Another look at creativity and intelligence: Exploring higher-order models and probable confounds

By: Paul J. Silvia

Silvia, P. J. (2008). Another look at creativity and intelligence: Exploring higher-order models and probable confounds. *Personality and Individual Differences, 44,* 1012-1021. doi:10.1016/j.paid.2007.10.027

*****Note: Figures may be missing from this format of the document**

Abstract:
How strongly is creativity related to intelligence? Although a large body of work has found a small relationship between them, there are reasons to suspect that their relationship has been underestimated. Most studies have assessed creativity and intelligence with observed scores, not as latent variables, and few studies have examined higher-order latent intelligence factors. A sample of university students (n = 226) completed divergent thinking tasks and measures of fluid reasoning, verbal fluency, and strategy generation. Creativity was modestly related to the three lower-order cognitive factors, but it was substantially related (β = .43) to a higher-order intelligence factor composed of the lower-order factors. This effect declined (β = .26) when openness to experience, a likely confounding variable, was considered.
Keywords: Creativity; Intelligence; Fluid reasoning; Verbal fluency; Divergent thinking

Article:

1. Exploring higher-order models and probable confounds

Are creative people smart? The relation between creativity and intelligence is a venerable problem in the psychology of creativity. (Guilford, 1950) and (Guilford, 1967) made seminal contributions to both fields, and the overlap between creativity and intelligence received book-length treatment in two classic works ([Getzels and Jackson, 1962] and [Wallach and Kogan, 1965]). The distinction was significant in enriching the notion of childhood giftedness (Getzels & Jackson, 1962), motivating the development of better measures of creativity (Wallach & Kogan, 1965), and suggesting the viability of interventions to enhance creativity. Modern research continues to explore, synthesize, and evaluate the relation between creativity and intelligence ([Kim, 2005], [Preckel et al., 2006], [Sligh et al., 2005] and [Sternberg and O'Hara, 1999]).

The present paper takes a new look at the relation between creativity and intelligence. A recent meta-analysis found a modest relation between them (r = .17; Kim, 2005), but there are good reasons to think that the relation has been underestimated. Advanced multivariate techniques were not widely available until relatively recently ([Kline, 2005] and [Loehlin, 2004]), and most studies have focused on observed measures of lower-order intelligence factors, not the higher-order latent *g* factor. But there are also good reasons to think that the relation has been overestimated. Most research has been guilty of neglecting third variables that could predict both intelligence and creativity. People high in openness to experience, for example, are both more intelligent (DeYoung, Peterson, & Higgins, 2005) and more creative (King, Walker, & Broyles, 1996).
A large sample latent variable study examined the relationship between intelligence and creativity, using measures and statistical methods intended to overcome some of the limitations of past research. We explored two questions. First, is the relation between creativity and intelligence strengthened when some of the methodological and statistical limitations of past research are addressed? Second, is the relation between creativity and intelligence weakened when plausible third variables are considered?

2. Underestimating and overestimating intelligence

There's good reason to believe that past work has underestimated the relationship between intelligence and creativity. Most research has estimated correlations between observed measures of the constructs; latent variable analysis wasn't available when much of the research was conducted. It is hard to overstate the value of latent variable models for studying individual differences (see Loehlin, 2004). Researchers can pool information from multiple measures, use measures with different methods, and model the sources of error variance. Latent variable analyses, in general, will find stronger relationships than analyses of observed variables (Coffman & MacCallum, 2005). For example, a latent variable reanalysis of Wallach and Kogan's (1965) classic study found a correlation of $r = .20$ (Silvia, in press), which is higher than Wallach and Kogan's original correlational analysis ($r = .09$) and higher than the meta-analytic average of studies that used their tasks ($r = .12$; Kim, 2005, p. 61).

Furthermore, latent variable models allow researchers to estimate higher-order latent factors, such as a latent *g* factor composed of lower-order latent factors. General intelligence is the abstract factor that explains why diverse cognitive tests correlate, not the specific factors measured by the tests (Carroll, 1993). Strictly speaking, testing the relationship between intelligence and creativity would require modeling intelligence as a higher-order, general factor composed of lower-order cognitive skills. Few studies, however, have done so.

On the other hand, one could expect that the relationship between intelligence and creativity has been overstated. Intelligence and creativity share relationships with other variables, and there are good reasons to think that third variables confound the relationship between them. Of the major dimensions of personality, openness to experience has the strongest and most consistent relationship with intelligence (Chamorro-Premuzic & Furnham, 2006). Many studies have found that people high in openness score higher on measures of intelligence (e.g., DeYoung et al., 2005). In lexical studies of personality, the openness factor often resembles an intelligence factor (De Raad, 1994). Openness is also a strong predictor of creativity ([Feist, 1998], [Feist, 2006], [King et al., 1996], [McCrae, 1987] and [Weisberg, 2006]), so it is reasonable to suspect that openness to experience confounds correlations between intelligence and creativity.

