or Neuroticism. Neuroticism appeared to be more consistently associated with concurrent test score than Extraversion.

The contrast analysis showed, controlling for the Lie scale, a significant difference between two categories: those with low scores (0-11) on both Extraversion and Neuroticism, and those with high scores on both dimensions (12-24). See Figure 1 for distribution of personality scores divided into the four categories, and Table 3 for a summary of the contrast analysis using 'High E / High N' as the reference group. This group showed a lower estimated average score on the composite measure of cognitive function at baseline than the 'Low E / Low N' group. This difference was substantial, or proportional to 43% of the baseline standard deviation of the composite measure. Similar differences for the other contrasts were 32% (p = .122) and 36% (p = .075) for the 'Low E / High N', and 'High E / Low N' contrasts, respectively. Controlling for sex and level of education resulted in slightly lower estimates. In line with findings reported above, we found no significant associations with rate of decline.

Table 1

Mean and standard deviation of outcomes and predictors

Variable	Age	N	Mean	SD
Composite of	70	765	-0.025	0.772
cognitive function	75	560	-0.155	0.820
	79	420	-0.352	0.916
Synonyms	70	741	17.87	6.50
	75	547	17.55	6.97
	79	405	16.90	7.69
Figure Logic	70	748	13.32	4.71
	75	283	12.43	5.27
	79	181	12.00	5.33
Block Design	70	576	14.74	7.20
	75	554	13.26	6.96
	79	416	11.25	7.51
Identical Forms	70	572	18.19	7.68
	75	543	16.76	7.14
	79	398	14.45	7.43
Digit Span	70	572	9.52	1.88
	75	551	9.27	1.95
	79	410	9.06	2.34
Extraversion	70/75 [a]	554	9.06	3.50
Neuroticism	70/75 [a]	554	7.56	4.86
Lie scale	70/75 [a]	554	5.70	1.72

Notes. [a] Measures at age 75 for birth cohort 1901/02 and at age 70 for birth cohort 1906/07

Table 2

Parameter estimates from growth curve models using a composite measure of cognitive function as outcome

Parameters	Model 1		Model 2		Model 3	
	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*
Coefficient (fixed effects)						
Intercept	-0.012	0.028	0.100**	0.030	0.091	0.046
Age	-0.050**	0.003	-0.048**	0.004	-0.048**	0.004
Extraversion	-	-	-0.020*	0.009	-0.020*	0.009
Neuroticism	-	-	-0.025**	0.006	-0.025**	0.007
Lie	-	-	-0.092**	0.018	-0.093**	0.019
Extraversion x Age	-	-	0.001	0.001	0.001	0.001
Neuroticism x Age	-	-	0.000	0.001	0.000	0.001
Lie x Age	-	-	0.000	0.002	0.000	0.002
Sex	-	-	-	-	0.021	0.062
Level of education	-	-	-	-	0.067**	0.025
Variance components (random effects)						
Residual	0.097**	0.007	0.097**	0.007	0.097**	0.007
Intercept	0.503**	0.031	0.393**	0.030	0.393**	0.030
Slope	0.003**	0.000	0.003**	0.000	0.003**	0.000
Covariance	0.000	0.003	-0.002	0.003	-0.002	0.003
Model fit						
-2 Log Likelihood	3313.309		2273.580		2236.941	
Akaike's Information Criterion	3325.309		2297.580		2264.941	

