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A Neuropsychological Study of Personality: Trait Openness in Relation to Intelligence, Fluency, and Executive Functioning

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Abstract

Openness is a personality trait that has been linked to intelligence and divergent thinking. DeYoung, Peterson, and Higgins (2005) theorized that trait Openness depends on dopamine function, especially in the prefrontal cortex. We tested their theory in 335 healthy adults by hypothesizing that individual differences in Openness would correlate more strongly with performance on tests of executive function than on tests of intelligence and fluency. However, Openness correlated more strongly with verbal/crystallized intelligence (Gc; r=0.44) than with executive functioning (r=0.16) and fluency (r=0.24). Further, the partial correlation between Openness and Gc increased from r=0.26 among young adults to r=0.53 among elderly adults. These findings suggest that Openness is more closely associated with the acquisition of broad verbal intellectual skills and knowledge than with executive abilities localized to a specific brain region or neurotransmitter system.

Keywords

Openness; crystallized intelligence; fluid intelligence; personality; neuropsychology; prefrontal cortex; executive function

Introduction

Costa and McCrae (1992) construe the personality trait "Openness to Experience" as involving aesthetic sensitivity, awareness of one's emotions, preference for novelty, intellectual curiosity, and a leaning toward nontraditional values. Because lexical research places greater emphasis on artistic imagination, introspective reflection, and intellectual knowledge to define a similar factor, "Intellect" (Goldberg, 1993), others use the compound

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label “Openness/Intellect” (Ashton, Lee, Vernon, & Jang, 2000). The NEO Five Factor Inventory (NEO-FFI) is a questionnaire that consists of 60 items taken from the NEO Personality Inventory-Revised (Costa & McCrae, 1992). It yields reliable and valid measures of the “big five” personality traits, which include Neuroticism, Extraversion, Openness to Experience, Agreeableness, and Conscientiousness.

Openness typically shows positive correlations with IQ test performance. Thus, McCrae and Costa (1997) suggest that it might reflect the expression of intelligence in personality. In some studies, Openness correlated more strongly with verbal/crystallized (Gc) than spatial/fluid (Gf) intelligence (Ackerman & Heggestad, 1997; Ashton, et al., 2000; Bates & Shieles, 2003; Goff & Ackerman, 1992). In others it has been found to correlate about equally with Gc and Gf (Holland, Dollinger, Holland, & MacDonald, 1995; McCrae, 1993). Based on the results of structural equation modeling, Bates and Shieles (2003) argued that Openness potentiates the effect of fluid intelligence (Gf) on the acquisition of knowledge (Gc).

Some investigators have examined the relationship between Openness and other domains of cognitive function. For example, because highly Open persons are oriented toward creativity and experience for its own sake, McCrae (1987) hypothesized and found that self-rated Openness correlated more strongly with performance on measures of divergent thinking, including ideational fluency, than with crystallized intelligence. While many contemporary neuropsychologists think of fluency tasks as measuring an aspect of executive functioning, Guilford (1957) conceptualized them as measuring divergent thinking. He regarded fluency, flexibility and elaboration as the essential building blocks of creativity. Aside from McCrae (1987), however, few investigators have compared the correlation of Openness and creativity to the correlation of Openness with other cognitive abilities.

DeYoung, Peterson, and Higgins (2005) recently advanced a neurobiological theory of trait Openness. They note that McCrae and Costa (1997) describe highly Open persons as “permeable” to new ideas and experience and motivated to “enlarge” both by searching for novelty, even in the familiar. They assert that, while dopamine release is often associated with the brain's reward system, mounting evidence suggests that dopamine release might be linked more specifically to the rewarding aspects of novelty. Further, dopaminergic projections from the midbrain to the frontal lobes primarily influence the dorsolateral prefrontal cortex (DLPFC), which mediates such abilities as cognitive flexibility, ideational fluency, and working memory. On this basis, DeYoung et al. (2005) theorized that Openness represents a type of motivated cognitive flexibility related to dopaminergic function, especially in the dorsolateral prefrontal cortex (DLPFC). They tested this model using measures of personality, intelligence, and several executive function tasks that are associated with the DLPFC, in 175 undergraduate students. Openness correlated ($r = 0.21$; $p < .01$) with performance on the DLPFC test battery. Openness also showed equally strong correlations with Gc ($r = 0.34$; $p < 0.01$) and Gf ($r = 0.25$; $p < 0.01$). Nonetheless, DeYoung et al. argued that the results supported their model based on evidence linking Gf abilities to the DLPFC (Gray, Chabris, & Braver, 2003).

