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Personality and Cognitive Decline in the Baltimore Epidemiologic Catchment Area Follow-up Study

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Abstract

Objective—To determine the association between personality domains and 11-year cognitive decline in a sample from a population-based study.

Method—Data from Waves 3 (1993–1996) and 4 (2003–2004) of the Baltimore cohort of the Epidemiologic Catchment Area (ECA) study were used for analyses. The sample included 561 adults (mean age $\pm$ SD = 45.2 $\pm$ 10.78 years) who completed the NEO Personality Inventory-Revised (NEO PI-R) prior to Wave 4. Participants also completed the Mini-Mental State Examination (MMSE) and immediate and delayed word recall tests at Wave 3, and at Wave 4 10.9 $\pm$ 0.6 years later.

Results—In models adjusted for baseline cognitive performance, demographic characteristics, medical conditions, depressive symptoms, and psychotropic medication use, each 10-point increase in Neuroticism *T*-scores was associated with a 0.15-point decrease in MMSE scores (*B* = –0.15 95% confidence interval (CI) –0.30, –0.01), whereas each 10-point increase in Conscientiousness *T*-scores was associated with a 0.18-point increase on the MMSE (*B* = 0.18, 95% CI 0.04, 0.32) and a 0.21-point increase in immediate recall (*B* = 0.21, 95% CI 0.003, 0.41) between baseline and follow-up.

Conclusion—Findings suggest that greater Neuroticism is associated with decline, and greater Conscientiousness is associated with improvement in performance on measures of general cognitive function, and memory in adults. Further studies are needed to determine the extent to

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which personality traits in midlife are associated with clinically significant cognitive outcomes in older adults, such as mild cognitive impairment and dementia, and to identify potential mediators of the association between personality and cognitive trajectories.

Keywords

Personality; Neuroticism; Conscientiousness; Cognition; Dementia; Depression

Introduction

Cognitive decline is associated with great disability and a profound burden on caregivers and the healthcare system.^{1,2} The US population of adults aged 65 and older is projected to double between 2010 and 2030, reaching approximately 72 million by 2030 and representing almost 20 percent of the population.³ In parallel, both the incidence and prevalence of dementia are expected to rise dramatically over the next several decades.⁴ Identifying individuals at elevated risk for cognitive decline is critical to understanding the etiology of neurodegenerative diseases and to developing prevention efforts.⁵

Personality domains have been linked to variables with relevance to cognitive outcomes. For example, greater Neuroticism, characterized by stress reactivity and negative affect, has been identified as a risk factor for inflammation⁶ and reduced brain volume.⁷ Also, Extraversion, characterized by a proclivity for social engagement and stimulation, has been inversely linked to major depressive disorder.⁸

Several studies have reported associations between personality and cognition.^{9–13} For example, higher Neuroticism has been linked to cognitive impairment or decline,^{11,14} while higher Openness and Conscientiousness may be protective against decline.^{10,11} Studies have reported similar findings in terms of these personality domains and risk of Alzheimer's disease (AD),^{9,12,13} The relationships between Extraversion, Agreeableness and cognition are less clear with one study reporting a protective role of moderate Extraversion,¹⁴ one study reporting an association between increased Extraversion and worse cognitive functioning,¹¹ and no studies reporting significant findings for Agreeableness and cognition.^{9–13}

However, studies of personality and cognition have had methodological limitations. Some have used retrospective⁹ or case-control¹⁴ designs, or primarily Caucasian^{9,12} or highly selected populations (e.g., nuns, priests).¹³ Others have excluded participants based on medical status,¹² limiting generalizability to less healthy populations. Further, studies have generally been restricted to older adults.^{9,12} Studying personality as a predictor of cognitive decline in older adults can be problematic, because neurodegenerative diseases are prevalent in this population and can produce both personality change and cognitive decline.¹⁵ Thus, it can be difficult to demonstrate compelling causal links between “pre-morbid” personality and cognitive change in older populations.¹²