∗ p < .05; ∗∗ p < .01

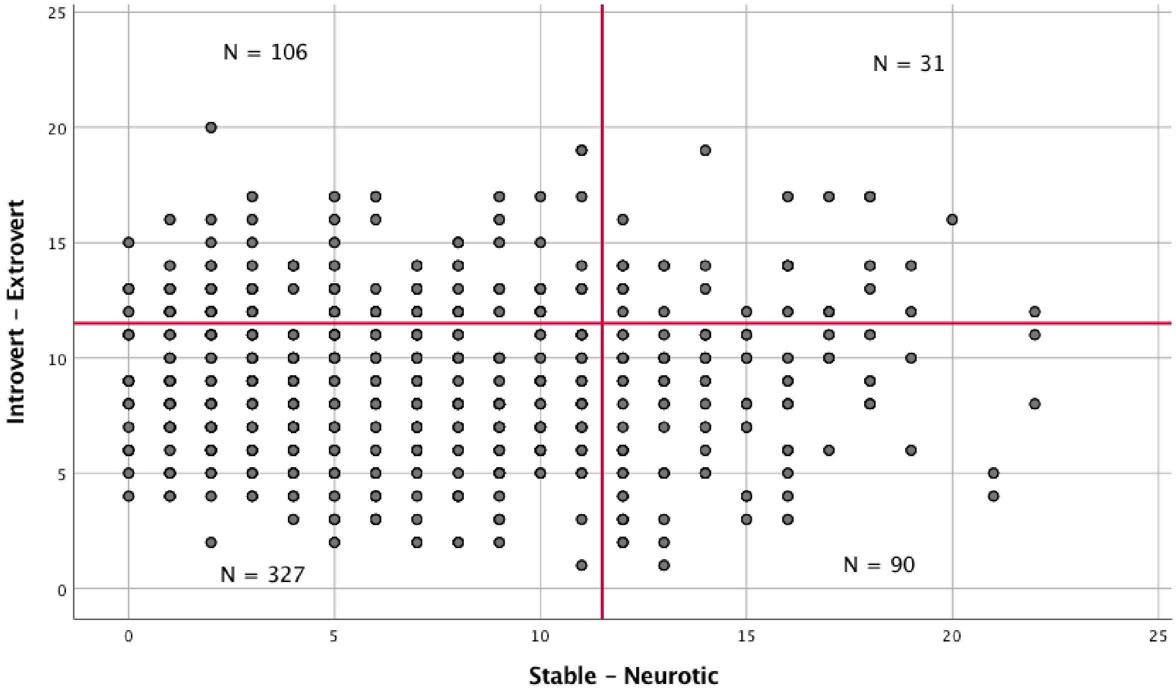

Figure 1. Distribution across the personality categories

Table 3

Parameter estimates from growth curve models using a composite measure of cognitive function as outcome and categorizing the personality scales into four categories

Contrast	Model 4		Model 5	
	Estimate	*SE*	Estimate	*SE*
Reference: High E / High N				
Intercept	-0.241	0.138	-0.151	0.146
Low E / Low N	0.332*	0.138	0.289*	0.146
Low E / High N	0.244	0.157	0.245	0.157
High E / Low N	0.277	0.155	0.233	0.156
Lie	-0.051**	0.019	-0.043*	0.019
Age	-0.043*	0.017	-0.042*	0.017
Sex	-	-	-0.092	0.065
Level of education	-	-	0.053*	0.027
Low E / Low N x Age	-0.006	0.018	-0.006	0.018
Low E / High N x Age	0.004	0.020	0.003	0.020
High E / Low N x Age	-0.007	0.019	-0.008	0.019

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

Discussion

The aim of this study was to investigate the associations between three personality variables and concurrent cognitive function, as well as rate of cognitive decline during aging. Overall, our findings supported the notion that individual differences in the two personality traits Extraversion and Neuroticism, as well as the Lie scale included in the EPI, can explain a degree of between person variance in cognitive test performance in late life. In our models, using the composite measure of cognitive function, the intercept variance was reduced by just over 20% when these predictors were added. This suggests that these aspects of personality, combined, do have value in explaining why 70 year olds differ in their performance during cognitive testing. More specifically, we found that each of the personality variables bore a small negative association with cognitive function at age 70. We found no indication, however, that personality differences can explain variance in the rate at which cognitive function deteriorates between the ages of 70 and 79.

These findings held true when controlling for sex and level of education. Sex had no association with cognitive function, whereas level of education had a positive association with cognitive test performance at age 70. This is unsurprising as education attainment has been found to be associated with level of cognitive function late in life, and, conversely, a higher cognitive ability may lead to higher levels of educational attainment (Lövdén, Fratiglioni, Glymour, Lindenberger & Tucker-Drob, 2020).

