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Openness to Experience, Intellect, and Cognitive Ability

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An instrument designed to separate 2 midlevel traits within each of the Big Five (the Big Five Aspect Scales [BFAS]) was used to clarify the relation of personality to cognitive ability. The BFAS measures Openness to Experience and Intellect as separate (although related) traits, and refers to the broader Big Five trait as Openness/Intellect. In 2 samples ($N = 125$ and 189), Intellect was independently associated with general intelligence (g) and with verbal and nonverbal intelligence about equally. Openness was independently associated only with verbal intelligence. Implications of these findings are discussed for the empirical and conceptual relations of intelligence to personality and for the mechanisms potentially underlying both Openness/Intellect and cognitive ability.

The Five-factor model or Big Five—the most widely used taxonomy of personality traits in psychology—was developed empirically rather than theoretically, by examining patterns of correlation among personality trait descriptors (John, Naumann, & Soto, 2008). After the statistical identification of five factors in the pool of personality traits, it remained to interpret and label the factors, sometimes a contentious process. The most extensive debate has surrounded the interpretation of the fifth factor, which has been described variously as Culture, Intellect, Openness to Experience, and Imagination. Currently, the most widely used label for this factor is Openness to Experience, but the compound label Openness/Intellect is increasingly in use, reflecting research indicating that Openness to Experience and Intellect represent two equally central aspects of the broader factor, which are correlated but separable (J. A. Johnson, 1994; Saucier, 1992, 1994). Personality traits are hierarchically organized, and Openness and Intellect can be considered distinct traits at a level of personality organization below the Big Five (DeYoung, Quilty, & Peterson, 2007). The Big Five trait Openness/Intellect reflects the shared variance of the two lower level traits.

Throughout this article, we refer to the Big Five factor by the compound label Openness/Intellect. Whenever we refer to Openness or Intellect alone, we are referring to a subtrait that constitutes one aspect of this domain. Trait constructs stemming from factor analysis are capitalized as a reminder that trait labels denote scientific constructs that might not be identical to colloquial understandings of words like *intellect* or *openness*. Factors need labels, but no label is perfect, and it is important to remember that the constructs in question exist as dimensions of personality variation independently of their labels.

Intellect encompasses perceived intelligence and intellectual engagement and is reflected in lexical studies by adjectives like *intellectual, intelligent, clever,* and *philosophical*. Openness encompasses engagement with perceptual and aesthetic domains and is reflected in lexical studies by adjectives like *artistic, perceptive, poetic,* and *fantasy-prone*. The lexicon additionally includes adjectives that are associated with both Intellect and Openness, such as *imaginative, original, curious,* and *innovative*. The latter observation led Saucier (1994) to propose "Imagination" as an alternative label for the Openness/Intellect factor as a whole, because imagination can be manifest both intellectually and aesthetically.

The psychological function that appears to be common to all of the traits encompassed by the Openness/Intellect factor is cognitive exploration. Cognition here is conceived broadly in terms of mental processes involved in learning about the world and one's experience, including both reasoning and perceptual processes. Cognitive exploration involves exploration of information and is in contrast to behavioral exploration, in which motor activity is used to explore and emphasis is given to acquiring reward rather than information. (Behavioral exploration appears to be primarily associated with Extraversion in the Big Five; Depue & Collins, 1999; DeYoung, 2010.) Individuals high in Openness/Intellect display the ability and tendency to seek, detect, comprehend, and utilize more information than those low in Openness/Intellect.

MEASURING THE TWO ASPECTS OF OPENNESS/INTELLECT

Beyond what is common to both Openness and Intellect, an important question for research is what distinguishes these two traits. Conceptually, the distinction between reasoning and perceptual processes appears crucial. Intellect reflects the ability

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and tendency to explore abstract information through reasoning, whereas Openness reflects the ability and tendency to explore sensory and aesthetic information through perception, fantasy, and artistic endeavor. Emprically, research on the question of what distinguishes Openness and Intellect was hindered until recently by the lack of a measurement instrument designed specifically to assess Openness and Intellect as distinct traits. Although some measures of the broader Openness/Intellect factor were formally labeled Openness to Experience and others Intellect, they typically included content reflecting both Openness and Intellect, regardless of their label, and exhibited similar external correlates (DeYoung, Peterson, & Higgins, 2005).