We determined the association between personality domains and 11-year cognitive decline in the Baltimore Epidemiologic Catchment Area (ECA) study, a population-based cohort of adults from a broad range of age groups and diverse racial/ethnic backgrounds.¹⁶ Personality

assessment was measured using the NEO PI-R, a comprehensive five-factor model that yields the following personality domains: Neuroticism (reactivity to stress and tendency to experience negative affect); Extraversion (loquaciousness, proclivity for people, large groups, activity, excitement, and overall stimulation); Openness to Experience (inclination for intellectual curiosity, variety, imagination, aesthetic sensitivity, and attention to inner feelings); Agreeableness (ability to trust, sympathize with, and cooperate with others); and Conscientiousness (high degree of self control, active planning, and carrying out tasks in an organized fashion).¹⁷ We hypothesized that higher levels of Neuroticism would be associated with greater cognitive decline, and that higher levels of Extraversion, Openness, Agreeableness, and Conscientiousness would be associated with greater stability of cognitive performance.

Methods

Participants

Baltimore is one of five sites of the ECA Study, an NIMH-sponsored population-based study of psychopathology over the adult life course.¹⁶ A probability sample of 3,481 East Baltimore residents was enrolled in 1981 (Wave 1) with follow-up in 1982 (Wave 2), 1993–1996 (Wave 3), and 2003–2004 (Wave 4). Of the original sample, 2,768 were retained at Wave 2, 1,920 at Wave 3, and 1,071 at Wave 4. At each wave, participants completed multiple cognitive and psychosocial measures. Psychopathology was assessed using the NIMH Diagnostic Interview Scale (DIS).¹⁸ Participants were included in the present analysis if they completed the NEO PI-R assessment at or after Wave 3 but before Wave 4 ($N = 824$) and at least one of three cognitive tests (see below) at both Waves 3 and 4 ($N = 561$). Here, we refer to Wave 3 as “baseline,” and to Wave 4 as “follow-up.”

Measures

Personality—In the Baltimore ECA, personality was assessed in multiple substudies using the Revised NEO Personality Inventory (NEO PI-R).¹⁷ The NEO PI-R is a 240-item self-report measure; responses are made on a 5-point Likert scale (0 = strongly disagree, 5 = strongly agree). This instrument has been validated in a range of diverse populations, including the ECA sample.^{19,20} Raw scores were standardized as *T*-scores ($M = 50$, $SD = 10$), as described in the Manual.¹⁷

In one ECA substudy, the NEO PI-R was administered at our baseline (Wave 3) to participants with either incident DIS disorders (since Wave 1) from major diagnostic categories, or with these disorders at multiple Waves, and also to a subset without these disorders. Similarly, a second substudy collected personality data after our baseline from participants with history of a DIS disorder from major diagnostic categories, and a random sample without such a history. Personality data were also collected for two other ECA subsamples, one of which enrolled participants younger than age 50, and one that recruited participants with symptoms of psychosis or anxiety on the DIS. Of the NEO PI-R tests within our sample, 48.8% (274/561) were administered at baseline (1993–1994). The rest were administered at subsequent interviews, the last of which was in 1999 (approximately 4 years before Wave 4).

Cognitive Performance

Participants completed at least one of these three cognitive tests at both baseline and follow-up.

Mini-Mental State Examination (MMSE)—The MMSE is a brief global measure of cognition that is commonly used in clinical and research settings.²¹ It measures a range of domains, including memory, language, attention and concentration, and visuospatial ability. Scores range from 0 to 30, with higher scores indicating better cognitive function.²¹

Immediate and Delayed Word Recall Tasks—These tests were developed for the Iowa Established Populations for Epidemiologic Studies of the Elderly project.²² Research staff read aloud a list of 20 common words. For immediate recall, participants were asked to recall as many of these words as they could, in any order, just after hearing the list. For delayed recall, participants were asked to recall words from the same list 20 minutes later. Scores for each component reflect the total number of words correctly recalled; each ranges from 0 to 20.