In sum, several conceptualizations of Openness have been advanced. One holds that Openness is the expression of intelligence in personality. Another is that it reflects creativity. Third, and most recently, it has been conceptualized as a type of motivated cognitive flexibility that is linked to dopamine function, especially in DLPFC. These three conceptual models suggest that trait Openness should correlate to differing degrees with intelligence, ideational fluency, and other measures of executive functioning. However, we are not aware of any studies that directly compared all three conceptual models of Openness using neurocognitive tests. DeYoung et al. (2005) assessed intelligence, fluency, and executive functioning in their study, and interpreted the findings as supporting their theory of Openness as motivated cognitive flexibility. Others might interpret the same findings as supporting the view that Openness represents the expression of intelligence in personality. In this study we aimed to compare the relationship of self-rated Openness to Experience with performance on cognitive tests that represent essential constructs of these three conceptual models. Specifically, we assessed verbal/crystallized and spatial/fluid intelligence, divergent thinking (ideational fluency), and executive functioning (card-sorting) in a broadly representative sample of healthy community-dwelling adults. We tested DeYoung et al.'s (2005) theoretical model by hypothesizing that Openness would correlate more highly with performance on measures of executive functioning than with performance on tests of intelligence and ideational fluency.

Method

Participants and Procedure

Participants in this study were drawn from a total sample of 394 adults who were recruited from the Baltimore, Maryland and Hartford, Connecticut areas via random digit dialing, invitations to randomly selected elderly Medicare beneficiaries, and telephone calls to randomly selected listings in residential directories for a study of normal aging. Screening procedures included a medical history, psychiatric interview, physical and neurological examinations, laboratory blood studies, and brain magnetic resonance imaging scan. Participants with schizophrenia, current bipolar disorder or major depression, current substance abuse/dependence, Parkinson's disease, dementia, or multiple sclerosis were excluded from the present analysis. Other exclusion criteria included any history of stroke, traumatic brain injury with prolonged loss of consciousness, a score below 24/30 on the Mini-Mental State Exam (MMSE; Folstein, Folstein, & McHugh, 1975), or failure to complete the NEO-FFI. Forty-eight (12.2%) participants were excluded from the present analysis due to health problems or because they scored below 24/30 on the MMSE, and 11 were excluded because they did not complete the NEO-FFI, leaving a total sample of 335 participants whose demographic characteristics are shown in Table 1.

Each participant was administered a battery of neurocognitive tests and the NEO-FFI. Participants recruited from Baltimore completed a seven-subtest short form (Ward, 1990) of the Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981). Those recruited from Hartford completed the same short form of the Wechsler Adult Intelligence Scale, Third Edition (WAIS-III; Wechsler, 1997). Indices of verbal/crystallized (Gc), spatial/fluid (Gf), word/design generation (Fluency), and card-sorting (Executive) abilities were constructed using the WAIS-R/WAIS-III and five other cognitive tests. The latter included a modified Wisconsin Card Sorting Test (WCST; Nelson, 1976) from which we used total category sorts and perseverative errors. Word list generation was assessed by asking participants to recite as many words as possible beginning with the letters “s” and “p” (letter fluency) and to name as many supermarket items and animals (semantic fluency) as possible in four consecutive one-minute trials. Following Jones-Gotman and Milner (1977), we assessed design fluency by asking participants to draw as many novel, non-nameable designs as possible in four minutes (Kingery, et al., 2006). We recorded the total numbers of acceptable words for letter and category word fluency, as well as the total number of acceptable drawings produced for design fluency. All participants also completed the Hopkins Adult Reading Test (HART; Schretlen, et al., 2009), for which we recorded the number of correct responses, and the Rey Complex Figure Test (CFT; Rey, 1941), which was scored for copy accuracy using the Meyers and Meyers (1995) criteria. Finally, we used the WAIS-R/WAIS-III Information, Similarities, Arithmetic, Picture Completion, Block Design and Digit Symbol subtests along with other measures to construct four cognitive index scores based on a factor analysis. The Johns Hopkins University Institutional Review Board approved this study, and all participants gave written informed consent to participate.