The results with regard to Neuroticism and concurrent cognitive function are largely in line with our hypothesis and with previous research. A higher score on the Neuroticism scale predicted slightly poorer cognitive function on average at age 70, across all outcome measures. The processing efficiency theory (see Eysenck et al., 2007) gives a plausible explanation for this, suggesting that worry takes up cognitive resources, impairing processing efficiency during a cognitive testing situation. In a later development of this theory, that is the attentional control theory, Eysenck et al. (2007) put forth that high anxiety and self-preoccupation reduces one’s ability to inhibit impulses and focus attention on task-related stimuli. The Impulsiveness facet of Neuroticism, as included in the Five Factor Model, may play a role in this association.

The trait showed no association whatsoever with rate of cognitive decline, however. It could be that the follow up period of nine years was not sufficiently long to detect any effects, or that this sample simply was not subject to the neurological ill-effects of Neuroticism described in the literature.

Extraversion followed a similar pattern, albeit showing a smaller effect size than Neuroticism with regard to the composite measure of cognitive function, and significant negative associations with performance on only two of the five cognitive tests. Our hypothesis of both negative and positive associations with concurrent cognitive function was therefore not supported; our results do not suggest that the assertiveness and cognitive agility of extraverts helps them perform better. Chapman et al. (2012) also found a negative association with test performance across their follow up period, which they suggest may be due to extraverts seeking external stimulation, and therefore having trouble focusing their attention on the test. Aiken-Morgan (2012) put forth a similar notion (although their results refuted this hypothesis). Extraverts may experience similar difficulties with attentional control as do neurotics, albeit to a lesser degree and for different reasons.

Interestingly, Extraversion showed a significant negative association with performance on the one test related to verbal ability (i.e., Synonyms) which can be seen to refute the otherwise compelling arguments put forth by Sutin et al. (2011), with regard to extraverts likely being more verbally able than introverts. However, the Synonyms test is in many ways different from the verbal fluency test used by Sutin et al. Firstly, Synonyms is written rather than spoken. Secondly, it does not require speed and creativity in the same way as the verbal fluency test, but rather demands accuracy and linguistic knowledge; perhaps crossword puzzles would be good practice. Seen in this light, it is unsurprising that introverts might do better than extraverts.

Figure Logic was the other test with which Extraversion was negatively associated at age 70. This is a test that demands attention to detail, participants must quickly select the correct figure and move on to the next, without making mistakes. It has been suggested that extraverts may be less patient and deliberate during a cognitive test situation (see Curtis et al., 2015), so we can imagine that they may have been more prone to move quickly through this test without taking enough care to select the correct figure each time, as compared to a more introverted individual. However, extraverts showed a very small yet significant tendency to decline less on this test over time. We are at a loss as to what mechanisms might explain this peculiar finding.

Overall, the notion that extraverts' more sociable and fast-paced lives gives their brains much needed exercise in order to stay healthy during the aging process was not supported by our longitudinal findings. Again, it could be the case that the follow up period was too short to detect any such effect, but longitudinal studies spanning over longer periods of time have also failed to show any effect. It seems likely that Extraversion entails a wide range of possible behavioural tendencies, which weakens its explanatory potential. While some specific aspects (such as having high quality social networks) may well have some protective effects, simply classifying someone as an extravert tells us next to nothing about their expected rate of cognitive decline during aging. This could explain why some previous researchers (Aiken-Morgan, 2012) using the Five Factor Model have found significant associations on the facet level, but none on the trait level. Different facets affecting behaviour and cognition in different ways could muddy the waters, making it difficult to detect any trait level effects on cognitive function.

Creating categorical personality profiles out of the Extraversion and Neuroticism variables allowed us to evaluate how different combinations of these traits might affect the cognitive outcome. We found that individuals high on both traits fared slightly worse at baseline than those low on both, so we can conclude that the two traits did interact in that sense. It seems plausible that the neurotic extraverts were doubly distracted during the cognitive tests, both by their seeking social stimulation, and by their anxious ruminations. Perhaps the theory of attentional control (Eysenck et al., 2007) could be further developed to explain this interaction. Stable introverts, on the other hand, may have had an easier time maintaining deliberate attention to the task at hand, thereby gaining higher scores. We found no indication, however, that the traits interacted to affect the rate of cognitive decline.

