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Article *in* Journal of Personality · December 2015

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Openness to Experience and Intellect Differentially Predict Creative Achievement in the Arts and Sciences

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Abstract

The Big Five personality dimension Openness/Intellect is the trait most closely associated with creativity and creative achievement. Little is known, however, regarding the discriminant validity of its two aspects—Openness to Experience (reflecting cognitive engagement with perception, fantasy, aesthetics, and emotions) and Intellect (reflecting cognitive engagement with abstract and semantic information, primarily through reasoning)—in relation to creativity. In four demographically diverse samples totaling 1,035 participants, we investigated the independent predictive validity of Openness and Intellect by assessing the relations among cognitive ability, divergent thinking, personality, and creative achievement across the arts and sciences. We confirmed the hypothesis that whereas Openness predicts creative achievement in the arts, Intellect predicts creative achievement in the sciences. Inclusion of performance measures of general cognitive ability and divergent thinking indicated that the relation of Intellect to scientific creativity may be due at least in part to these abilities. Lastly, we found that Extraversion additionally predicted creative achievement in the arts, independently of Openness. Results are discussed in the context of dual-process theory.

The Five-Factor Model, or Big Five, provides a useful taxonomy of personality traits, and these traits predict many important life outcomes, including achievement in school and work, physical and mental health, and social behavior (Ozer & Benet-Martinez, 2006). The Big Five factor labeled *Openness/Intellect* predicts outcomes in all of these categories (DeYoung, 2014) and is also the only factor consistently and broadly related to creativity, predicting creative achievement and divergent thinking, as well as creative hobbies, personal goals, and thinking styles (Batey & Furnham, 2006; Carson, Peterson, & Higgins, 2003; Feist, 1998; Feist & Barron, 2003; King, Walker, & Broyles, 1996; McCrae, 1987; Silvia, Nusbaum, Berg, Martin, & O'Connor, 2009; Silvia et al., 2008). As its compound label suggests, however, Openness/Intellect is not monolithic; it can be divided into subtraits, which may have differential relations to creativity. Given the centrality of this domain of personality to creative functioning, it is crucial to investigate more finely differentiated associations of its component traits with various forms of creativity.

Although Openness/Intellect can be generally characterized as a dimension of personality reflecting the tendency toward cognitive exploration, it can also be meaningfully separated into distinct (but correlated) subtraits of Openness to Experience and Intellect (DeYoung, 2014; DeYoung, Quilty, & Peterson, 2007). This conclusion helps reconcile an old debate about how to characterize this factor of personality. Although it was suggested over 20 years ago that Openness and Intellect characterize distinct but equally central aspects of the factor (Johnson, 1994; Saucier, 1992), the empirical demonstration that these are the two major subfactors was relatively recent (DeYoung et al., 2007; Woo et al., 2014). Intellect reflects cognitive engagement with abstract and semantic information, primarily through reasoning, whereas Openness reflects cognitive engagement with perception, fantasy, aesthetics, and

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emotions (DeYoung, Grazioplene, & Peterson, 2012). These factors appear to be genetically as well as phenotypically distinct (DeYoung, 2014; DeYoung et al., 2007).

The identification of separable Openness and Intellect factors enabled the development of scales specifically designed to measure these factors, which are included in the Big Five Aspect Scales (BFAS; DeYoung et al., 2007). (Previous Big Five measures labeled *Openness to Experience* or *Intellect* typically measured the same general Openness/Intellect factor; DeYoung, Peterson, & Higgins, 2005.) Openness and Intellect demonstrate discriminant validity for many phenomena, including IQ, academic performance, industrial performance, mental health, and brain function (for a review, see DeYoung, 2014).

Investigating Openness and Intellect separately appears promising in the attempt to clarify the association of personality with creativity, particularly in the arts and sciences. Nusbaum and Silvia (2011a) found that Openness significantly predicted total creative achievement but not fluid reasoning, whereas Intellect predicted fluid reasoning but not total creative achievement. This result might suggest a unique relation between Openness and creativity. However, this research did not distinguish between different domains of creative achievement, and their assessment of creative achievement was weighted heavily toward artistic creativity.

Both the differing trait content of Openness and Intellect and theories of their underlying mechanisms suggest that Openness should predict creativity in the arts, but that Intellect should predict creative achievement in the sciences. Openness encompasses artistic interests, whereas Intellect encompasses interest in ideas. The sources of these differences may lie in basic cognitive mechanisms. Openness is associated with cognitive processes like implicit learning that are involved in the detection of correlational patterns in sensory experience. Intellect, in contrast, is associated with cognitive processes like working memory that aid in analyzing causal and logical patterns (DeYoung, 2014; S. B. Kaufman et al., 2010).

S. B. Kaufman (2013a) placed these findings in the dual-process theoretical framework (Epstein, 1991, 2014; Evans, 2008; Evans & Frankish, 2009; Kahneman, 2011; S. B. Kaufman, 2011, 2013a; Stanovich & West, 2000). *Type 1* processes consist of a variety of (not necessarily correlated) processes that operate automatically and are not dependent on input from high-level control systems, including affect, intuition, implicit learning, latent inhibition, and spreading activation among learned associations (Evans, 2008; Stanovich & Toplak, 2012). In contrast, *Type 2* processes require limited voluntary attentional resources and are associated with general cognitive ability (*g*) and executive functioning. Within this framework, artistic creativity should be more strongly influenced by the experiential Type 1 processes associated with Openness, whereas scientific creativity should be more strongly influenced by the rational Type 2 processes associated with Intellect (Epstein, 2014).

We hypothesized, therefore, that whereas Openness should predict creative achievement in the arts, Intellect should predict creative achievement in the sciences. We focused on creative achievement—that is, formally recognized creative production—rather than on creativity more generally. This focus has the advantage of allowing assessment in terms of life history; however, it is possible that our results might not entirely generalize to day-to-day creativity that does not lead to publicly recognized products. It is also possible that traits related to hard work and perseverance, such as Conscientiousness, might influence creative achievement independently of Openness and Intellect, and we were able to examine that possibility as well.