For data analysis, we transformed the raw cognitive test scores into scaled scores (M=10; SD=3) using the distributions produced by each sample. In order to construct cognitive indices for correlation with NEO-FFI self-ratings, we conducted a factor analysis of the 13 cognitive measures described above, using a Varimax rotation. This yielded four factors with eigenvalues greater than unity, and accounted for 71.0% of the total variance. The first rotated factor, labeled verbal/crystallized ability (Gc), was defined by primary loadings of 0.65 to 0.88 for the HART, Information, Similarities and Arithmetic tests. The second factor, labeled spatial/fluid ability (Gf), was defined by primary loadings of 0.57 to 0.82 for the Picture Completion, Block Design, Digit Symbol and Rey CFT. The third factor, labeled Fluency, was defined by primary loadings of 0.57 to 0.80 for the Letter Word, Category Word, and Design Fluency tests. Finally, the fourth factor, labeled Executive, was defined by loadings of 0.88 and 0.89 for WCST category sorts and perseverative errors, respectively. Digit Symbol showed a secondary loading of 0.52 on factor 3, and Design Fluency showed a secondary loading of 0.43 on factor 2, but the secondary loadings of all other variables were below 0.33 and most were below 0.2. Based on these findings, we computed Gc, Gf, Fluency, and Executive ability indices as the mean of the scaled scores whose primary loadings defined the factor corresponding to each index. Digit Span was excluded from the final analysis because its primary loading (0.47) was so much lower than all of the other variables that defined factor 1 in an initial analysis. Reliability analyses revealed acceptable internal consistency for each index, as follows: Gc ($\alpha = 0.86$), Gf ($\alpha = 0.80$), Fluency ($\alpha = 0.73$), and Executive ($\alpha = 0.83$).

We next computed the partial correlations, controlling for age, sex, and race, between each cognitive index and the five NEO-FFI personality factor scores. We did not to control for years of education because this would treat the variance that both Openness and cognitive test performance share with education as error variance, which it clearly is not. Descriptive statistics for the cognitive index and NEO-FFI factor T-scores are shown in Table 1.

Results

Partial correlations, controlling for age, sex, and race, between each cognitive index and the NEO-FFI factor T-scores are shown in Table 2. The two separate samples yielded strikingly similar associations between trait Openness and cognitive test performance. In both samples, Openness showed strong positive correlations with Gc, intermediate correlations with Gf and fluency, and relatively weak correlations with executive functioning. Pooling the two samples, we next conducted a series of t-tests for dependent correlations (Bruning & Kintz, 1987), which showed that the correlation between Openness and Gc was significantly larger than the correlations between Openness and executive function ($t_{(332)} = 5.05$; $p < 0.001$), fluency ($t_{(332)} = 4.48$; $p < 0.001$), and Gf ($t_{(332)} = 2.65$; $p < 0.005$). Based on the same type of analysis, the correlation between Openness and executive functioning also was significantly weaker than that between Openness and Gf ($t_{(332)} = 2.68$; $p < 0.005$) but not between Openness and fluency ($t_{(332)} = 1.21$; $p > 0.1$). Thus, the findings clearly did not support DeYoung et al.'s (2005) hypothesis that Openness would show stronger correlations with executive functioning and fluency than with Gc. In fact, the opposite pattern was obtained.