Additional Covariates

Participants' sociodemographic characteristics, lifetime medical histories, depressive symptoms, and past week medication use were obtained via self-report at Wave 3. For medication use, reports were verified by examining prescription and over-the-counter medication bottles, which participants were asked to provide. We obtained the number of depressive symptoms ever experienced for at least a two-week period ("lifetime depressive symptoms") by summing the number of DSM-III-R depressive symptoms endorsed (range 0 to 9).

Statistical Analyses

We compared baseline demographics of individuals who participated in Wave 3 but not Wave 4, with those who participated in both Waves using *t*-tests, Wilcoxon rank-sum tests, chi squared statistics, and Fisher's exact tests. We then determined the association between personality domains and decline in cognitive test scores from baseline to follow-up by fitting linear regression models. Our primary predictors were the five NEO-PI-R domains (each entered in a separate model) and our outcomes were change in each of the cognitive test scores between baseline and follow-up (i.e., score at Wave 4 minus score at Wave 3). To control for potential confounding, we adjusted for known predictors of cognitive decline and variables associated with any predictor and outcome at the $p < 0.10$ level. We also adjusted for sex and use in the past week of antidepressants, benzodiazepines, or other psychotropic medications. We divided personality domain *T*-scores by ten to facilitate interpretation; regression coefficients reflect the change in cognitive test score associated with a 1-standard deviation increase in personality *T*-scores.

We fit three sets of models: a base model, adjusted for baseline cognitive test score; a partially adjusted model (Model II), in which we added age, sex, education, and race as covariates; and a fully adjusted model (Model III), in which we added the following to the partially-adjusted model: history of heart problems (angina pectoris, heart attack, congestive

heart failure, rheumatic fever, or rheumatic heart disease), hypertension, diabetes, stroke, participant report of past week psychotropic medication use (different classes entered as separate variables), and number of lifetime depressive symptoms. Because Conscientiousness plays an important role in self-regulation, especially in health and risk behaviors, we explored the interactions of Conscientiousness with each personality domain. Analyses were conducted using Stata Version 11.0 (StataCorp, College Station, TX).

Results

Participant Characteristics

At baseline, participants' mean age $\pm$ standard deviation (SD) was 45.2 ± 10.8 years, and ranged from 30 to 85 years (Table 1). Approximately 65% were women and 40% were non-white. Participants had 12.6 ± 2.5 years of education. In terms of lifetime medical history, at baseline, 12.1 % reported heart problems, 26.9% hypertension, 10.4% diabetes, and 2.0% a stroke. Participants reported an average of 2.3 ± 2.6 out of 9 possible lifetime depressive symptoms from the DSM III-R criteria. When asked about medication use in the past week, 4.5% reported using antidepressants, 3.6% reported using benzodiazepines, and 2.7% reported use of other psychotropic medications.

In our sample, the mean interval $\pm$ SD between cognitive assessments at Waves 3 and 4 was 10.9 ± 0.6 years (Min = 8.7, Max = 12.1 years). Data regarding the precise interval from personality assessment to Wave 4 were not available, but study records indicate that the maximum interval from personality assessment to Wave 4 was 11 years; the minimum was 4 years.

When we compared those with both baseline cognitive and personality assessments and follow-up cognitive assessments to those with baseline cognitive and personality assessments but not follow-up cognitive assessments, we found that those who dropped out were, on average, older ($z = -6.3, p < 0.001$), more likely to be male ($\chi^2 = 3.9, df = 1, p < 0.05$), less educated ($z = 5.3, p < 0.001$), and more likely to have health conditions, including heart problems ($\chi^2 = 6.7, df = 1, p < 0.05$), hypertension ($\chi^2 = 11.3, df = 1, p < 0.01$), or stroke (Fisher's exact < 0.01). They did not differ by race ($\chi^2 = 0.1, df = 1, p = 0.831$), history of diabetes ($\chi^2 = 0.7, df = 1, p = 0.417$), number of depressive symptoms ($z = -0.8, p = 0.398$), or baseline use of antidepressants ($\chi^2 = 0.6, df = 1, p = 0.433$), benzodiazepines (Fisher's exact = 0.178), or other psychotropic medications (Fisher's exact = 0.806). In addition, those who dropped out before Wave 4 had significantly higher scores on Neuroticism ($z = -3.0, p < 0.01$) and significantly lower scores on Extraversion ($z = 3.3, p < 0.01$) and Conscientiousness ($z = 2.7, p < 0.01$) but did not differ significantly on Openness ($z = 1.8, p = 0.080$) or Agreeableness ($z = -0.4, p = 0.659$).