Consistent with our hypothesis, S. B. Kaufman (2013a) investigated the relations among a four-factor model of Openness/Intellect and creative achievement in the arts and sciences among a sample of English sixth-form students (equivalent to the final 2 years of American high school). Two factors relating to Openness (affective engagement and aesthetic engagement) were significantly associated with creative achievement in the arts, whereas two factors relating to Intellect (explicit cognitive ability and intellectual engagement) were significantly associated with creative achievement in the sciences.

The present study reexamined these data using the BFAS Openness and Intellect scales and also extended the analysis to creative achievement in three additional samples. Because Openness and Intellect are correlated subfactors of the same broader Big Five trait, we used them as simultaneous predictors in regression to assess their independent contributions to creative achievement. This procedure is important because if Openness were correlated with achievement in the sciences or Intellect with achievement in the arts, this might simply be due to the variance shared between the two aspects, rather than to an independent association. Two additional strengths make this study more than a mere replication of S. B. Kaufman's (2013a) prior work. First, Kaufman (2013a) did not specifically test the prediction of creative achievement by Openness and Intellect, but rather focused on a four-factor solution of the Openness/Intellect domain, which is less well established than the basic distinction between Openness and Intellect. Second, Kaufman (2013a) analyzed a sample of adolescents at a very selective school (which could restrict the range of relevant variables), whereas the present analyses include a diverse set of adult samples, yielding a much larger and more representative total sample.

A further question that we were able to examine in these samples was the extent to which Openness and Intellect predict creative achievement independently of *g* and divergent thinking—two relevant cognitive variables that are substantially related to Openness/Intellect (DeYoung, 2014). Divergent thinking is a commonly used construct in the study of creativity, referring to the ability to generate numerous unusual answers to problems such as "What are all the uses you can think of for a brick?" Divergent thinking is typically contrasted

with convergent thinking, in which reasoning is used to identify a single correct answer to a problem. Most standard measures of *g*, such as IQ tests, are primarily tests of convergent thinking (as their items require participants to provide a single correct answer). Nonetheless, it is possible to use individually administered IQ tests to extract some information about an individual's divergent thinking ability (J. C. Kaufman, Kaufman, & Lichtenberger, 2011), and, using latent variable modeling, *g* moderately predicts divergent thinking (Beaty & Silvia, 2012; Silvia, 2008a, 2008b). Because both *g* and divergent thinking have been shown to predict creative achievement (Carson, Peterson, & Higgins, 2005; S. B. Kaufman, 2013a; Mar, DeYoung, Higgins, & Peterson, 2006), it is of interest to test whether the relation between personality and creative achievement is independent of them.

Finally, we were able to test whether Openness and Intellect predict creative achievement independently of other Big Five traits. Because past research suggests that creative achievement is likely to be influenced by multiple traits (Feist, 1998; S. B. Kaufman, 2013b; Simonton, 1994), we were interested in testing not only our main hypothesis, but also whether other personality traits emerged as consistent predictors.

In sum, the primary aim of the current investigation was to assess the relations between the two major aspects of Openness/Intellect (i.e., Openness to Experience and Intellect) and creative achievement in the arts and sciences. The secondary aim was to assess the extent to which these relations held, controlling for the rest of the Big Five, *g*, and divergent thinking. To increase generalizability, we report the results from four independent samples across a range of age, gender, and ethnicity.

METHOD

Participants

Sample 1 consisted of 177 students (56 males, 121 females) who attended a selective sixth-form college (which takes high-achieving students who are in their last 2 years of secondary education) in Cambridge, England. They ranged in age from 16 to 19 years ($M = 16.9$, $SD = 0.6$). While creative achievement scores were collected for 177 participants, there were missing scores for other variables presented in this study. This was due to the fact that there were three testing sessions, with some attrition in the later sessions (creative achievement and cognitive ability were assessed in the first testing session, other measures not relevant to this analysis were assessed in the second testing session, and personality measures were assessed in the third testing session). Therefore, the results presented below include only 166 participants.

Sample 2 consisted of 239 White men recruited in and around New Haven, Connecticut, primarily through Internet sites (restrictions by race and gender were designed to facilitate genetic analyses unrelated to the present study; e.g., DeYoung et al., 2011; Shehzad, DeYoung, Kang, Grigorenko, & Gray, 2012; creative achievement data have not previously been reported). They ranged in age from 18 to 40 years ($M = 23.6$, $SD = 5.0$). About half of the sample (124) were students, with 48 attending Yale University and the others attending nearby colleges and universities. The rest of the sample had a range of mostly lower- and middle-class occupations, with 20 indicating that they were currently unemployed. All participants were given monetary compensation for their participation.

Sample 3 consisted of 329 students (177 males, 147 females, five unreported) in universities in southern Ontario, Canada, who completed the relevant measures online for course credit in the context of several different studies (creative achievement data have not previously been reported). They ranged in age from 17 to 61 years ($M = 20.59$, $SD = 3.25$, four with unreported age). A variety of ethnicities was represented in the sample, including East Asians (46.8%), Whites (30.7%), and South Asians (11.9%), along with a smaller number of Black, Hispanic, Middle Eastern, and Native American students (10.6%).

Sample 4 consisted of 305 people (154 females) between the ages of 20 and 40 ($M = 26.25$, $SD = 5.06$) recruited from the community around Minneapolis and St. Paul, Minnesota, primarily through Internet advertisements. The sample consisted of a variety of professions, including relatively few students (11.8%; 10.8% did not report profession). The ethnicity of this sample was predominantly White/Caucasian (72.4%); other ethnicities represented were 6.6% Black or African American, 2.6% Hispanic or Latino, 3.9% Asian or Asian American, 13.1% Mixed Heritage, and 1.0% Native American.