Although fluid intelligence declines with advancing age, crystallized intellectual skills and knowledge normally do not show the same trajectory of decline throughout adulthood (Horn & Cattell, 1967; McArdle, Ferrer-Caja, Hamagami, & Woodcock, 2002). Thus, assuming that high trait Openness manifests as an enduring orientation toward intellectual stimulation and learning, we hypothesized that its correlation with verbal/crystallized ability will become increasingly evident over the adult life span. In order to test this hypothesis, we re-computed the partial correlations between Gc and Openness for young (ages 18–39; $n = 87$), middle-aged (ages 40–59; $n = 115$), and elderly (ages 60–92; $n = 133$) adults. The results clearly showed that the association strengthened from young ($r = 0.26$; $p < 0.018$) to middle-aged ($r = 0.41$; $p < 0.001$) and elderly ($r = 0.53$; $p < 0.0001$) participants. Based on a z-test for the difference between two independent correlations, Openness correlated with Gc more strongly among elderly than young adults ($z = 2.31$; $p = 0.01$), but not more strongly among elderly than middle-aged ($z = 1.2$; $p = 0.12$) or middle-aged than young adults ($z = 1.29$; $p = 0.09$).

Discussion

In this broadly representative community sample, self-rated trait Openness correlated most strongly with performance on a composite index of verbal/crystallized intelligence that included tests of word knowledge, fund of information, similarities, and arithmetic skills. Contrary to our hypothesis, individual differences in Openness correlated more weakly with performance on measures of executive functioning derived from the WCST and divergent thinking (Word and Design Fluency). Because the tasks that comprise both the Fluency and Executive indices have been associated with functioning of the prefrontal cortex (Heaton, Chelune, Talley, Kay, & Curtis, 1993; Henry & Crawford, 2004; Jones-Gotman & Milner, 1977; Stuss, et al., 2000), the present findings argue against the conceptualization of Openness as primarily reflecting a type of cognitive flexibility mediated by the DLPFC (DeYoung, et al., 2005). Rather, our findings indicate that Openness is more closely associated with verbal/crystallized than spatial/fluid intelligence (Ackerman & Heggestad, 1997; Ashton, et al., 2000). Notwithstanding their conceptual model, DeYoung et al. (2005) also found that self-rated Openness correlated at least as highly with Gc as it did with both executive functioning and Gf. McCrae (1987) found that Openness correlated more strongly with measures of divergent thinking (including word fluency) than with a single test of Gc (WAIS Vocabulary).

Given the consistency of our results with previous findings that link Openness with performance on tests of verbal/crystallized intelligence, we wondered whether persons who prefer novelty, ask questions, and enjoy learning (i.e., are high in Openness) would be more likely to accrue a broad repertoire of intellectual skills and semantic knowledge throughout life than those who are lower in Openness. Consistent with this, the correlation between Openness and Gc clearly strengthened across age cohorts in our sample. Whether these findings reflect differences in the strength of this association over the adult life span or a stable association that becomes increasingly evident with the passage of time is a provocative question that cannot be answered based on this cross-sectional study. Nevertheless, a potential implication of the present findings is that trait Openness reflects an enduring orientation toward precisely the types of lifelong cognitive activities that have been associated with enhanced cognitive reserve and reduced risk of mild cognitive impairment and dementia in late life (Stern, 2009; Wilson, et al., 2005).

Several limitations of this study warrant attention. First, because we did not measure dopamine function or dorsolateral prefrontal cortex, these findings cannot directly refute the frontal/executive hypothesis advanced by DeYoung et al. (2005). Because we assessed executive functioning with two measures derived from a single test, neither can we exclude the possibility that Openness might correlate more highly with aspects of executive functioning that were not assessed in this study. However, word and design fluency are often conceptualized as executive functions, and Openness correlated more strongly with Gc than ideational fluency in this study. Second, one could argue that their varied dependence on verbal vs. nonverbal information processing obscures interpretation of the cognitive indices used for correlation with NEO-FFI ratings. As a result, we cannot determine whether the correlation between Openness and our verbal/crystallized index is due to its association with verbal or crystallized abilities. This confound also characterizes other studies of Gc and Gf, as most tests of acquired knowledge and skills depend heavily on language, and many tests of reasoning rely heavily on visual stimuli. In any case, the tasks that comprised our cognitive indices are valid measures of the constructs we aimed to assess, and their assignment to each index was clearly supported by the factor analysis.