In terms of personality *T*-scores, mean Neuroticism was 49.5 ± 9.3 (range: 24.8 – 93.6); mean Extraversion was 48.6 ± 9.4 (range: 4.2 – 79.7); mean Openness was 46.2 ± 8.9 (range: 9.3 – 79.1); mean Agreeableness was 48.4 ± 10.4 (range: 5.2 – 85.1); and mean Conscientiousness was 47.5 ± 9.8 (range: 5.8 – 76.7). As expected, higher levels of Neuroticism were significantly correlated with lower levels of Extraversion, Agreeableness, and Conscientiousness and positively correlated with depressive symptoms (Table 2).

Extraversion was positively correlated with Openness, Agreeableness, and Conscientiousness and was negatively correlated with depressive symptoms. Openness was positively correlated with Agreeableness and depressive symptoms.

Personality Domains and Cognitive Decline

On the MMSE, mean scores were 28.8 ± 1.7 at baseline and 28.6 ± 1.9 at follow-up. Mean immediate word recall scores were 8.1 ± 2.7 at baseline and 7.3 ± 2.7 at follow-up. Participants mean delayed word recall scores were 6.4 ± 2.8 at baseline and 5.6 ± 2.8 at follow-up. In the overall sample, mean performance declined slightly on all cognitive tests from baseline to follow-up ($p < 0.01$ for all) (Table 3).

In base regression models, each 10-point increase in Neuroticism was associated with a 0.12 to 0.21-point decline in performance on cognitive tests between baseline and follow-up, although this association was only significant for immediate word recall (Table 4). In the fully adjusted models, however, this association was only statistically significant for the MMSE ($B = -0.15$, 95% confidence interval (CI) $-0.30, -0.01$).

With respect to Extraversion, in base models, each 10-point increase in this domain was associated with a 0.16 to 0.24-point improvement in performance on cognitive tests between baseline and follow-up. These associations were statistically significant for all three cognitive tests, but decreased and became non-significant after multivariable adjustment.

Where Openness was concerned, each 10-point increase was associated with statistically significant 0.17 to 0.36-point increases in test performance on all three cognitive tests in base models. As was the case with Extraversion, however, these associations decreased and were not statistically significant after multivariable adjustment.

In base models, there were no significant associations between Agreeableness and cognitive outcomes. However, there was a significant association in the fully adjusted model, such that each 10-point increase in Agreeableness was associated with a 0.20-point increase in number of words recalled after a delay ($B = 0.20$, 95% CI 0.002, 0.39). There were no significant associations between Agreeableness and the immediate word recall or MMSE in fully adjusted models.

Finally, in base models, each 10-point increase in Conscientiousness was associated with 0.22 to 0.28-point increases in test performance. These associations decreased slightly but remained significant in the partially adjusted models for the MMSE and immediate recall tests. In the fully adjusted model, each 10-point increase in Conscientiousness was associated with a 0.18-point increase in MMSE scores ($B = 0.18$, 95% CI 0.04, 0.32) and a 0.21-point increase in words immediately recalled ($B = 0.21$, 95% CI 0.003, 0.41). No significant interactions were observed between Conscientiousness and any of the other personality domains (results not shown).

Discussion

We evaluated the association between personality and cognitive change over an 11-year interval in the Baltimore Epidemiologic Catchment Area Study, a population-based cohort

representing a broad range of ages and races/ethnicities. After accounting for a range of potential confounders, including depressive symptomatology, we found that greater Neuroticism was associated with decline in performance on a test of global cognitive function, greater Conscientiousness was associated with improved global cognitive function and immediate recall, and greater Agreeableness was associated with improved delayed recall. While other associations in our models did not reach statistical significance, the point estimates all were in hypothesized directions, with Neuroticism predicting decline and Extraversion, Openness, Agreeableness, and Conscientiousness predicting stability or improvements.