Measures and Procedures

Creative Achievement. All four samples completed the Creative Achievement Questionnaire (CAQ; Carson et al., 2005), in which creative achievements are assessed in 10 domains: visual arts, music, dance, architectural design, creative writing, humor, inventions, scientific discovery, theater and film, and culinary arts. The CAQ has been well validated and predicts many other performance and questionnaire measures of creativity (Carson et al., 2005; Silvia, Wigert, Reiter-Palmon, & Kaufman, 2012). Points are awarded in each domain based on seven levels of achievement, with greater points awarded for higher levels, yielding skewed scores that reflect the fact that relatively few people reach the highest levels of creative achievement. (Based on advice from one of the authors of the CAQ, we did not use the optional scoring method of multiplying some levels by the number of achievements at that level; S. H. Carson, personal communication, May 7, 2006.) Scores across domains were summed to create a total creativity score. Although the CAQ relies on self-report, the concreteness of the response structure reduces the likelihood of self-enhancement, relative to trait-rating scales. For example, in the creative writing domain, options include "My work has won an award

or prize" (Level 2) and "My work has been reviewed in national publications" (Level 7). We followed Carson et al. (2005) in creating a two-factor breakdown of the CAQ, in which creative achievement in the arts is represented as the sum of scores for visual arts, music, dance, creative writing, humor, and theater and film, whereas creative achievement in the sciences is represented as the sum for inventions and scientific discovery.

Big Five Personality Traits. All four samples completed the BFAS, which measures a level of personality structure between the Big Five and their many facets (DeYoung et al., 2007). It was derived from factor analyses of 15 facet scales within each of the Big Five, in which the minimum average partial (MAP) test indicated the presence of just two subfactors for each broader dimension. Ten scales to measure these factors were then created by examining factor-score correlations with over 2,000 items from the International Personality Item Pool (IPIP; Goldberg, 1999) and selecting balanced numbers of positively and negatively keyed items from among the strongest correlates. The BFAS is well validated, converging strongly with other standard measures of the Big Five, including the NEO Personality Inventory-Revised and the Big Five Inventory (Costa & McCrae, 1992; DeYoung et al., 2007; John, Naumann, & Soto, 2008), and is one of the only measures of an empirically derived substructure for the Big Five (lists of facets have typically been derived intuitively or algorithmically rather than empirically). The two aspects of each Big Five domain are, therefore, likely to provide important differentiations for assessing discriminant validity within each domain. Total Big Five scores can be derived by averaging the scores for the two aspects. The Openness scale includes items like "See beauty in things that others might not notice" and "Seldom daydream" (reversed), whereas the Intellect scale includes items like "Am quick to understand things" and "Avoid philosophical discussions" (reversed).

General Cognitive Ability (g)

Sample 1. Participants completed three markers of general cognitive ability—one *verbal* analogical reasoning test, one *perceptual* reasoning test, and one mental *rotation* test—to cover the three subfactors of *g* identified by Johnson and Bouchard in their VPR model (2005). Perceptual reasoning was measured with Raven's Advanced Progressive Matrices Test, Set II (Raven, Raven, & Court, 1998), verbal analogical reasoning was measured with the verbal reasoning section of the Differential Aptitudes Test (Psychological Corporation, 1995), and mental rotation ability was measured with the Mental Rotations Test, Set A (Vandenberg & Kruse, 1978). Correlations among the three tests ranged from .43 to .57. To combine the three markers of general cognitive ability into a unitary estimate of *g*, scores were standardized and averaged.

Sample 2. Participants completed four subtests from the third edition of the Wechsler Adult Intelligence Scale (WAIS-III; Wechsler, 1997): Matrix Reasoning, Block Design, Vocabulary, and Similarities. Scaled scores for all four subtests were averaged to create an estimate of *g.* Correlations among the subtests ranged from .23 to .55 (DeYoung, Quilty, Peterson, & Gray, 2014).

Sample 3. Only a subset of Sample 3 ($n = 124$; 91 females, 33 males) completed a brief assessment of cognitive ability in the lab (because only one of the studies from which this sample was compiled involved the lab component; DeYoung et al., 2014). They ranged in age from 17 to 38 ($M = 19.47$, $SD = 3.0$). Scaled scores from the Matrix Reasoning and Vocabulary subtests of the WAIS-III were averaged to estimate *g*. The correlation between the two subtests was $r = .24$.

Sample 4. Participants completed the same four subtests from the WAIS as in Sample 2, but from the fourth edition (WAIS-IV; Wechsler, 2008). Correlations among the subtests ranged from .29 to .63.

Divergent Thinking. Samples 2 and 4, and the subset of Sample 3 just described, completed the same measure of divergent thinking, three tests derived from the Torrance Tests of Creative Thinking (Torrance, 1972). Participants were given 3 minutes per problem to generate as many answers as they could for three problems: (a) "Suppose that all humans were born with six fingers on each hand instead of five. List all the consequences or implications that you can think of"; (b) "List as many white, edible things as you can"; (c) "List all the uses you can think of for a brick." Scores were based on three indices: fluency, originality, and flexibility. Fluency is the total number of responses given. Originality is scored with reference to all valid responses in the sample, with 1 point being awarded to responses given by between 3% and 10% of respondents, 2 points to responses given by 3% or fewer, and 3 points to unique responses. Flexibility is the number of times participants switch categories as they list answers (e.g., categories for the second problem included fruits, vegetables, meat, dairy, baked goods, seafood, and other). These three indices, which correlate very highly with each other (mean $r = .79$), were standardized and averaged to create a single divergent thinking score.

RESULTS

Table 1 provides distributional information regarding the main variables of interest for our hypotheses. CAQ scores were skewed, as expected based on theory and prior research (Carson et al., 2005; Eysenck, 1995; Silvia et al., 2012; Simonton, 1999, 2005), and we therefore report the median as well as the mean.