As shown in Table 2, correlation coefficients between Openness and Gc ranged from 0.43 to 0.46, while those between Openness and executive functioning ranged from 0.15 to 0.17. In order to appreciate the strength of these associations, it is instructive to consider the magnitude of Pearson *r* values that characterize associations among other health variables. Based on their extensive literature review, Meyer, Finn, Eyde, Kay, Moreland, Dies, et al. (2001) found much smaller correlations for many well-accepted associations. For example, the Pearson *r* between antihypertensive medication and reduced risk of stroke is 0.03, and the correlation between non-steroidal anti-inflammatory medicines and pain reduction is 0.14. The Pearson *r* between traditional electrocardiogram stress test results and current coronary artery disease is about 0.22, and the correlation between digitally enhanced dental x-rays and diagnosis of biting surface cavities is 0.44. Thus, the association of trait Openness with Gc found in this study is substantial. This correlation also is noteworthy because (squaring) it reflects the amount of variance shared between a self-report measure of personality and performance on cognitive testing. Correlations between self-report and performance-based measures, even when both assess the same construct, often do not differ significantly from zero.

In summary, the results of this study suggest that Openness is more closely associated with individual differences in the accrual of broad verbal intellectual skills and knowledge than with narrower executive abilities that are localized to a specific brain region or neurotransmitter system. The association between Openness and knowledge acquisition might either strengthen or become increasingly evident over the adult life span. Given that individual differences in intelligence appear to depend on widespread neural circuitry (Haier, Jung, Yeo, Head, & Alkire, 2004), future research might further elucidate the neurobiological substrate of Openness by correlating individual differences in this personality dimension with individual differences in neuroanatomy. We currently are exploring neuroanatomic correlates of both Openness and Gc in a large community sample of reasonably healthy adults to address precisely this question.

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References

Ackerman PL, Heggestad ED. Intelligence, personality, and interests: Evidence for overlapping traits. Psychological Bulletin 1997;121(2):219–245. [PubMed: 9100487]

Ashton MC, Lee K, Vernon PA, Jang KL. Fluid intelligence, crystallized intelligence, and the openness/intellect factor. Journal of Research in Personality 2000;34(2):198–207.

Bates TC, Shieles A. Crystallized intelligence as product of speed and drive for experience: The relationship of inspection time and openness to g and Gc. Intelligence 2003;31(3):275–287.

Bruning, JL.; Kintz, BL. Computational handbook of statistics. 3rd. Glenview, IL: Harper-Collins Publishers; 1987.

Costa, PT.; McCrae, RR. Revised NEO Personality Inventory (NEO-PI-R) and NEO Five-Factor Inventory (NEO-FFI) - Professional Manual. Odessa, FL: Psychological Assessment Resources, Inc.; 1992.

DeYoung CG, Peterson JB, Higgins DM. Sources of openness/intellect: cognitive and neuropsychological correlates of the fifth factor of personality. J Pers 2005;73(4):825–858. [PubMed: 15958136]

Folstein MF, Folstein SE, McHugh PR. “Mini-mental state”. A practical method for grading the cognitive state of patients for the clinician. Journal of Psychiatric Research 1975;12(3):189–198. [PubMed: 1202204]

Goff M, Ackerman PL. Personality-Intelligence Relations: Assessment of Typical Intellectual Engagement. Journal of Educational Psychology 1992;84(4):537–552.

Goldberg LR. The Structure of Phenotypic Personality Traits. American Psychologist 1993;48(1):26–34. [PubMed: 8427480]

Gray JR, Chabris CF, Braver TS. Neural mechanisms of general fluid intelligence. Nature Neuroscience 2003;6(3):316–322.