DeYoung et al. (2007) created specific Openness and Intellect scales using the International Personality Item Pool (IPIP; Goldberg et al., 2006), following the identification of distinct but correlated Openness and Intellect factors in 15 scales designed to measure facets (subtraits) of Openness/Intellect. Velicer's MAP test (O'Connor, 2000) indicated exactly two factors in the 15 facets, and both Openness and Intellect factors were clearly marked by 6 facets, suggesting their equal importance to the broader Openness/Intellect domain. Scales to measure these factors were developed by examining correlations of factor scores with more than 2,000 IPIP items, then selecting items that were among the most strongly correlated with each facet. Items were excluded from the final scales if their loading on the other subfactor of Openness/Intellect was within .10 of their primary loading (or within .10 of their loading on any other factor within the other four of the Big Five). This procedure was repeated for the factors identified within the other Big Five domains. The resulting instrument, the Big Five Aspect Scales (BFAS; DeYoung et al., 2007), measures two correlated subfactors, or aspects, within each of the Big Five.

Openness/Intellect and Intelligence

The goal of this study was to utilize the BFAS to clarify the relations of Openness and Intellect to cognitive ability. Openness/Intellect is the only one of the Big Five that is consistently positively correlated with intelligence tests ($r = .30$; Ackerman & Heggestad, 1997; DeYoung, 2011) with an effect size larger than two thirds of all significant effects reported in psychology for variables that do not share method variance (Hemphill, 2003). Neuroticism consistently shows a weak negative correlation with intelligence tests ($r = –.15$; Ackerman & Heggestad, 1997), but this correlation appears to be due to test anxiety (Moutafi, Furnham, & Tsaousis, 2006).

The fact that Openness/Intellect shows by far the largest correlation with intelligence tests of any of the Big Five is consistent with the fact that descriptors of intelligence fall within this personality dimension in factor analysis. Indeed, given that the average intercorrelation among facets of Openness/Intellect in the most widely used Big Five inventory is only .28 (Costa & McCrae, 1992), one might argue that intelligence should be considered a facet of the Openness/Intellect domain. Some have argued that personality traits are distinct from abilities, with the latter reflecting maximal ability and the former typical behavior, but this distinction has been challenged (DeYoung, 2011). The lexical studies that produced the Big Five model have almost always included descriptors of abilities, and personality is a broad enough concept to cover both.

The association of Openness/Intellect with intelligence is well established, but questions remain about the associations of intelligence with Openness and Intellect separately. Simply based on descriptive content, one would hypothesize that intelligence tests should be associated more strongly with Intellect than with Openness. Although previous research has lacked dedicated measures of Intellect and Openness, this hypothesis can be provisionally tested by examining research that has utilized the NEO PI–R facet scales (Costa & McCrae, 1992).[1] The Ideas facet of the NEO PI–R is a good marker of Intellect, and the following four facets are good markers of Openness (listed from largest to smallest loading): Aesthetics, Fantasy, Feelings, and Actions (DeYoung et al., 2007). In studies that consider these facets individually, Ideas typically predicts intelligence more strongly than do the four facets that mark Openness (DeYoung et al., 2005; DeYoung, Shamosh, Green, Braver, & Gray, 2009; Furnham, Dissou, Sloan, & Chamorro-Premuzic, 2007; Holland, Dollinger, Holland, & MacDonald, 1995; McCrae, 1993; Moutafi, Furnham, & Crump, 2003, 2006). This pattern suggests that Intellect is indeed more strongly associated with intelligence than is Openness.

Although Intellect appears to be more strongly associated with intelligence, the four NEO PI–R facets that mark Openness often do show significant associations with intelligence. However, any association between Openness and intelligence might be due only to the variance that Openness shares with Intellect. In other words, Openness might not be associated with intelligence after controlling for Intellect. This study provides the first test of this possibility, by using the BFAS Openness and Intellect scales as simultaneous predictors in regression. Although such a test could be conducted using facets of the NEO PI–R in previously reported data (e.g., DeYoung et al., 2005), this study has the advantage of using an instrument specifically designed to measure Openness and Intellect as distinct factors at a level of personality structure below the Big Five but above the facets.