3. The present research

The present study examines the relationships between intelligence and creativity while addressing some limitations of past research. First, all of the constructs were modeled as latent variables, which should offer cleaner estimates of their relationships. Second, intelligence was modeled as a higher-order latent variable composed of lower-order latent factors. This model will show if intelligence predicts creativity more strongly when it is assessed at a more abstract, general level. And finally, we explored if including openness to experience diminished the relationship between intelligence and creativity. If so, then openness would appear to be a "third variable" that explains the relationship.

4. Method

4.1. Participants

The data were taken from the creativity and cognition project, which was first described in Silvia et al. (in press). A total of 242 college students completed a wide range of measures of creativity, personality, knowledge, and cognitive abilities. After excluding people with limited English proficiency and extensive missing data, we had a final sample of 226 people (178 women, 48 men). Most of the participants (82%) were 18 or 19 years old. The most common college majors in the sample were nursing (31%), undeclared (11%), and biology (5%). Around 9% of the sample had a major related to the arts (e.g., majors such as music, theatre, fine art, dance, and interior architecture), and less than 3% of the sample majored in psychology.

4.2. Procedure

People participated in groups of 1–13; they completed several measures of cognitive abilities and creativity. The tasks were completed in the order in which they are described.

4.3. Creativity

Two unusual uses tasks — uses for a brick and uses for a knife — were administered to measure individual differences in creativity. An earlier generalizability analysis found that unusual uses tasks produce dependable scores (Silvia et al., in press, Study 1). The experimenter told the participants that the tasks assessed how people come up with creative ideas. The participants were told to try to come up with creative responses. These instructions were intended to raise the ceiling of creativity, expand the variance in creativity scores, and enhance the validity of the tasks as measures of individual differences (see [Christensen et al., 1957], [Harrington, 1975] and [Runco et al., 2005]). After completing each task, the experimenter asked the participants to review their responses and to circle the two that they thought were their two most creative responses.

Three raters independently judged the responses on a 1–5 scale (1 = not at all creative, 5 = very creative). Prior to rating, each response was entered into a database and then sorted alphabetically. As a result, the raters were unaware of which person gave the response, whether a response was picked as a “top two” response, the person’s other responses, the serial order of the response within the set, and the person’s total number of responses. Ratings of these “top two scores” served as the measure of creativity (Silvia et al., in press, Study 2). First suggested by Michael and Wright (1989), this approach (1) controls for the number of responses that make up each person’s score and (2) assesses people’s level of creativity based on their best responses.

4.4. Intelligence

4.4.1. Fluid reasoning

One first-order factor was fluid reasoning, the ability to solve novel problems and to induce rules and patterns (Carroll, 1993). Three tasks assessed fluid reasoning: (1) the 18 odd-numbered items from the Raven’s Progressive Matrices (12 min); (2) a 16 item Letter Sets task, in which people discern which set of four letters violates a rule followed by other sets of letters (4 min); and (3) a 10-item Paper Folding test, in which people decide how folded sheets of paper would appear when mentally unfolded (4 min). The Paper Folding task and Letter Sets task were taken from the Kit of Factor-Referenced Tests (Ekstrom, French, Harman, & Dermen, 1976).

4.4.2. Verbal fluency

A second first-order factor was verbal fluency, the ability to retrieve words based on a rule ([Bousfield and Sedgewick, 1944] and [Troyer et al., 1997]). Two tasks measured letter fluency: people were asked to generate all of the words they could think of that started with the letter F and the letter M. Two tasks measured semantic fluency: people were asked to generate as many kinds of animals and as many occupations as possible. People had 2 min for each task; they completed them in F, animals, M, occupations order. People were told that duplications of roots (e.g., forty, forty-one) and proper names would not count.

4.4.3. Strategy generation

A third first-order factor was composed of three strategy generation tasks. Developed by Phillips (1999), these tasks ask participants to generate successful strategies for a verbal fluency task. For example, one task told people to imagine that they were asked to list as many parts of the body as possible. People then had to list strategies that would help them list a lot of parts of the body, such as “starting at the top and working down” and “list parts based on the body’s systems.” Performance on this task requires generating novel rules; it correlates highly with other measures of intelligence (Phillips, 1999), and it appears to capture both verbal and fluid aspects of intelligence. We used three tasks: strategies for listing parts of the body, examples of food, and countries in the world. People had 2 min for each task. The tasks were scored by counting the number of distinct strategies that people generated.

4.5. Openness to experience

Openness to experience was measured with three self-report scales. People completed the 12-item Openness scale from Costa and McCrae’s (1992) Five Factor Inventory (1 = strongly disagree, 5 = strongly agree); a 10-item Openness scale (1 = very inaccurate description of me, 5 = very accurate description of me) formed from the International Personality Item Pool (IPIP; Goldberg et al., 2006); and the 2-item Openness scale from Gosling, Rentfrow, and Swann’s (2003) brief Big 5 scale (1 = very inaccurate description of me, 5 = very accurate description of me). Cronbach’s alpha was strongest for the IPIP scale (.83), lower for the NEO scale (.67), and lowest for the 2-item brief scale (.30).