A noteworthy finding in this study is that the predictor variable displaying the greatest effect size with regard to global cognitive function was the Lie scale. The estimates for the variable were significant for all five cognitive tests, and were consistently larger than those for Neuroticism and Extraversion. This can be seen as support for the notion that the Lie scale carries more weight than simply measuring the validity of an individual's EPI results. Perhaps it does measure some fundamental aspect of personality, such as conformity or social acquiescence, as has been suggested by Jackson and Francis (1999). We can imagine how a hyper-awareness of how one comes across to others may interfere with performance on cognitive tests that require a high degree of focused attention on the task at hand.

The larger effect size may also partly be due to the fact that the Lie scale most likely measures a more discreet aspect of personality than either the Extraversion or the Neuroticism scales. Perhaps the Lie scale could be said to measure a specific facet of personality, rather than a trait, in which case any effects present would be easier to detect.

The finding also supports the idea that inclusion of the Lie scale may have lowered the contribution of Neuroticism, given that a high score on the Lie scale may imply that the respondent has understated their true neurotic nature. Indeed, the bivariate correlation between the two scales was r = -0.289 ($p < .01$), implying that the Lie scale may have had a confounding effect.

Implications for clinical practice and future research

Our findings reinforce the importance of taking personality into account when assessing cognitive function among older individuals. A poorer performance on cognitive tests can in some cases partly be accounted for by personality traits getting in the way, and need not fully reflect the patient's true cognitive ability. Perhaps certain tendencies, such as anxious thoughts, being very eager to be seen in a favourable light, and a focus on the social aspects of the test situation, make it more difficult to pay deliberate attention to the task. We have no doubt that experienced practitioners in the field of cognitive evaluations develop an intuition about this. Oftentimes they can surely sense when someone is especially anxious about being evaluated, or more interested in making small talk, and bear this in mind on some level. Especially if a person shows both of these tendencies simultaneously.

The fact that we found no interactions with age signifies that being highly neurotic and/or extraverted does not in and of itself give reason for concern for these individuals' cognitive development as they age.

That a patient may become so distracted and/or anxious during a cognitive test situation that their results show a poorer cognitive function than the individual experiences in daily life, could be compared to the so-called white coat syndrome that has been observed in relation to blood pressure testing (Pickering, 1994). One way to overcome this effect is to have patients take their blood pressure themselves, at home, where they feel more comfortable and less anxious (e.g. see George & McDonald, 2015). This could be an option for cognitive evaluations also – giving patients the option of completing at least some cognitive tests at home on a tablet or smartphone could potentially reduce both social distraction and anxiety, thereby giving a more valid and usable test result.

Future research would do well to delve deeper into the facets of Neuroticism, and especially Extraversion, to distinguish which specific tendencies that may have an effect on different aspects of concurrent cognitive test performance. The Lie scale included in the EPI deserves further attention also. It would be interesting to see whether these particular results could be replicated, and how this scale correlates with traits and facets included in the Five Factor Model.

Strengths and Limitations

A major strength of this study was the high participation rate, which made for a relatively large population-based representative sample. The repeated measures over a nine-year period also provided rare and valuable longitudinal data. Finally, attrition was mainly due to mortality, thereby justifying generalisation to other populations.

It is also important, however, to view the results of this study in light of its limitations. Firstly, cognitive tests and personality measurements have been improved since the 1970s. The instruments used in the H70 study may not have the validity and reliability of those available today, which renders the comparison between our results and those found in previous research imperfect. Secondly, we did not have access to raw data at the item level for outcomes or predictors, and could therefore not produce item level analyses or calculate the reliability of the scales used.

Further, even though multi-level modelling can account for missing data, only 78 participants in our sample had completed all tests at all three time points. This may diminish the validity of our results, especially with regard to changes in outcomes over time.

Finally, although the trait theory of personality rests on the supposition that personality remains stable across the lifespan, more recent research has indicated that traits can fluctuate well into old age (e.g. see Roberts, Walton & Viechtbauer, 2006). It is also possible that cognitive decline in aging influences personality in various ways, so it difficult to draw firm conclusions about causality.