Guilford JP. Creative abilities in the arts. Psychological Review 1957;64(2):110–118. [PubMed: 13420286]

Haier RJ, Jung RE, Yeo RA, Head K, Alkire MT. Structural brain variation and general intelligence. Neuroimage 2004;23(1):425–433. [PubMed: 15325390]

Heaton, R.; Chelune, GJ.; Talley, JL.; Kay, GG.; Curtis, G. Wisconsin Card Sorting Test (WCST) Manual - Revised and Expanded. Odessa, FL: Psychological Assessment Resources, Inc.; 1993.

Henry JD, Crawford JR. A meta-analytic review of verbal fluency performance following focal cortical lesions. Neuropsychology 2004;18(2):284–295. [PubMed: 15099151]

Holland DC, Dollinger SJ, Holland CJ, MacDonald DA. The relationship between psychometric intelligence and the five-factor model of personality in a rehabilitation sample. Journal of Clinical Psychology 1995;51(1):79–88. [PubMed: 7782479]

Horn JL, Cattell RB. Age differences in fluid and crystallized intelligence. Acta Psychologica 1967;26(2):107–129. [PubMed: 6037305]

Jones-Gotman M, Milner B. Design fluency: The invention of nonsense drawings after focal cortical lesions. Neuropsychologia 1977;15:653–674. [PubMed: 896022]

Kingery LR, Schretlen DJ, Sateri S, Langley LK, Marano NC, Meyer SM. Interrater and test-retest reliability of a fixed condition design fluency test. The Clinical Neuropsychologist 2006;20(4): 729–740. [PubMed: 16980258]

McArdle JJ, Ferrer-Caja E, Hamagami F, Woodcock RW. Comparative longitudinal structural analyses of the growth and decline of multiple intellectual abilities over the life span. Dev Psychol 2002;38(1):115–142. [PubMed: 11806695]

McCrae RR. Creativity, divergent thinking, and Openness to Experience. Journal of Personality and Social Psychology 1987;52(6):1258–1265.

McCrae RR. Openness to experience as a basic dimension of personality. Imagination, Cognition and Personality 1993;13(1):39–55.

McCrae, RR.; Costa, PT, Jr. Conceptions and correlates of openness to experience. In: Hogan, R.; Johnson, JA.; Briggs, SR., editors. Handbook of personality psychology. San Diego: Academic Press, Inc.; 1997. p. 825-847.

Meyer GJ, Finn SE, Eyde LD, Kay GG, Moreland KL, Dies RR, et al. Psychological testing and psychological assessment: A review of evidence and issues. American Psychologist 2001;56(2): 128–165. [PubMed: 11279806]

Meyers, JE.; Meyers, KR. Rey Complex Figure Test and recognition trial professional manual. Odessa, FL: Psychological Assessment Resources, Inc.; 1995.

Nelson HE. A modified card sorting test sensitive to frontal lobe defects. Cortex 1976;11:918–932.

Rey A. L'examen psychologique dans les cas d'encephalopathie traumatique. (Les problems.). Archives de Psychologie 1941;28:215–285.

Schretlen DJ, Winicki JM, Meyer SM, Testa SM, Pearlson GD, Gordon B. Development, Psychometric Properties, and Validity of the Hopkins Adult Reading Test (HART). The Clinical Neuropsychologist 2009:1–18. [PubMed: 19101860]

Stern Y. Cognitive reserve. Neuropsychologia 2009;47(10):2015–2028. [PubMed: 19467352]

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Stuss DT, Levine B, Alexander MP, Hong J, Palumbo C, Hamer L, et al. Wisconsin Card Sorting Test performance in patients with focal frontal and posterior brain damage: effects of lesion location and test structure on separable cognitive processes. Neuropsychologia 2000;38(4):388–402. [PubMed: 10683390]

Ward LC. Prediction of verbal, performance, and full scale IQs from seven subtests of the WAIS-R. Journal of Clinical Psychology 1990;46(4):436–440. [PubMed: 2212047]

Wechsler, D. Wechsler Adult Intelligence Scale-Revised. New York: Psychological Corporation; 1981.