The present study extends existing research by investigating these associations in a population that is more diverse in terms of racial/ethnic background (40% non-white) and medical status than populations previously examined, and by measuring personality at an earlier mean age. Our findings are consistent with existing research linking higher levels of Neuroticism to a greater risk for cognitive decline^{9,12,14} and greater Extraversion,¹⁴ Openness,^{10,12} and Conscientiousness^{12,13} to a lower risk. Our finding of a protective effect of Agreeableness on delayed recall diverges from existing studies,^{9,12,14} and needs to be replicated.

An implication of our findings is that levels of Neuroticism, Agreeableness, and Conscientiousness may help identify people at risk for poor cognitive outcomes. Interventions to alter personality features (i.e., reductions in Neuroticism, increases in Agreeableness and Conscientiousness) might lead to corresponding alterations in cognitive trajectories. This could have a public health impact, given the rapidly increasing population of older adults at risk for cognitive impairment. Research is still in its infancy regarding how best to modify personality features. In Five-Factor Theory, (McCrae and Costa, 2008) created to explain the large body of empirical associations with the Five-Factor Model, there is a distinction between traits as underlying dispositions and the characteristic adaptations (CAs) or maladaptations that they promote in concert with environmental context.²³ Even though traits may be more difficult to modify or are even perhaps unmodifiable, their characteristic behaviors, thoughts, feelings, values, and attitudes could be the target of change efforts, i.e. targeting CAs rather than the underlying dispositions.

It should be noted that our findings indicate small to moderate associations between personality dimensions and cognitive decline. However, our results are in a mixed-age sample so it remains unclear what the magnitude of these associations would be in a sample comprised entirely of older adults at the time of follow-up. Further studies that follow participants until more of the sample reaches older age are needed to determine the clinical significance of these associations in older adults.

Both biological and behavioral mechanisms may explain the association between personality and risk of cognitive decline. Previous studies have reported that chronic strong reactions to stress may lead to brain volume loss.^{24,25} Individuals high in Neuroticism experience heightened emotional reactions to stress,¹⁷ including increased exposure to cortisol²⁶ and inflammation,⁶ which may damage the brain over time.²⁷ Personality traits also are associated with health behaviors, including dietary patterns,²⁸ drug and alcohol use,²⁹ and

medication adherence.³⁰ People scoring high in Neuroticism are more likely to engage in unhealthy behaviors, such as binge eating and drinking, perhaps due to their poorer impulse control,³¹ and they may also have poorer sleep quality.³² Meanwhile, people who score high in Conscientiousness are more likely to engage in health-protective behaviors such as exercising,³³ seeing a doctor regularly, and adhering to medical prescriptions.³⁴ Diet, substance use, sleep, and taking care of one's physical health all are linked to cognitive status in later life.^{35,36} Studies are needed to further elucidate mediators and pathways of the personality-cognition association.

Of note, we found that Neuroticism was significantly associated with global cognitive decline even after adjustment for lifetime depressive symptoms, suggesting that this personality domain is not merely a marker for depressive symptomatology. Personality domains such as Neuroticism tend to be conceived of as "traits" while depressive symptoms are often thought of as "states" that may fluctuate over time.³⁷ Because Neuroticism appears to be a risk factor for cognitive decline in its own right and is thought to be more stable over time, it may be a more reliable marker than depressive symptoms for identifying individuals at higher risk for decline.

The present study has several strengths, including a sample drawn from a population-based and ethnically diverse study of adults, and a longitudinal design with an average of 11 years of follow-up. However, this study also has some limitations. First, although we adjusted for potential confounders, there might have been residual confounding by unmeasured medical comorbidities and medication use. For instance, although we adjusted for lifetime depressive symptoms and psychiatric medication use, we did not adjust for symptoms of anxiety. It may be that observed associations (particularly with Neuroticism) are accounted for, at least in part, by anxiety.