Conclusions

In conclusion, personality does appear to bear some relevance to cognitive test performance late in life, while our findings do not support the notion that personality affects cognitive aging as such. Both Neuroticism and Extraversion are traits that may impede an individual's ability to focus their attention on a cognitive test. Neurotic extraverts may be expected to perform worse than stable introverts. The Lie scale included in the EPI appears to measure some facet of personality that is more strongly associated with poorer cognitive test performance than either of the traits studied, and warrants further investigation. These insights are potentially of importance to clinicians evaluating cognitive function among elderly patients, in that a low score could partly be explained by personality factors impeding performance, and need not necessarily indicate an onset of a steeper than average rate of cognitive decline. Cognitive evaluations would therefore optimally be done using repeated testing as patients age.

References

Aiken-Morgan, A., Bichsel, J., Allaire, J. C., Savla, J., Edwards, C. L., & Whitfield, K. E. (2012). Personality as a source of individual differences in cognition among older african americans. *Journal of Research in Personality, 46*(5), 465-471. doi:http://dx.doi.org.ezproxy.ub.gu.se/10.1016/j.jrp.2012.04.006

Allen, P. A., Kaut, K., Baena, E., Lien, M., & Ruthruff, E. (2011). Individual differences in positive affect moderate age-related declines in episodic long-term

memory. *Journal of Cognitive Psychology, 23*(6), 768-779. doi:http://dx.doi.org.ezproxy.ub.gu.se/10.1080/20445911.2011.570254
Berg, S. (1980). *Psychological Functioning in 70- and 75-year-old People: A Study in an Industrialized City.* Copenhagen: Munksgaard.
Bielak, A. A. M. (2010). How can we not 'lose it' if we still don't understand how to 'use it'? unanswered questions about the influence of activity participation on cognitive performance in older age—A mini-review. *Gerontology, 56*(5), 507 519. doi:http://dx.doi.org.ezproxy.ub.gu.se/10.1159/000264918
Booth, J. E., Schinka, J. A., Brown, L. M., Mortimer, J. A., & Borenstein, A. R. (2006). Five-factor personality dimensions, mood states, and cognitive performance in older adults. *Journal of Clinical and Experimental Neuropsychology, 28*(5), 676 683. doi:http://dx.doi.org.ezproxy.ub.gu.se/10.1080/13803390590954209
Boyle, L. L., Lyness, J. M., Duberstein, P. R., Karuza, J., King, D. A., Messing, S., & Tu, X. (2010). Trait neuroticism, depression, and cognitive function in older primary care patients. *The American Journal of Geriatric Psychiatry, 18*(4), 305 312. doi:http://dx.doi.org.ezproxy.ub.gu.se/10.1097/JGP.0b013e3181c2941b
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. doi:http://dx.doi.org.ezproxy.ub.gu.se/10.1097/JGP.0b013e31822cc9cb
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. doi:http://dx.doi.org.ezproxy.ub.gu.se/10.1080/13825585.2014.888392
Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion, 7*(2), 336-353. doi:http://dx.doi.org.ezproxy.ub.gu.se/10.1037/1528-3542.7.2.336
George, J., & MacDonald, T. (2015). Home blood pressure monitoring. *European cardiology, 10*(2), 95–101. https://doi.org/10.15420/ecr.2015.10.2.95
Graham, E. K., James, B. D., Jackson, K. L., Willroth, E. C., Boyle, P., Wilson, R., Bennett, D. A. & Mroczek, D. K. (2021). Associations between personality traits and cognitive resilience in older adults. *Journals of Gerontology: Psychological Sciences, 76*(1), 6-19. doi:10.1093/geronb/gbaa135
Graham, J. W. (2009). Missing data analysis: Making it work in the real world. *Annual Review of Psychology, 60,* 549-576. doi:http://dx.doi.org.ezproxy.ub.gu.se/10.1146/annurev.psych.58.110405.085530
Heck, R. H., Thomas, S. L., & Tabata, L. N. (2011). *Quantitative methodology series.Multilevel and longitudinal modeling with IBM SPSS.* Routledge/Taylor & Francis Group
Hertzog, C., Kramer, A. F., Wilson, R. S., & Lindenberger, U. (2008). Enrichment effects on adult cognitive development: Can the functional capacity of older adults be preserved and enhanced? *Psychological Science in the Public Interest, 9*(1), 1-65. Retrieved from https://www-proquest com.ezproxy.ub.gu.se/scholarly-journals/enrichment-effects-on-adult-cognitive development/docview/621998541/se-2?accountid=11162
Howarth, E. (1976). A psychometric investigation of Eysenck's personality inventory. *Journal of Personality Assessment, 40*(2), 173-185. doi:https://doi.org/10.1207/s15327752jpa4002_9