Table 2 shows correlations of the BFAS, *g*, and divergent thinking with creative achievement pooled across all four samples (*n*-weighted correlations). (Correlation matrices for each sample are available upon request.) Creative achievement in the arts and sciences were uncorrelated in Samples 1 and 2

Table 1 Distributional Information for Creative Achievement

	Sample 1 ($N = 166$)				Sample 2 ($N = 239$)				Sample 3 ($N = 329$)				Sample 4 ($N = 305$)			
	M (*SD*)	Mdn	Sk	Ku	*M* (*SD*)	Mdn	Sk	Ku	*M* (*SD*)	Mdn	Sk	Ku	*M* (*SD*)	Mdn	Sk	Ku
CAQ total	15.96 (13.24)	12.00	1.60	2.57	22.74 (18.29)	18.00	1.63	3.69	11.17 (11.02)	8.00	2.21	6.76	9.23 (5.95)	8.00	1.14	1.55
CAQ arts	13.43 (12.96)	10.00	1.86	3.49	16.99 (15.33)	13.00	1.39	1.80	8.98 (9.77)	6.00	2.45	7.95	6.58 (4.95)	5.00	1.09	1.23
CAQ sciences	1.61 (2.38)	1.00	2.66	9.22	4.15 (5.67)	2.00	2.37	7.41	1.56 (2.70)	.00	2.57	7.77	1.64 (1.49)	1.00	1.83	6.02

Note. CAQ = Creative Achievement Questionnaire; Mdn = median; Sk = skewness; Ku = kurtosis.

Table 2 Relations Among Predictor Variables and Creative Achievement Pooled Across Four Samples

	g	Div. Think	Visual Arts	Music	Dance	Architectural Design	Creative Writing	Humor	Inventions	Scientific Discovery	Theater/ Film	Culinary Arts	CAQ Total	CAQ Arts	CAQ Sciences
g	—	**.37**	.03	.11	−.09	.01	.04	−.01	.11	**.27**	.11	−.08	.11	.06	**.24**
Divergent thinking	**.37**	—	.10	.11	−.10	.03	**.16**	.06	**.15**	**.17**	**.16**	.09	**.19**	**.15**	**.20**
Openness/Intellect	**.32**	**.27**	**.18**	**.19**	.03	.01	**.31**	.13	**.15**	**.21**	**.19**	.12	**.36**	**.33**	**.21**
Intellect	**.36**	**.27**	.03	.09	−.02	.00	**.24**	.10	**.15**	**.29**	.10	.10	**.22**	**.16**	**.27**
Openness	**.16**	**.18**	**.26**	**.23**	.07	.02	**.28**	.13	.11	.07	**.22**	.09	**.38**	**.39**	.10
Neuroticism	−.08	−.10	.01	−.01	−.01	.02	.00	−.01	−.09	−.10	.01	−.08	.00	.03	−.10
Volatility	−.12	−.08	.02	−.01	.01	.01	.02	.03	−.08	−.12	.05	−.05	.03	.07	−.11
Withdrawal	−.01	−.10	.00	−.02	−.02	.01	−.02	−.06	−.08	−.05	−.03	−.10	−.02	.00	−.07
Agreeableness	.06	.02	.07	.01	.08	−.05	.02	−.07	−.04	−.05	.01	−.02	.01	.03	−.06
Compassion	.10	.11	.09	.05	.06	−.02	.07	.04	.02	−.05	.10	.04	.10	.12	−.02
Politeness	.00	−.07	.04	−.02	.08	−.05	−.05	**−.15**	−.08	−.04	−.07	−.07	−.07	−.06	−.08
Conscientiousness	−.13	.02	−.01	−.05	.07	.01	−.02	−.12	−.07	−.02	−.09	.06	−.06	−.07	−.05
Industriousness	−.11	.03	−.04	−.02	.05	−.02	.00	−.06	−.01	.00	−.07	.08	−.04	−.05	−.01
Orderliness	−.11	−.01	.01	−.07	.07	.01	−.04	−.14	−.13	−.04	−.08	.03	−.08	−.07	−.09
Extraversion	−.02	.11	.01	.05	.08	−.03	.13	**.22**	.08	−.02	**.17**	**.16**	**.17**	**.17**	.03
Enthusiasm	−.03	.04	−.01	.03	.06	−.05	.05	.13	.00	−.06	.11	.08	.07	.10	−.05
Assertiveness	−.01	.14	.02	.06	.08	.01	**.18**	**.24**	.12	.02	**.19**	**.18**	**.21**	**.20**	.09

Note. $N = 1{,}035$, except for correlations involving *g* ($N = 844$) and divergent thinking ($N = 671$). Div. Think = divergent thinking; CAQ = Creative Achievement Questionnaire. The *n*-weighted mean correlations are shown. Correlations with the CAQ are Spearman's rho; all others are Pearson correlations. All correlations greater than .14 are in boldface.

(Spearman's $\rho = -.05$, $p = .54$, and $\rho = .10$, $p = .14$, respectively), and positively correlated in Samples 3 and 4 ($\rho = .21$, $p < .01$, and $\rho = .39$, $p < .01$, respectively). Openness/Intellect showed the strongest correlations with creative achievement across both the arts and sciences. At the aspect level, Openness was more strongly associated with creative achievement in the arts than the sciences, whereas Intellect was more strongly correlated with creative achievement in the sciences than the arts. The only other personality trait that consistently demonstrated significant correlations with creative achievement was Extraversion, which was positively correlated with creative achievement in the arts (but not the sciences) in all four samples.

Consistent with prior research, *g* and divergent thinking were substantially correlated with each other (Beaty & Silvia, 2012; Silvia, 2008a, 2008b). Also consistent with prior research, *g* was more strongly related to Intellect than Openness (DeYoung et al., 2013). Because our measures of *g* differed across samples, Table 3 presents the correlations of *g* with the variables involved in our hypotheses, separated by sample. Only for creative achievement in the arts did correlations with *g* differ significantly across samples, and even there, only marginally, $\chi^2_{(3)} = 7.84$, $p = .05$.

Table 3 Correlations of *g* With Measures in Each Sample

	Sample 1 ($N = 166$)	Sample 2 ($N = 239$)	Sample 3 ($N = 124$)	Sample 4 ($N = 305$)
Intellect	.39	.34	.35	.37
Openness	.19	.13	.24	.13
CAQ arts	−.04	−.03	.18	.14
CAQ sciences	.27	.30	.11	.22
DT	—	.33	.42	.38

Note. CAQ = Creative Achievement Questionnaire; DT = divergent thinking. Correlations with the CAQ are Spearman's rho; all others are Pearson correlations.