Verbal and Nonverbal Intelligence

This study examined the relations of Openness and Intellect not only to general intelligence (*g*) but also to different subcomponents of inteligence. Intelligence is hierarchically organized, with *g* located at the apex of the hierarchy. Below *g* in the hierarchy are a few abilities that are more specific than *g* but still fairly general, and below these are a great many specific abilities (Carroll, 1993; W. Johnson & Bouchard, 2005a, 2005b). The most widely used distinction, at the level of the hierarchy immediately below *g,* is between fluid and crystallized intelligence (Horn & Cattell, 1966). *Fluid intelligence* refers to abilities that are innate and independent of prior education or experience, whereas *crystallized intelligence* refers to abilities that require knowledge or skill acquired from education or experience. However, recent evidence from factor analysis suggests that individual differences in cognitive abilities do not, in fact, covary

[1] Note that, in the NEO PI–R, the Openness/Intellect domain is labeled Openness to Experience, despite the fact that it contains a facet measuring Intellect rather than Openness according to a previous factor analysis (DeYoung et al., 2007). In this article, we distinguish between Openness and Intellect facets of the NEO PI–R based on that factor analysis, rather than labeling them all as facets of Openness to Experience.

according to whether they are fluid or crystallized, but rather according to whether they are verbal or nonverbal (Johnson & Bouchard, 2005a, 2005b).

Of course, some components of ability might be experience-independent (fluid), whereas others might be experience-dependent (crystallized), but most—perhaps all—tests of cognitive ability involve both fluid and crystallized components, such that tests traditionally considered to measure fluid versus crystallized intelligence do not, in fact, measure those two constructs distinctly. Instead, most putatively "fluid" tests measure nonverbal intelligence, and most putatively "crystallized" tests measure verbal intelligence. The verbal tests cannot be considered purely crystallized because verbal ability is just as heritable (genetically influenced) as nonverbal ability, even when controlling for *g* (W. Johnson & Bouchard, 2007; W. Johnson et al., 2007). Nonverbal tests cannot be considered purely fluid because (a) nonverbal ability is influenced by environmental factors in studies of heritability (W. Johnson & Bouchard, 2007; W. Johnson et al., 2007), and (b) it may be improved by schooling (Ceci, 1991) and by training on video games (Feng, Spence, & Pratt, 2007), working memory tasks (Jaeggi, Buschkuehl, Jonides, & Perrig, 2008; but see Moody, 2009), and other mentally stimulating activities (Tranter & Koutstaal, 2008). For these reasons, we refer to *verbal* and *nonverbal* intelligence, rather than to fluid and crystallized intelligence.

Total Openness/Intellect is more strongly associated with verbal than nonverbal intelligence (Ackerman & Heggestad, 1997; Ashton, Lee, Vernon, & Jang, 2000; Austin, Deary, & Gibson, 1997; Baker & Bichsel, 2006; Bates & Shieles, 2003; Beauducel, Liepmann, Felfe, & Nettelnstroth, 2007; DeYoung et al., 2005; Holland et al., 1995). This study examined the hypothesis that this reflects different patterns of association of verbal and nonverbal intelligence with Intellect versus Openness. This conjecture was based in part on three studies that have reported associations of the NEO PI–R facets with separate tests of verbal and nonverbal intelligence (DeYoung et al., 2005; McCrae, 1993; Moutafi, Furnham, & Crump, 2006). In these studies, the four facets that mark Openness appeared more likely to be associated with tests of verbal intelligence than with tests of nonverbal intelligence, whereas Ideas was often associated with both forms of intelligence about equally (but see Holland et al., 1995). Our specific hypothesis, therefore, was that, in multiple regression, Intellect would predict both verbal and nonverbal intelligence, whereas Openness would predict only verbal intelligence.

Note that this hypothesis implies that Openness will be associated with verbal intelligence even after controlling for Intellect. Why would Openness, which seems primarily to reflect engagement with sensory information, be associated with verbal intelligence independently of Intellect? One possible reason is that Openness is associated with implicit learning, the ability to unconsciously detect patterns in the environment (Kaufman et al., 2010). Implicit learning appears to contribute to verbal ability specifically, but not to *g,* perhaps because it facilitates language learning (Kaufman et al., 2010). Our hypothesis in this study was based in part on the recent finding that Openness and Intellect show a double dissociation in predicting individual differences in implicit learning and working memory (Kaufman et al., 2010). In multiple regression, Intellect was associated with working memory (a key contributor to *g;* Conway, Kane, & Engle, 2003; Gray & Thompson, 2004) but not implicit learning, whereas Openness was associated with implicit learning but not working memory (Kaufman et al., 2010). This pattern of association with basic cognitive mechanisms is in keeping with the hypothesis that Intellect is associated with all aspects of intelligence, whereas Openness is independently associated only with verbal intelligence. We tested this hypothesis in two samples.