Jackson, J., Balota, D. A., & Head, D. (2011). Exploring the relationship between personality and regional brain volume in healthy aging. *Neurobiology of Aging, 32*(12), 2162-2171. doi:http://dx.doi.org.ezproxy.ub.gu.se/10.1016/j.neurobiolaging.2009.12.009

Jackson, C. J., & Francis, L. J. (1999). Interpreting the correlation between neuroticism and lie scale scores. *Personality and Individual Differences, 26*(1), 59-63. doi:http://dx.doi.org.ezproxy.ub.gu.se/10.1016/S0191-8869(98)00142-1

Jelicic, M., Bosma, H., Ponds, R. W. H. M., van Boxtel, M. P. J., Houx, P. J. & Jolles, J. (2003). Neuroticism does not affect cognitive functioning in later life. *Experimental Aging Research, 29*(1), 73-78. doi:10.1080/03610730303704

Jensen, A. R. (*1958*). The Maudsley personality inventory. *Acta Psychologica, 14,* 314 325. doi:https://doi.org/10.1016/0001-6918(58)90023-4

Johansson, B., Berg, S., Steen, G. (2003). Minne och Kognition. In B. Steen (Ed.). *Att bli äldre: H70 De gerontologiska och geriatriska populationsstudierna i Göteborg* (pp. 53-61). Göteborg: Avdelningen för geriatrik, Göteborgs Universitet.

Larsen, R. J. & Buss, D. M. (2010). *Personality Psychology: Domains of Knowledge about Human Nature (4th ed).* New York: McGraw Hill.

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. *The Journals of Gerontology: Series B: Psychological Sciences and Social Sciences, 71*(4), 591-601. doi:http://dx.doi.org.ezproxy.ub.gu.se/10.1093/geronb/gbu184

Lövdén, M., Fratiglioni, L., Glymour, M. M., Lindenberger, U., & Tucker-Drob, E. (2020). Education and cognitive functioning across the life span. *Psychological Science in the Public Interest, 21*(1), 6-41. doi:http://dx.doi.org.ezproxy.ub.gu.se/10.1177/1529100620920576

McCrae, R., & Costa, P. (2002). *Personality in adulthood: A five-factor theory perspective.* New York: Taylor & Francis Group.

Meier, B., Perrig-Chiello, P., & Perrig, W. (2002). Personality and memory in old age. *Aging, Neuropsychology, and Cognition, 9*(2), 135-144. doi:http://dx.doi.org.ezproxy.ub.gu.se/10.1076/anec.9.2.135.9544

Pickering T. G. (1994). Blood pressure measurement and detection of hypertension. *Lancet, 344*(8914), 31–35. doi:https://doi.org/10.1016/s0140 6736(94)91053-7

Rinder, L., Roupe, S., Steen, B., & Svanborg, A. (1975). Seventy-year-old people in Gothenburg: A population study in an industrialized Swedish City. *Acta medica Scandinavica, 198,* 397-407.

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. doi:http://dx.doi.org.ezproxy.ub.gu.se/10.1037/0033-2909.132.1.1

Stephan, Y., Sutin, A. R., Luchetti, M. & Terracciano, A. (2020a). Memory and personality development in adulthood: Evidence from four longitudinal studies. *Journals of Gerontology: Psychological Sciences, 76*(1), 88-97. doi:10.1093/geronb/gbaa086

Stephan, Y., Sutin, A. R., Luchetti, M., & Terracciano, A. (2020b). Personality and memory performance over twenty years: Findings from three prospective studies. *Journal of Psychosomatic Research, 128*, 4. doi:http://dx.doi.org.ezproxy.ub.gu.se/10.1016/j.jpsychores.2019.109885