Tables 4–7 show the results of the regression analyses predicting creative achievement in the arts and sciences. The first block of the analysis, designed to test our primary hypothesis, included age, sex (except in Sample 2, which was all male), Intellect, and Openness. In the second block, we added the rest of the Big Five personality traits (Neuroticism, Agreeableness, Conscientiousness, and Extraversion). Finally, to investigate the robustness of the Intellect and Openness findings when controlling for cognitive ability, we included *g* and divergent thinking (where available) in the last block of the regression analyses.

Table 4 Robust Poisson Regressions Predicting Creative Achievement in the Arts and Sciences in Sample 1 (Cambridge)

	Arts					Sciences				
	b	*SE*	95% CI	Wald χ^2	*p*	*b*	*SE*	95% CI	Wald χ^2	*p*
Block 1										
Age	–0.11	0.11	[–0.33, 0.10]	1.08	.30	–0.09	0.17	[–0.43, 0.25]	0.29	.59
Sex	0.26	0.16	[–0.05, 0.58]	2.70	.10	**–0.81**	**0.22**	**[–1.24, –0.38]**	**13.50**	**< .01**
Intellect	0.10	0.12	[–0.13, 0.34]	0.74	.39	**0.50**	**0.15**	**[0.20, 0.80]**	**10.60**	**< .01**
Openness	**0.41**	**0.10**	**[0.21, 0.61]**	**16.60**	**< .01**	–0.06	0.18	[–0.41, 0.30]	0.10	.75
Block 2										
Age	–0.06	0.11	[–0.27, 0.15]	0.34	.56	–0.10	0.17	[–0.44, 0.24]	0.35	.56
Sex	0.17	0.15	[–0.13, 0.47]	1.20	.27	**–0.69**	**0.24**	**[–1.17, –0.22]**	**8.06**	**.01**
Intellect	–0.00	0.11	[–0.21, 0.22]	0.00	.98	**0.56**	**0.20**	**[0.17, 0.95]**	**7.96**	**.01**
Openness	**0.42**	**0.12**	**[0.18, 0.66]**	**12.21**	**< .01**	–0.06	0.22	[–0.49, 0.38]	0.07	.79
Neuroticism	–0.04	0.07	[–0.18, 0.09]	0.42	.52	–0.10	0.08	[–0.26, 0.06]	1.47	.23
Agreeableness	0.09	0.08	[–0.06, 0.24]	1.28	.26	0.01	0.12	[–0.23, 0.24]	0.00	.96
Conscientiousness	0.08	0.06	[–0.02, 0.26]	2.23	.13	–0.05	0.09	[–0.23, 0.13]	0.27	.60
Extraversion	**0.14**	**0.06**	**[0.02, 0.26]**	**5.12**	**.02**	–0.10	0.08	[–0.23, 0.05]	1.52	.22
Block 3										
Age	–0.06	0.11	[–0.27, 0.15]	0.34	.56	–0.11	0.17	[–0.44, 0.21]	0.47	.49
Sex	0.17	0.15	[–0.14, 0.47]	1.17	.28	**–0.65**	**0.26**	**[–1.15, –0.14]**	**6.25**	**.01**
Intellect	0.01	0.12	[–0.23, 0.24]	0.00	.96	**0.49**	**0.20**	**[0.10, 0.87]**	**6.10**	**.01**
Openness	**0.42**	**0.12**	**[0.18, 0.66]**	**12.19**	**< .01**	–0.11	0.23	[–0.57, 0.35]	0.23	.64
Neuroticism	–0.04	0.06	[–0.18, 0.09]	0.42	.52	–0.09	0.08	[–0.25, 0.07]	1.30	.25
Agreeableness	0.09	0.08	[–0.06, 0.24]	1.29	.26	0.01	0.12	[–0.23, 0.24]	0.00	.96
Conscientiousness	0.08	0.06	[–0.03, 0.19]	2.25	.13	–0.04	0.09	[–0.22, 0.14]	0.18	.68
Extraversion	**0.14**	**0.06**	**[0.02, 0.26]**	**4.88**	**.03**	–0.07	0.07	[–0.21, 0.07]	0.89	.35
g	–0.01	0.08	[–0.16, 0.15]	0.00	.95	0.16	0.17	[–0.17, 0.48]	0.88	.35

Note. $N = 166$. *SE* = standard error; CI = confidence interval. Sex was coded: 0 = male; 1 = female. Significant effects ($p < .05$) are in boldface.

Table 5 Robust Poisson Regressions Predicting Creative Achievement in the Arts and Sciences in Sample 2 (New Haven)