METHOD

Participants

Sample 1 consisted of 125 undergraduates (92 female, 33 male) at the University of Toronto, who completed the study for course credit. By race and ethnicity, they were 46% East Asian, 26.5% White, 13.5% South Asian, 6.5% Black, 5% Middle Eastern, and 2.5% Hispanic. They ranged in age from 17 to 38 ($M = 19.47$, $SD = 3.03$). This sample is a subset of the sample described by DeYoung et al. (2007, Study 2) in relation to the construction of the BFAS. This subset came into the laboratory for a session that included cognitive testing, whereas the rest of that sample simply completed questionnaires via the Internet.

Sample 2 consisted of 191 White men recruited from the area around New Haven, Connecticut, including from several colleges. Flyers and Internet advertisements were used to recruit for "psychology studies involving genetics and brain imaging," and participation was restricted by race and sex to avoid heterogeneity in genetic data not discussed here. Two participants were not included in analyses because BFAS data were unavailable due to computer error. The remaining 189 ranged in age from 18 to 40 ($M = 24.23$, $SD = 5.18$). Seventy-four participants were students.[2] The rest of the sample had a wide range of mostly lower- and middle-class occupations, with 20 indicating that they were currently unemployed. All participants completed assessments in the laboratory and were given monetary compensation for their participation.

Measures

Sample 1. The Big Five and their 10 aspects were assessed using the BFAS (DeYoung et al., 2007), with responses given on a 5-point Likert scale. Each of the 10 scales included 10 items, and scores for the Big Five were computed by averaging scores for the two aspect scales in each domain. Descriptive statistics for the BFAS are presented in Table 1. Intelligence was assessed by the Matrix Reasoning and Vocabulary subtests of the Wechsler Adult Intelligence Scale–III (WAIS–III; Wechsler, 1997). The Matrix Reasoning subtest is an indicator of nonverbal intelligence, requiring participants to identify a patterned rectangle that logically completes an abstract visual pattern. The Vocabulary subtest is an indicator of verbal intelligence. Raw scores for both subtests were scaled to yield age appropriate scores. Matrix Reasoning had a mean of 11.74 ($SD = 2.68$), and

[2]None of these were students at Yale University; Yale students were excluded to avoid skewing the distribution of intelligence scores in the sample. Importantly, this exclusion did not lead to a truncated upper range of intelligence; estimated IQ in the sample without Yale students ranged from 92 to 144. If 48 additional Yale students were included in the sample, effect sizes were slightly attenuated, but results remained substantively the same. The most notable difference in results was that, in regression, Openness only marginally predicted verbal intelligence, $\beta = .12$, $p = .08$. However, if status as a Yale student was entered as an additional covariate (dummy coded), Openness significantly predicted verbal intelligence at a comparable level to that reported here, $\beta = .19$, $p < .01$.

TABLE 1.—Descriptive statistics for the Big Five Aspect Scales (BFAS).

	Sample 1			Sample 2		
	M	*SD*	α	*M*	*SD*	α
Neuroticism	2.88	0.72	.90	2.59	0.68	.91
Volatility	2.75	0.87	.89	2.55	0.78	.89
Withdrawal	3.00	0.74	.80	2.63	0.72	.85
Agreeableness	3.85	0.54	.83	3.77	0.51	.83
Compassion	4.06	0.63	.86	4.06	0.60	.85
Politeness	3.64	0.69	.77	3.48	0.64	.73
Conscientiousness	3.20	0.59	.82	3.21	0.63	.87
Industriousness	2.98	0.76	.82	3.25	0.72	.84
Orderliness	3.41	0.63	.69	3.17	0.73	.82
Extraversion	3.42	0.66	.89	3.67	0.56	.89
Enthusiasm	3.57	0.73	.82	3.67	0.66	.83
Assertiveness	3.27	0.78	.87	3.68	0.66	.86
Openness/Intellect	3.58	0.52	.82	3.99	0.50	.83
Intellect	3.45	0.72	.84	3.92	0.60	.79
Openness	3.72	0.63	.71	4.07	0.62	.78

Note. Sample 1 $N = 125$; Sample 2 $N = 189$.