Also, because this was an observational study, selection bias may have affected our results. We found that participants who dropped out of our sample before follow-up scored significantly higher on Neuroticism and significantly lower on Extraversion and Conscientiousness than those who remained in our sample. Because those who dropped out were less healthy and had lower baseline cognitive test scores, it is likely that this differential attrition by personality traits biased our results toward the null. That we still observed significant associations despite this potential bias gives us greater confidence in our findings. In addition, ECA participants who completed the NEO were not randomly selected from the cohort, but were part of substudies that recruited based on various selection criteria. Therefore, the associations we observed may differ in a truly representative sample.

Another potential criticism is that our sample was not limited to older adults. However, evidence suggests that cognitive change begins in midlife.^{38,39} Although personality domains may well predict cognitive decline in older adults, as others have pointed out, studying personality and cognition in samples comprised entirely of older adults can be problematic. Personality change can be caused by neurodegenerative processes and may begin in the subclinical stage, prior to diagnosis.¹² Studying personality and cognition in a younger sample is advantageous because neurodegenerative disease that leads to change in

both personality and cognition is less likely among younger people. Another limitation is that the ECA included a restricted range of cognitive tests.

A final limitation is that about one half (292/561) of the personality assessments were administered between baseline and follow-up, and thus occurred after the initial cognitive test. We are assuming that there was not enough cognitive impairment in most participants to greatly alter personality between baseline cognitive assessment and personality measures, and that in the absence of neuropathology, personality is relatively stable over time. In fact, another analysis using the Baltimore ECA sample demonstrated NEO stability between Waves 3 and 4.⁴⁰ Although we do not think this likely affected our results, replication of our findings is needed.

In summary, our findings suggest that greater Neuroticism may be associated with global cognitive decline, and that greater Conscientiousness and Agreeableness may be protective. An interesting aspect of this study is that there was little average change in cognitive measures over the eleven-year period in our sample, yet personality was significantly related to cognitive decline. Further prospective studies are needed to replicate our findings, particularly in cognitively healthy older adults in whom “premorbid” personality is known to be intact. In addition, research is needed to explore potential mechanisms linking personality to cognitive decline, to inform interventions aimed at preventing adverse health outcomes and promoting healthy cognitive aging.

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Table 1Participant characteristics at baseline (mean $\pm$ SD or *n* (%)).

Age (range 30–85 years)	45.2 $\pm$ 10.8
Education (range 5–17 years)	12.6 $\pm$ 2.5
Sex	
Male	197 (35.1)
Female	364 (64.9)
Race	
White	339 (60.4)
Non-white	222 (39.6)
Medical History (lifetime)	
Heart problems*	67 (12.1)
Hypertension	150 (26.9)
Diabetes	58 (10.4)
Stroke	11 (2.0)
Number of depressive symptoms (lifetime) (range 0–9)	2.3 $\pm$ 2.6
Antidepressant use (past week)	25 (4.5)
Benzodiazepine/sedative use (past week)	20 (3.6)
Other psychotropic medication use (past week)	15 (2.7)

N ranges from 553 to 561.

* Includes rheumatic fever, rheumatic heart disease, angina pectoris, a heart attack, and congestive heart failure.

Table 2

Correlations across personality domains and depressive symptoms (*r*).

	Neuroticism	Extraversion	Openness	Agreeableness	Conscientiousness	Depressive symptoms
Neuroticism	1.00					
Extraversion	−0.35 ^c	1.00				
Openness	−0.03	0.46 ^c	1.00			
Agreeableness	−0.31 ^c	0.13 ^b	0.11 ^a	1.00		
Conscientiousness	−0.57 ^c	0.37 ^c	0.12 ^b	0.30 ^c	1.00	
Depressive symptoms	0.31 ^c	−0.15 ^c	0.12 ^b	−0.07	−0.16 ^c	1.00

N=561.
^a *p*<0.05;
^b *p*<0.01;
^c *p*<0.001

Table 3

Cognitive test performance (mean $\pm$ SD).