	Arts					Sciences				
	b	*SE*	95% CI	Wald χ^2	*p*	*b*	*SE*	95% CI	Wald χ^2	*p*
Block 1										
Age	–0.01	0.01	[–0.03, 0.01]	0.88	.35	0.01	0.01	[–0.02, 0.04]	0.26	.61
Intellect	0.01	0.09	[–0.17, 0.18]	0.01	.93	**0.43**	**0.15**	**[0.13, 0.73]**	**7.84**	**.01**
Openness	**0.60**	**0.10**	**[0.40, 0.81]**	**33.50**	**< .01**	0.00	0.17	[–0.33, 0.33]	0.00	1.00
Block 2										
Age	–0.01	0.01	[–0.03, 0.01]	0.80	.37	0.01	0.02	[–0.03, 0.03]	1.00	.76
Intellect	0.00	0.11	[–0.21, 0.21]	0.00	.99	0.50	**0.19**	**[0.13, 0.87]**	**6.97**	**.01**
Openness	**0.64**	**0.11**	**[0.42, 0.85]**	**33.58**	**< .01**	0.11	0.18	[–0.25, 0.47]	0.35	.56
Neuroticism	0.13	0.09	[–0.05, 0.31]	1.92	.17	–0.20	0.15	[–0.50, 0.09]	1.81	.18
Agreeableness	**–0.39**	**0.11**	**[–0.60, –0.18]**	**13.05**	**< .01**	**–0.48**	**0.18**	**[–0.84, –0.13]**	**7.09**	**.01**
Conscientiousness	0.01	0.09	[–0.17, 0.20]	0.02	.90	–0.08	0.15	[–0.38, 0.22]	0.29	.59
Extraversion	**0.32**	**0.11**	**[0.11, 0.53]**	**8.77**	**< .01**	–0.28	0.21	[–0.68, 0.13]	1.81	.18
Block 3										
Age	–0.02	0.01	[–0.04, 0.01]	2.10	.15	0.01	0.02	[–0.02, 0.04]	0.39	.54
Intellect	0.11	0.13	[–0.13, 0.36]	0.87	.35	0.22	0.19	[–0.14, 0.59]	1.46	.23
Openness	**0.64**	**0.11**	**[0.42, 0.85]**	**33.90**	**< .01**	0.12	0.17	[–0.21, 0.45]	0.49	.49
Neuroticism	0.16	0.10	[–0.02, 0.34]	2.93	.09	–0.18	0.15	[–0.48, 0.12]	1.38	.24
Agreeableness	**–0.35**	**0.10**	**[–0.54, –0.16]**	**12.83**	**< .01**	**–0.50**	**0.18**	**[–0.86, –0.13]**	**7.22**	**.01**
Conscientiousness	–0.03	0.10	[–0.23, 0.16]	0.12	.73	0.00	0.16	[–0.30, 0.31]	0.00	.99
Extraversion	**0.30**	**0.11**	**[0.09, 0.51]**	**7.54**	**.01**	–0.22	0.19	[–0.60, 0.15]	1.34	.25
g	**–0.11**	**0.04**	**[–0.18, –0.04]**	**8.85**	**< .01**	0.11	0.05	[0.00, 0.21]	3.83	.05
Divergent thinking	0.09	0.05	[–0.02, 0.19]	2.76	.10	**0.26**	**0.13**	**[0.01, 0.52]**	**4.23**	**.04**

Note. $N = 236$, except for Block 3 ($N = 235$). *SE* = standard error; CI = confidence interval. Significant effects ($p < .05$) are in boldface.

Table 6 Robust Poisson Regressions Predicting Creative Achievement in the Arts and Sciences in Sample 3 (Southern Ontario)

	Arts					Sciences				
	b	*SE*	95% CI	Wald χ^2	*p*	*b*	*SE*	95% CI	Wald χ^2	*p*
Block 1										
Age	**–0.05**	**0.02**	**[–0.08, –0.01]**	**5.14**	**.02**	0.00	0.03	[–0.05, 0.05]	0.01	.94
Sex	–0.08	0.11	[–0.30, 0.14]	0.50	.48	–0.22	0.19	[–0.60, 0.16]	1.32	.25
Intellect	0.15	0.10	[–0.05, 0.34]	2.05	.15	**0.62**	**0.16**	**[0.30, 0.94]**	**14.50**	**< .01**
Openness	**0.38**	**0.10**	**[0.20, 0.57]**	**16.33**	**< .01**	–0.17	0.20	[–0.55, 0.22]	0.73	.39
Block 2										
Age	–0.04	0.02	[–0.09, 0.00]	3.97	.05	–0.01	0.02	[–0.06, 0.04]	0.11	.74
Sex	–0.06	0.11	[–0.28, 0.16]	0.28	.60	–0.23	0.19	[–0.61, 0.16]	1.35	.25
Intellect	0.07	0.12	[–0.17, 0.31]	0.34	.56	**0.58**	**0.19**	**[0.20, 0.95]**	**9.03**	**< .01**
Openness	**0.41**	**0.10**	**[0.21, 0.61]**	**16.18**	**< .01**	–0.06	0.22	[–0.49, 0.37]	0.07	.79
Neuroticism	0.17	0.09	[0.00, 0.34]	3.90	.05	–0.28	0.20	[–0.68, 0.13]	1.83	.18
Agreeableness	–0.08	0.11	[–0.29, 0.13]	0.53	.47	–0.27	0.22	[–0.71, 0.17]	1.42	.23
Conscientiousness	**0.23**	**0.10**	**[0.03, 0.43]**	**5.06**	**.02**	0.00	0.17	[–0.33, 0.33]	0.00	.99
Extraversion	**0.20**	**0.09**	**[0.03, 0.38]**	**5.31**	**.02**	–0.21	0.20	[–0.59, 0.18]	1.08	.30
Block 3										
Age	**–0.07**	**0.03**	**[–0.13, –0.01]**	**5.21**	**.02**	–0.03	0.05	[–0.12, 0.07]	0.33	.56
Sex	–0.06	0.18	[–0.42, 0.29]	0.12	.73	**–0.82**	**0.28**	**[–1.36, –0.28]**	**8.93**	**< .01**
Intellect	–0.07	0.18	[–0.43, 0.29]	0.15	.70	0.27	0.21	[–0.14, 0.68]	1.64	.20
Openness	**0.43**	**0.14**	**[0.16, 0.71]**	**9.56**	**< .01**	–0.09	0.24	[–0.57, 0.39]	0.14	.71
Neuroticism	0.12	0.12	[–0.10, 0.35]	1.13	.29	–0.27	0.23	[–0.71, 0.17]	1.42	.23
Agreeableness	–0.06	0.16	[–0.37, 0.25]	0.14	.71	**–0.82**	**0.27**	**[–1.34, –0.30]**	**9.53**	**< .01**
Conscientiousness	**0.36**	**0.14**	**[0.08, 0.63]**	**6.23**	**.01**	–0.08	0.20	[–0.47, 0.32]	0.16	.69
Extraversion	**0.32**	**0.12**	**[0.07, 0.56]**	**5.56**	**.01**	–0.05	0.23	[–0.50, 0.39]	0.06	.81
g	**0.02**	**0.02**	**[–0.02, 0.06]**	**1.02**	**.31**	–0.02	0.02	[–0.06, 0.03]	0.37	.54
Divergent thinking	–0.07	0.12	[–0.30, 0.16]	0.38	.54	**0.76**	**0.17**	**[0.41, 1.10]**	**18.73**	**< .01**

Note. $N = 323$, except for Block 3 ($N = 123$). *SE* = standard error; CI = confidence interval. Sex was coded: 0 = male; 1 = female. Significant effects ($p < .05$) are in boldface.