Vocabulary had a mean of 11.58 ($SD = 3.07$). The two subtests were correlated, $r = .24$ ($p < .01$), and the average of the two subtests was used as an estimate of *g*.

Sample 2. The Big Five and their 10 aspects were assessed with the BFAS as in Sample 1. Intelligence was assessed with four subtests of the WAIS–III (Wechsler, 1997). Matrix Reasoning and Block Design were used as indicators of nonverbal intelligence. Vocabulary and Similarities were used as indicators of verbal intelligence. Matrix Reasoning and Vocabulary were as described for Study 1. Block Design requires participants to re-create designs as fast as possible, using cubic blocks that are red on two sides, white on two sides, and half-red, half-white on the other sides. Similarities requires participants to explain analogies (e.g., "How are an enemy and a friend alike?"). Raw scores for all subtests were scaled to yield age-appropriate scores (Wechsler, 1997). Descriptive statistics and correlations among the four subtests are presented in Table 2. The average of Vocabulary and Similarities was used as an indicator of verbal intelligence, and the average of Matrix Reasoning and Block Design was used as an index of nonverbal intelligence. Verbal and nonverbal intelligence were correlated, $r = .38$ ($p < .01$), and their average was used as an estimate of *g* (factor scores were not used, to avoid capitalizing on sampling variability).

TABLE 2.—Correlations and descriptive statistics for Wechsler Adult Intelligence Scale–III (WAIS–III) subtests in Sample 2.

	Block Design	Matrix Reasoning	Vocabulary	Similarities
Block Design	—			
Matrix Reasoning	.37	—		
Vocabulary	.28	.35	—	
Similarities	.23	.27	.55	—
M	12.40	12.67	14.61	12.85
SD	2.88	2.32	2.44	2.46

Note. $N = 189$. All correlations significant at $p < .01$.

TABLE 3.—Correlations among measures of cognitive ability and the Big Five Aspect Scales (BFAS).

	Sample 1			Sample 2		
	g	Nonverbal	Verbal	*g*	Nonverbal	Verbal
Neuroticism	−.15	−.12	−.12	−.12	−.17	−.03
Volatility	−.11	−.05	−.12	−.18	−.21	−.09
Withdrawal	−.17	−.18	−.09	−.02	−.08	.05
Agreeableness	.15	.04	.19	.19	.14	.18
Compassion	.19	.05	.24	.23	.17	.21
Politeness	.06	.01	.08	.10	.07	.09
Conscientiousness	−.02	.02	−.04	−.07	.02	−.14
Industriousness	−.01	.03	−.04	−.05	.03	−.12
Orderliness	−.02	.00	−.03	−.07	.00	−.12
Extraversion	.14	.08	.14	.02	.07	−.04
Enthusiasm	.13	.04	.16	.02	.04	−.01
Assertiveness	.12	.11	.08	.01	.08	−.06
Openness/Intellect	.37	.18	.40	.31	.16	.35
Intellect	.35	.25	.30	.32	.24	.29
Openness	.23	.03	.32	.19	.03	.29

Note. Sample 1 $N = 125$; Sample 2 $N = 189$. All correlations greater than .17 are significant at $p < .05$ in Sample 1, and all correlations greater than .15 are significant at $p < .05$ in Sample 2.

RESULTS

Table 3 shows correlations between the BFAS and the cognitive variables, *g* nonverbal intelligence, and verbal intelligence. As expected, Openness/Intellect and its two aspects showed the strongest and most consistent correlations with cognitive ability. Of interest, however, traits from two other domains, Neuroticism and Agreeableness, also showed correlations with cognitive ability in both samples. Correlations with Neuroticism were inconsistent across the two samples (associated with Withdrawal in Sample 1, but with Volatility in Sample 2). In contrast, correlations with Agreeableness were more consistent: Both samples showed positive correlations of Compassion with *g* and verbal intelligence.

The pattern of correlations of cognitive ability with the two aspects of Openness/Intellect was as predicted, in both samples. Intellect showed correlations of similar magnitude with both verbal and nonverbal intelligence, whereas Openness was correlated only with verbal intelligence. Correlations with *g* were systematically related to the correlations with its subcomponents: Intellect was correlated more strongly with *g* than with either verbal or nonverbal intelligence alone, whereas Openness was correlated more weakly with *g* than with verbal intelligence because of the lack of association between Openness and nonverbal intelligence.