Wechsler, D. Wechsler Adult Intelligence Scale - Third Edition. San Antonio: The Psychological Corporation Harcourt Brace & Company; 1997.

Wilson RS, Barnes LL, Krueger KR, Hoganson G, Bienias JL, Bennett DA. Early and late life cognitive activity and cognitive systems in old age. J Int Neuropsychol Soc 2005;11(4):400–407. [PubMed: 16209420]

Table 1

Descriptive statistics for demographic characteristics of the participants and their test results

Variable	Baltimore, MD (*n* = 253)	Hartford, CT (*n* = 82)	Combined (*n* = 335)
Age, years	55.3 ± 18.4	48.8 ± 17.9	53.7 ± 18.5
Education, years	13.7 ± 3.2	15.0 ± 2.7	14.1 ± 3.1
Sex, male–female (%)	47.0–53.0	34.1–65.9	43.9–56.1
Race, black–white/other (%)	22.5–77.5	3.7–96.3	17.9–82.1
Estimated Full Scale IQ[1]	104.8 ± 15.0	110.7 ± 13.8	106.2 ± 14.9
Executive function index	9.7 ± 2.3	9.9 ± 2.1	9.7 ± 2.3
Fluency index	10.0 ± 2.4	10.0 ± 2.6	10.0 ± 2.4
Verbal/crystallized index	10.0 ± 2.5	9.9 ± 2.5	10.0 ± 2.5
Spatial/fluid index	10.0 ± 2.4	10.0 ± 2.3	10.0 ± 2.4
NEO Neuroticism[2]	46.1 ± 11.2	46.6 ± 11.7	46.2 ± 11.4
NEO Extraversion[2]	50. 1± 11.7	50.4 ± 10.5	50.4 ± 11.4
NEO Openness[2]	48.4 ± 10.1	52.2 ± 11.3	49.3 ± 10.4
NEO Agreeableness[2]	51.6 ± 11.4	53.2 ± 11.9	52.0 ± 11.6
NEO Conscientiousness[2]	50.5 ± 10.6	49.0 ± 10.9	50.2 ± 10.6

[1] Seven-subtest estimates of Full Scale IQ were based on WAIS-R for Baltimore participants and WAIS-III for Hartford participants.

[2] NEO-FFI self-ratings expressed as *T*-scores.

Note: Columns show mean ± standard deviation for each variable unless otherwise indicated.

Table 2

Partial correlations[1] of NEO-FFI factor scores with cognitive test performance

	Baltimore, MD (df = 247)				Hartford, CT (df = 75)				Combined (df = 327)			
NEO-FFI Factor	**Exec.**	**Fluency**	***Gc***	***Gf***	**Exec.**	**Fluency**	***Gc***	***Gf***	**Exec.**	**Fluency**	***Gc***	***Gf***
Neuroticism	-.23***	-.15*	-.21**	-.25***	-.13	-.03	-.12	-.12	-.21***	-.13*	-.20***	-.23***
Extraversion	.09	.15*	.15*	.17*	.06	.19	-.03	.25*	.08	.16**	.12*	.18**
Openness	.17**	.25***	.43***	.33***	.15	.24*	.46***	.36**	.16**	.24***	.44***	.32***
Agreeableness	.12	.16*	.22***	.19**	-.01	.12	.33**	.29*	.09	.15**	.25***	.20***
Conscientiousness	.13*	.09	.06	.12	-.04	.01	-.13	.07	.10	.08	.02	.12*

[1] Partial correlations controlling for age, sex, and race.

Note: Exec. = executive function; Fluency = fluency; *Gc* = crystallized/verbal intelligence; *Gf* = fluid/spatial intelligence

* $p < 0.05$;

** $p < 0.01$;

*** $p < 0.001$