Because the distribution of creative achievement was skewed right with many zero scores, we employed Poisson regression, using the robust Huber-White sandwich estimator to account for overdispersion (Silvia & Kimbrel, 2010; Silvia et al., 2012). Note that the regression weights are unstandardized values and thus less easily interpreted than standardized weights. There is no equivalent to the R^2 statistic for Poisson regression.

There were no consistent effects of age on creative achievement (although there were some sample-specific effects). In the three samples that had variance in gender, being female consistently negatively predicted creative achievement in the sciences (when all measures of personality and cognition were included in the regression). When controlling for the rest of the Big Five, Openness consistently predicted creative achievements in the arts (but not the sciences), whereas Intellect consistently predicted creative achievement in the sciences (but not the arts). Extraversion was consistently an additional independent predictor of artistic creativity. We do not interpret the inconsistent effects that appeared in one or two samples for Conscientiousness and Agreeableness. However, in the future, researchers may want to investigate the possibly more nuanced relations among Conscientiousness, Agreeableness, and creative achievement across domains.

When *g* and divergent thinking were added to the regression analysis, Openness and Extraversion remained significant, independent predictors of artistic creativity in all four samples. Intellect, however, remained a significant predictor of scientific creativity only in Sample 1 (which included *g* but not divergent thinking) and Sample 4 (which included both *g* and divergent thinking). For Samples 2 and 3, Intellect was no longer a significant predictor of creative achievement in the sciences. This suggests that Intellect's prediction of creative achievement in the sciences may be due, at least in part, to its association with general cognitive ability and divergent thinking.

DISCUSSION

Consistent with prior research, Openness/Intellect emerged as the most robust and consistent Big Five predictor of creative achievement across the arts and sciences (e.g., Batey & Furnham, 2006; Carson et al., 2005; Feist, 1998; Silvia, Kaufman, & Pretz, 2009). The primary aim of the current investigation, however, was to clarify the relations between the two major aspects of Openness/Intellect and creative achievement in the arts and sciences. In multiple regression, Openness to Experience independently predicted creative achievement in the arts (but not the sciences), whereas Intellect independently

Table 7 Robust Poisson Regressions Predicting Creative Achievement in the Arts and Sciences in Sample 4 (Minnesota)

	Arts					Sciences				
	b	*SE*	95% CI	Wald χ^2	*p*	*b*	*SE*	95% CI	Wald χ^2	*p*
Block 1										
Age	–0.02	0.01	[–0.02, 0.02]	0.06	.81	–0.01	0.01	[–0.03, 0.01]	1.95	.16
Sex	**–0.25**	**0.08**	**[0.10, 0.41]**	**10.30**	**< .01**	**–0.36**	**0.11**	**[0.15, 0.57]**	**10.99**	**.00**
Intellect	–0.01	0.07	[–0.15, 0.12]	0.04	.84	**0.42**	**0.10**	**[0.23, 0.61]**	**18.22**	**.00**
Openness	**0.51**	**0.07**	**[0.37, 0.65]**	**51.39**	**< .01**	–0.01	0.10	[–0.19, 0.17]	0.01	.93
Block 2										
Age	0.00	0.01	[–0.02, 0.02]	0.02	.89	–0.01	0.01	[–0.03, 0.01]	1.14	.29
Sex	**–0.25**	**0.09**	**[0.09, 0.42]**	**8.71**	**< .01**	**–0.35**	**0.11**	**[0.13, 0.56]**	**9.90**	**< .01**
Intellect	–0.03	0.08	[–0.18, 0.12]	0.16	.69	**0.44**	**0.11**	**[0.22, 0.66]**	**15.59**	**< .01**
Openness	**0.46**	**0.08**	**[0.31, 0.61]**	**35.08**	**< .01**	–0.09	0.11	[–0.30, 0.12]	0.67	.41
Neuroticism	0.09	0.07	[–0.05, 0.23]	1.52	.22	0.06	0.09	[–0.13, 0.24]	0.34	.56
Agreeableness	0.03	0.09	[–0.14, 0.21]	0.13	.72	0.09	0.11	[–0.12, 0.29]	0.63	.43
Conscientiousness	–0.08	0.07	[–0.23, 0.06]	1.25	.26	**–0.20**	**0.10**	**[–0.39, –0.01]**	**4.04**	**.04**
Extraversion	**0.21**	**0.07**	**[0.07, 0.35]**	**8.35**	**< .01**	0.08	0.12	[–0.15, 0.31]	0.47	.50
Block 3										
Age	0.00	0.01	[–0.02, 0.02]	0.07	.79	–0.01	0.01	[–0.03, 0.01]	0.92	.34
Sex	**–0.26**	**0.09**	**[0.09, 0.43]**	**9.34**	**< .01**	**–0.35**	**0.11**	**[0.14, 0.56]**	**10.71**	**< .01**
Intellect	–0.10	0.08	[–0.25, 0.05]	1.62	.20	**0.32**	**0.11**	**[0.11, 0.53]**	**8.69**	**< .01**
Openness	**0.45**	**0.08**	**[0.30, 0.60]**	**33.90**	**< .01**	–0.08	0.10	[–0.28, 0.12]	0.60	.44
Neuroticism	0.09	0.07	[–0.04, 0.23]	1.79	.18	0.05	0.09	[–0.13, 0.24]	0.32	.57
Agreeableness	0.04	0.09	[–0.14, 0.22]	0.20	.66	0.07	0.10	[–0.13, 0.28]	0.51	.47
Conscientiousness	–0.08	0.07	[–0.22, 0.07]	1.10	.29	–0.15	0.10	[–0.35, 0.04]	2.41	.12
Extraversion	**0.23**	**0.07**	**[0.09, 0.37]**	**10.68**	**< .01**	0.14	0.11	[–0.08, 0.35]	1.50	.23
g	0.06	0.06	[–0.05, 0.18]	1.12	.29	**0.18**	**0.08**	**[0.03, 0.34]**	**5.54**	**.02**
Divergent thinking	**0.04**	**0.02**	**[0.01, 0.07]**	**5.29**	**.02**	0.02	0.04	[–0.05, 0.09]	0.38	.54