Regressions were performed to test the independent contributions of Intellect and Openness to the three cognitive ability variables (Table 4). As predicted, only Intellect was significantly associated with *g* and nonverbal intelligence, but both Intellect and Openness predicted verbal intelligence independently. Both Intellect and Openness contributed incrementally to the prediction of verbal intelligence, whereas only Intellect contributed incrementally to the prediction of *g* and nonverbal intelligence.

DISCUSSION

Correlations of the BFAS Openness and Intellect scales confirmed several hypotheses regarding the associations of personality with cognitive ability. In keeping with its inclusion of descriptors of intelligence and intellectual engagement, Intellect

TABLE 4.—Regressions of cognitive abilities on Intellect and Openness.

Criterion	Predictors	β	t	R	ΔR
Sample 1					
g				.38**	
	Intellect	.31	3.55**		.14**
	Openness	.15	1.73		.03
Nonverbal				.25*	
	Intellect	.26	2.81**		.22**
	Openness	−.04	−0.43		.00
Verbal				.39**	
	Intellect	.23	2.68**		.07**
	Openness	.26	2.97**		.09**
Sample 2					
g				.33**	
	Intellect	.29	3.88**		.14**
	Openness	.09	1.16		.01
Nonverbal				.25**	
	Intellect	.26	3.42**		.21**
	Openness	−.06	−0.81		.01
Verbal				.35**	
	Intellect	.22	2.96**		.07**
	Openness	.21	2.79**		.06**

Note. Sample 1 $N = 125$; Sample 2 $N = 189$; ΔR = incremental R for each predictor when entered after the other predictor.
*$p < .05$. **$p < .01$.

was associated with *g* and with both verbal and nonverbal intelligence. Openness, which describes engagement with sensory information and aesthetics, was associated with *g* in zero-order correlations, but was not associated with *g* after controlling for Intellect. As predicted, the only association of Openness with cognitive ability after controlling for Intellect was with verbal intelligence. In multiple regression, Openness and Intellect contributed about equally to verbal intelligence. Notably, results were very similar in two samples that were very different demographically, suggesting that our findings are likely to be robust.

The pattern of results in this study clarifies two puzzles that have been noted regarding the relation of Openness/Intellect to intelligence (DeYoung, 2011). First, a number of studies have found that Openness/Intellect is more strongly related to verbal than nonverbal intelligence. Explanations for this phenomenon have often invoked the problematic description of verbal intelligence as "crystallized" and suggested that Openness/Intellect reflects greater motivation to learn, leading to greater crystallized intelligence. The findings reported here suggest another, simpler explanation: Openness/Intellect is more strongly related to verbal than nonverbal intelligence because both aspects of the domain are associated with verbal intelligence, whereas only Intellect is associated with nonverbal intelligence. Although Intellect does reflect, in part, intellectual engagement, this does not lead differentially to ability in the verbal domain; the correlations of Intellect with verbal and nonverbal intelligence were very similar in magnitude.

Second, several previous studies of NEO PI–R facet scales have suggested that Openness is probably less strongly related to intelligence and particularly nonverbal intelligence than is Intellect, but it was not clear whether any association of Openness with intelligence was simply due to variance shared with Intellect. This study indicates that any zero-order association of Openness with *g* or nonverbal intelligence is indeed probably due to variance shared with Intellect. However, Openness did predict verbal intelligence even after controlling for Intellect, indicating that the association of Openness with verbal intelligence cannot be explained by its association with Intellect.

An important question, therefore, is why Openness should be independently associated with verbal intelligence. One possibility is that part of the specific cognitive substrate of Openness contributes to verbal intelligence. Openness is associated with implicit learning, the ability to learn patterns unconsciously, whereas Intellect is not (Kaufman et al., 2010). Additionally, implicit learning is related to verbal (but not nonverbal) intelligence, independently of *g*. Individuals high in Openness might have greater verbal skill in part because they have more capacity for implicit learning of the patterns of language.