Tests	n	Baseline	Follow-up	Mean Change	Test Statistic	p-Value ^c
MMSE	550	28.8 $\pm$ 1.7	28.6 $\pm$ 1.9	-0.2 $\pm$ 1.8	z = 3.1	0.002
Word list recall						
Immediate	552	8.1 $\pm$ 2.7	7.3 $\pm$ 2.7	-0.8 $\pm$ 2.7	t = 6.9 ^a	<0.001
Delayed	548	6.4 $\pm$ 2.8	5.6 $\pm$ 2.8	-0.8 $\pm$ 2.8	t = 6.4 ^b	<0.001

MMSE = Mini-Mental State Examination.

^a degrees of freedom = 551;

^b degrees of freedom = 547;

^c p-values from Wilcoxon signed rank test for the MMSE and from t-tests for the immediate and delayed word list recall.

Table 4

Association between personality domain *T*-scores (per 10-point increase) and change in cognitive test performance.

Personality dimensions	Base Model B (95% CI)	Model II B (95% CI)	Model III B (95% CI)
MMSE			
N	−0.12 (−0.26, 0.03)	−0.13 (−0.27, 0.01)	−0.15 (−0.30, −0.01) ^a
E	0.16 (0.01, 0.31) ^a	0.08 (−0.07, 0.23)	0.04 (−0.10, 0.19)
O	0.17 (0.01, 0.33) ^a	0.09 (−0.07, 0.25)	0.01 (−0.15, 0.18)
A	0.02 (−0.11, 0.16)	0.11 (−0.03, 0.24)	0.07 (−0.06, 0.21)
C	0.22 (0.07, 0.36) ^b	0.17 (0.03, 0.31) ^a	0.18 (0.04, 0.32) ^a
Immediate recall			
N	−0.21 (−0.41, −0.01) ^a	−0.19 (−0.38, 0.00)	−0.17 (−0.38, 0.04)
E	0.23 (0.02, 0.44) ^a	0.09 (−0.12, 0.29)	0.06 (−0.15, 0.27)
O	0.25 (0.03, 0.48) ^a	0.08 (−0.15, 0.30)	0.06 (−0.17, 0.29)
A	0.07 (−0.13, 0.26)	0.13 (−0.06, 0.31)	0.14 (−0.05, 0.33)
C	0.28 (0.08, 0.48) ^b	0.20 (0.01, 0.39) ^a	0.21 (0.00, 0.41) ^a
Delayed recall			
N	−0.13 (−0.34, 0.07)	−0.10 (−0.30, 0.09)	−0.09 (−0.31, 0.12)
E	0.24 (0.02, 0.45) ^a	0.05 (−0.16, 0.26)	0.05 (−0.16, 0.27)
O	0.36 (0.13, 0.59) ^b	0.14 (−0.09, 0.37)	0.16 (−0.07, 0.40)
A	0.13 (−0.06, 0.33)	0.17 (−0.02, 0.36)	0.20 (0.002, 0.39) ^a
C	0.25 (0.04, 0.46) ^a	0.14 (−0.05, 0.34)	0.18 (−0.03, 0.39)

Note: *N* = 548–552 for unadjusted and 530–535 for fully-adjusted analyses. N = Neuroticism; E = Extraversion; O = Openness; A = Agreeableness; C = Conscientiousness. Base model adjusted for baseline cognitive test score; Model II = base model + age, sex, education, race; Model III = base model+ heart problems, hypertension, diabetes, stroke, number of depressive symptoms, and psychotropic medication use in the past week; Significance determined using *t*-tests; MMSE: degrees of freedom = 547 for Base model, 543 for Model I, 515 for Model II; Immediate Recall: degrees of freedom = 549 for Base model, 545 for Model I, 520 for Model II; Delayed Recall: degrees of freedom = 545 for Base model, 541 for Model I, 516 for Model II;

^a *p* < 0.05;

^b *p* < 0.01