Note. $N = 305$. *SE* = standard error; CI = confidence interval. Sex was coded: 0 = male; 1 = female. Significant effects ($p < .05$) are in boldface.

predicted creative achievement in the sciences (but not the arts). These results held even after controlling for the other Big Five personality traits. This result highlights the importance of separating Openness and Intellect, as well as considering different domains of creativity.

Although we had not predicted it, Extraversion also emerged as a consistent predictor of creative achievement in the arts, independent of the effects of other Big Five traits, general cognitive ability, and divergent thinking. This result is reminiscent of the finding of an association between plasticity (the shared variance of Extraversion and Openness/Intellect; see DeYoung, Peterson, & Higgins, 2002; Hirsh, DeYoung, & Peterson, 2009) and overall CAQ scores, which are weighted toward artistic creativity (Silvia et al., 2009). Also consistent with our findings, Silvia et al. (2009) did not find an association between plasticity and math-science creativity. Plasticity appears to reflect a general exploratory tendency in both behavior and cognition (DeYoung, 2013; Hirsh et al., 2009), with Extraversion reflecting more behavioral forms of exploration. It seems, therefore, that a behavioral exploratory tendency is more relevant to creativity in the arts than the sciences. This may be particularly true in performing arts that require expressiveness in a public setting.

Whereas Extraversion appears to be more relevant to creative achievement in the arts than in the sciences, cognitive abilities appear to be more relevant to creative achievement in the sciences. For two out of the three samples that included performance measures of both *g* and divergent thinking, Intellect no longer predicted achievement in the sciences after controlling for the two cognitive ability measures. (We conducted a follow-up analysis assessing the verbal and nonverbal components of *g* separately, and found that both displayed the same pattern of association, as each other, with creative achievement, and both had the same effect on other predictors in the regression as *g*.) Further, in three out of four samples, *g* or divergent thinking was a significant additional predictor of achievement in the sciences.

These results suggest that both ability and motivation components of Intellect are likely to be important for creative scientific achievement. The ability component is at least partially captured by *g* and divergent thinking (which is consistent with the theory that general cognitive ability is an important component of Intellect; DeYoung, 2011, 2014; DeYoung et al., 2012), whereas the motivation component of Intellect, reflecting intellectual curiosity, drive, and engagement, is presumably what remains after controlling for ability. The more basic cognitive processes underlying *g* and divergent thinking might include verbal and ideational fluency, mental flexibility, working memory, and the strategic retrieval and manipulation of knowledge (Beaty & Silvia, 2012; DeYoung,

Flanders, & Peterson, 2008; Gilhooly, Fioratou, Anthony, & Wynn, 2007; Nusbaum & Silvia, 2011b; von Stumm, Benedikt, & Chamorro-Premuzic, 2011). These abilities appear to be more important for creative achievement in the sciences, which requires application of reasoning and semantic ideation to an existing rational system, than for creative achievement in the arts, which requires aesthetic, affective, fantasy, imagination, and perceptual engagement (see S. B. Kaufman, 2013a).

Our results are consistent with the dual-process framework and suggest that artistic creativity draws more heavily on experiential Type 1 processes associated with Openness (e.g., perceptual, aesthetic, and implicit learning processes), whereas scientific creativity relies more heavily on Type 2 processes associated with Intellect and divergent thinking. Our finding of discriminant validity for the prediction of creative achievement by Openness and Intellect is consistent with a previous finding of double dissociation, in which Openness but not Intellect predicted implicit learning, whereas Intellect but not Openness predicted working memory capacity (S. B. Kaufman et al., 2010).

LIMITATIONS

The present study is not without limitations, one being the range of creative domains that were investigated. Whereas the current study focused on the arts and sciences, prior research has investigated a wider range of domains, including everyday, humanities, mechanical, business, realistic, and social/interpersonal forms of creativity (Ivcevic & Mayer, 2009; J. C. Kaufman, 2012; Kaufman, Pumaccahua, & Holt, 2013; Park, Lubinski, & Benbow, 2007). Assessing a wider range of domains can help inform the domain-general/domain-specific debate (Kaufman & Baer, 2004a, 2004b; Plucker, 2004; Silvia et al., 2009), as domains of cognition (e.g., verbal, nonverbal, divergent) and personality (e.g., Intellect, Openness) may show both domain-general and domain-specific contributions across a wider swath of creativity. Another potential limitation is the fact that the CAQ relies on formal recognition of creative products (e.g., publication, sales, and awards) to determine creative achievement. One might argue that public success is not a guarantee of creative quality. It would, therefore, be interesting to test whether our results hold for other modes of assessment of creative achievement.

CONCLUSION

In four demographically different samples, we found that Openness to Experience and Intellect differentially predicted creative achievement in the arts and sciences, respectively. These effects may stem from differing demands of artistic and scientific creativity for Type 1 versus Type 2 processing. We hope these findings lead the way toward productive new hypotheses and more nuanced tests of the complex relations among personality, cognition, and creativity.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interests with respect to the research, authorship, and/or publication of this article.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Data collection for Sample 2 was supported by grants to Colin DeYoung from NIH (F32 MH077382) and to Jeremy Gray from NSF (DRL 0644131). Data collection for Sample 4 was supported by grants to Colin DeYoung from NIH (R03 DA029177-01A1) and NSF (SES-1061817).

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