These results contribute to a program of research seeking to understand the mechanisms underlying Intellect and Openness. In part, the demonstration of the association between Intellect and intelligence simply serves as validation of Intellect as a construct, given that Intellect encompasses descriptors of intelligence. Although ability tests are more accurate than self-reports of intelligence (Paulhus, Lysy, & Yik, 1998), the latter nonetheless reflect intelligence to a meaningful extent. Cognitive and brain mechanisms that support intelligence, such as those associated with working memory, are likely to be a crucial substrate of Intellect (DeYoung et al., 2009). In contrast, mechanisms associated with perception and detection of patterns might be important components of the substrate of Openness (Kaufman et al., 2010). In addition to mechanisms specific to Intellect or Openness, there must also be mechanisms that the two traits share, one of which is likely to be a drive to explore information of all kinds. This drive has been linked to the neurotransmitter dopamine (DeYoung et al., 2011; DeYoung et al., 2005).

NEUROTICISM, AGREEABLENESS, AND INTELLIGENCE

We formed no hypotheses regarding the associations of cognitive ability with traits other than Openness and Intellect. It is worth noting, however, that traits in the Neuroticism and Agreeableness domains showed significant correlations with cognitive ability. With regard to Neuroticism, this was not unexpected because meta-analysis has indicated a weak negative association with intelligence, probably due to test anxiety (Ackerman & Heggestad, 1997).

The finding of an association of intelligence with the Compassion aspect of Agreeableness is more novel and might begin to address one of the remaining puzzles in the relation of intelligence to personality (DeYoung, 2011). Agreeableness is not typically correlated with intelligence; however, measures of certain traits that would usually be categorized within Agreeableness are correlated with intelligence. For example, questionnaire measures of aggression are typically negatively correlated with intelligence (Ackerman & Heggestad, 1997). Of more relevance to the findings here, assessments of the ability to empathize are often correlated with intelligence. The largest body of findings on this phenomenon is probably from the Mayer–Salovey–Caruso Emotional Intelligence Test (MSCEIT), which includes a battery of tasks like identifying emotions in facial expressions or judging how best to manage others' emotions in social situations, and which shows a correlation of about .3 with intelligence (Mayer, Salovey, & Caruso, 2004; Roberts, Schulze, & MacCann, 2008). This association is typically stronger for verbal ability, just as it was for Compassion

in these samples. Compassion includes items that describe empathy (e.g., "Feel others' emotions"; "Sympathize with others' feelings"), so the findings reported here using the BFAS are consistent with previous findings using the MSCEIT. (Notably, associations of Compassion with intelligence cannot be estimated from studies using the NEO PI–R because that instrument does not include any facets that are good indicators of Compassion separately from Politeness [DeYoung et al., 2007].)

It could be that the ability to empathize is facilitated by intelligence. However, another possibility is that the ability to empathize is facilitated by Openness, and this association might explain the correlation between Compassion and intelligence (especially verbal intelligence). This hypothesis is likely because Compassion and Openness are substantially correlated, $r = .40$ and .36 in these samples. Consistent with this hypothesis, post-hoc analyses in both samples showed that Compassion remained significantly related to verbal intelligence after controlling for Intellect, but not after controlling for Openness. These findings suggest an important role for Openness in empathy, which could be explored in future research.

Conclusion

The BFAS, an instrument that breaks down each of the Big Five personality traits into two correlated aspects, successfully clarified the relations of personality to cognitive ability. Although it has long been known that Openness/Intellect is the only Big Five trait that is positively associated with intelligence, the meaning of this association has remained unclear, both because of the possibility that it might be due specifically to verbal (often presumed to be "crystallized") intelligence, and because of lingering debate about the conceptual relation of Openness/Intellect to intelligence (DeYoung, 2011). Although descriptors of intelligence fall within Openness/Intellect, its most common label, Openness to Experience, does not seem to be closely related to intelligence conceptually.

Parsing the Big Five at the aspect level allows recognition that intelligence has a place in the Big Five, subsumed under Intellect, while acknowledging that Openness and Intellect are indeed distinct (although related), and that Openness does not subsume standard descriptors of intelligence. In keeping with this pattern, we found that Intellect was independently associated with *g* and with both verbal and nonverbal intelligence about equally. Additionally, however, Openness was independently associated with verbal intelligence, a finding that suggests a potentially fruitful avenue for further research. The association of Openness and verbal intelligence might be a function of the association of Openness with implicit learning (Kaufman et al., 2010). This study demonstrates the utility of measuring Openness and Intellect as separate but related constructs. Additionally, the demonstration of differential patterns of association for the BFAS Openness and Intellect scales provides new evidence of their validity.

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