Sutin, A. R., Terracciano, A., Kitner-Triolo, M., Uda, M., Schlessinger, D., & Zonderman, A. B. (2011). Personality traits prospectively predict verbal fluency in a lifespan sample. *Psychology and Aging, 26*(4), 994-999. doi:http://dx.doi.org.ezproxy.ub.gu.se/10.1037/a0024276

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: The Journal of the Alzheimer's Association, 10*(2), 179-186. doi:http://dx.doi.org.ezproxy.ub.gu.se/10.1016/j.jalz.2013.03.002

Thorvaldsson, V., Karlsson, P., Skoog, J., Skoog, I. & Johansson, B. (2017). Better cognition in new birth cohorts of 70 year olds, but greater decline thereafter. *Journals of Gerontology: Psychological Sciences, 72*(1), 16-24. doi:10.1093/geronb/gbw125

van Ockenburg, S. L., de Jonge, P., van der Harst, P., Ormel, J., & Rosmalen, J. G. M. (2014). Does neuroticism make you old? Prospective associations between neuroticism and leukocyte telomere length. *Psychological Medicine, 44*(4), 723 729. doi:http://dx.doi.org.ezproxy.ub.gu.se/10.1017/S0033291713001657

Wang, H. -X., Karp, A., Herlitz, A., Crowe, M., Kåreholt, I., Winblad, B., & Fratiglioni, L. (2009). Personality and lifestyle in relation to dementia incidence. *Neurology, 72*(3), 253-256. doi:http://dx.doi.org.ezproxy.ub.gu.se/10.1212/01.wnl.0000339485.39246.87

Wetherell, J. L., Reynolds, C. A., Gatz, M., & Pedersen, N. L. (2002). Anxiety, cognitive performance, and cognitive decline in normal aging. *The Journals of Gerontology: Series B: Psychological Sciences and Social Sciences, 57*(3), 246-255. doi:http://dx.doi.org.ezproxy.ub.gu.se/10.1093/geronb/57.3.P246

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. doi:http://dx.doi.org.ezproxy.ub.gu.se/10.1016/j.jrp.2010.06.002

Wilson, R. S., Barnes, L. L., Mendes de Leon, C. F., Aggarwal, N. T., Schneider, J. S., Bach, J., . . . Bennett, D. A. (2002). Depressive symptoms, cognitive decline, and risk of AD in older persons. *Neurology, 59*(3), 364-370. doi:http://dx.doi.org.ezproxy.ub.gu.se/10.1212/WNL.59.3.364

Appendix A

Frequency of academic and vocational education

Level of Education	Frequency	Percentage
Academic education[a]		
Missing	13	1.7
None	0	0
Uncompleted primary/secondary school	23	2.9
Completed primary/secondary school	624	79.9
Primary/secondary school + adult education	16	2.0
Uncompleted further education	84	10.7
Completed further education	9	1.1
Uncompleted higher education	2	0.3
Bachelor degree	12	1.5
Total	783	100
Vocational training[b]		
Missing	13	1.7
None	552	70.5
Vocational training or comparable	38	4.9
Domestic	13	1.7
Distance learning	8	1.0
Business	39	5.0
Technical	9	1.1
Other	111	14.2
Total	783	100

Notes. [a]Highest level attained, freely translated into UK equivalents. [b]Categories freely translated

Appendix B

Table B1

Parameter estimates from growth curve models using verbal ability (Synonyms) as outcome

Parameters	Model 1		Model 2	
	Estimate	*SE*	Estimate	*SE*
Coefficient (fixed effects)				
Intercept	17.861**	0.239	18.628**	0.257
Age	-0.192**	0.027	-0.177**	0.028
Extraversion	-		-0.283**	0.074
Neuroticism	-		-0.210**	0.055
Lie	-		-0.942**	0.157
Extraversion x Age	-		0.003	0.008
Neuroticism x Age	-		-0.006	0.006
Lie x Age	-		-0.037*	0.017
Variance components (random effects)				
Residual	7.494**	0.530	6.905**	0.523
Intercept	36.141**	2.289	29.856**	2.261
Slope	0.152**	0.028	0.130**	0.027
Covariance	0.252	0.189	0.063	0.183
Model fit				
-2 Log Likelihood	10352.322		7858.800	
Akaike's Information Criterion	10362.322		7882.800	

∗ $p < .05$; ∗∗ $p < .01$

Table B2

Parameter estimates from growth curve models using reasoning (Figure Logic) as outcome

Parameters	Model 1		Model 2	
	Estimate	*SE*	Estimate	*SE*
Coefficient (fixed effects)				
Intercept	13.327**	0.171	13.776**	0.189
Age	-0.196**	0.042	-0.166**	0.045
Extraversion	-		-0.103*	0.055
Neuroticism	-		-0.076*	0.041
Lie	-		-0.330**	0.116
Extraversion x Age	-		0.031*	0.013
Neuroticism x Age	-		-0.010	0.010
Lie x Age	-		0.030	0.026
Variance components (random effects)				
Residual	11.667**	1.143	11.352**	1.227
Intercept	10.696**	1.582	8.566**	1.659
Slope	0.177**	0.058	0.121*	0.057
Covariance	-0.1754	0.260	-0.112	0.263
Model fit				
-2 Log Likelihood	7190.937		5251.937	
Akaike's Information Criterion	7202.937		5275.937	

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

Table B3

Parameter estimates from growth curve models using spatial ability (Block Design) as outcome

Parameters	Model 1		Model 2	
	Estimate	*SE*	Estimate	*SE*
Coefficient (fixed effects)				
Intercept	14.749**	0.275	15.563**	0.302
Age	-0.426**	0.029	-0.454**	0.032
Extraversion	-		-0.078	0.087
Neuroticism	-		-0.278**	0.065
Lie	-		-0.509**	0.186
Extraversion x Age	-		-0.002	0.009
Neuroticism x Age	-		0.000	0.007
Lie x Age	-		-0.019	0.020
Variance components (random effects)				
Residual	11.162**	0.797	10.374**	0.811
Intercept	40.547**	2.932	36.969**	3.076
Slope	0.059	0.035	0.073*	0.036
Covariance	-0.312	0.239	-0.328	0.248
Model fit				
-2 Log Likelihood	9692.385		7574.975	
Akaike's Information Criterion	9704.385		7598.975	

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

Table B4

Parameter estimates from growth curve models using perceptual and motor speed (Identical Forms) as outcome

Parameters	Model 1		Model 2	
	Estimate	*SE*	Estimate	*SE*
Coefficient (fixed effects)				
Intercept	18.285**	0.300	19.050**	0.309
Age	-0.464**	0.038	-0.493**	0.040
Extraversion	-		-0.058	0.090
Neuroticism	-		-0.162*	0.066
Lie	-		-0.492*	0.191
Extraversion x Age	-		-0.003	0.012
Neuroticism x Age	-		0.000	0.009
Lie x Age	-		0.003	0.025
Variance components (random effects)				
Residual	12.950**	0.952	12.178**	0.977
Intercept	46.871**	3.512	35.907**	3.252
Slope	0.300**	0.053	0.253**	0.053
Covariance	-1.587**	0.348	-1.059**	0.329
Model fit				
-2 Log Likelihood	9821.171		7659.637	
Akaike's Information Criterion	9833.171		7683.637	

∗ p < .05; ∗∗ p < .01

Table B5

Parameter estimates from growth curve models using short-term/working memory (Digit Span) as outcome

Parameters	Model 1		Model 2	
	Estimate	*SE*	Estimate	*SE*
Coefficient (fixed effects)				
Intercept	9.561**	0.074	9.670**	0.084
Age	-0.076**	0.012	-0.068**	0.013
Extraversion	-		-0.003	0.024
Neuroticism	-		-0.040*	0.018
Lie	-		-0.138**	0.052
Extraversion x Age	-		0.002	0.004
Neuroticism x Age	-		0.000	0.003
Lie x Age	-		-0.005	0.008
Variance components (random effects)				
Residual	1.498**	0.110	1.272**	0.102
Intercept	2.050**	0.227	2.206**	0.245
Slope	0.027**	0.006	0.029**	0.006
Covariance	-0.024	0.028	-0.081**	0.030
Model fit				
-2 Log Likelihood	6187.824		4763.718	
Akaike's Information Criterion	6199.824		4787.718	

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