5. Results

5.1. Analysis overview

The analyses were conducted with Mplus 4.21, using full-information maximum likelihood estimation. The higher-order model is shown in Fig. 1. To assess construct reliability — also known as maximal reliability (Drewes, 2000) — for each latent factor, we estimated H, which indicates "the degree to which the indicators can capture information about the underlying factor" (Gagné & Hancock, 2006, p. 68). Creativity ($H = .39$) was modeled as a higher-order latent variable composed of two lower-order latent variables: one for the brick task ($H = .79$), and one for the knife task ($H = .78$). The paths to brick and knife were constrained to be equal for identification, and the variance of Creativity was set to 1. The three judges' ratings of people's top-two scores were the indicators. The paths to Rater 2 were set to 1, and the paths for Raters 1 and 3 were nearly identical and thus were constrained to be equal. General Intelligence ($H = .65$) was also modeled as a higher-order latent variable: it was composed of Fluid Reasoning ($H = .65$), Verbal Fluency ($H = .73$), and Strategy Generation ($H = .69$). The variances of the lower-order factors were set to 1. Because even small effects are significant with a large sample, we describe our findings in terms of small (around $\beta = 10$), medium (around $\beta = .30$), and large (around $\beta = .50$) effect sizes.

5.2. Creativity and the lower-order factors

We first examined the relationships between the lower-order cognitive factors — fluid intelligence, verbal fluency, and strategy generation — and creativity. This analysis provided a useful comparison to the analysis of higher-order intelligence and creativity, which is shown in Fig. 1. We regressed creativity on fluid intelligence, verbal fluency, strategy generation, and gender (scored 1 for men, 2 for women). The model fit well (RMSEA = .026, SRMR = .048, CFI = .98, $\chi^2/df = 1.15$), and it explained 14.4% of the variance in creativity. The effect sizes were small to moderate. Fluid intelligence had the largest relationship with creativity ($\beta = .24$); verbal fluency ($\beta = .16$), strategy generation ($\beta = .09$), and gender ($\beta = -.13$) all had small effects. All told, then, the lower-order cognitive factors had modest relationships with creativity, consistent with the typical effects found in Kim's (2005) meta-analysis.

5.3. Creativity and general intelligence

Did general intelligence predict creativity? Earlier we suggested that the intelligence–creativity relation may be stronger when intelligence is modeled at a higher level of abstraction. We thus regressed creativity on general intelligence (as depicted in Fig. 1) and gender. This model fit well (RMSEA = .027, SRMR = .051, CFI = .98, $\chi^2/df = 1.16$), and it explained 18.4% of the variance in creativity. The higher-order intelligence factor had a medium-to-large effect on creativity ($\beta = .43$); gender had a smaller effect ($\beta = -.18$). The effect of general intelligence was much larger than the effects of the lower-order factors, indicating that the abstract, general factor of intelligence is more relevant to creativity than the specific factors.

5.4. Creativity, openness, and general intelligence

Thus far, we have found that a higher-order factor of intelligence relates substantially to creativity, much more so than the typical effect found in past research (Kim, 2005). Is this effect independent of third variables, such as openness to experience? To appraise the unique relationship between intelligence and creativity, we added a latent Openness to Experience variable (composed of the three self-report scales; $H = .77$) to the model shown in Fig. 1. Creativity was regressed on intelligence, openness, and gender. This model fit well (RMSEA = .03, SRMR = .052, CFI = .97, $\chi^2/df = 1.20$), and it explained 32.6% of the variance in creativity. Openness correlated significantly with intelligence ($\beta = .32$), and it had a medium-to-large effect on creativity ($\beta = .43$). The higher-order intelligence factor had smaller effect on creativity ($\beta = .26$) when openness was in the model; gender had a very small effect ($\beta = -.07$). It appears that openness partly accounts for the relation between intelligence and creativity: the effect of intelligence declined when openness was entered (from $\beta = .43$ to $\beta = .26$), but the effect nevertheless remained medium in size.

6. General discussion

The psychometric approach has been interested in the relationship between intelligence and creativity since (Guilford, 1950) and (Guilford, 1967) pioneering research. The present research was motivated by two questions. First, has the creativity–intelligence relationship been underestimated? Second, does intelligence uniquely predict creativity when possible confounds are considered? Regarding the first question, past research has probably underestimated the creativity–intelligence relationship. When intelligence is modeled as a higher-order latent variable, it has a much stronger relationship to creativity than the typical effect found in past work ($r = .17$; Kim, 2005). Estimating a higher-order factor of intelligence appreciably boosts the relationship, indicating that studies of lower-order factors may provide misleading estimates of the true effect size.

Regarding the second question, the relationship between creativity and intelligence is due in part to other variables. Including openness to experience — a variable that predicts both intelligence and creativity — deflated intelligence's relationship with creativity. But the effect remained medium in size, suggesting that openness does not fully explain the relationship. Nevertheless, creativity researchers should consider possible personality confounds when examining cognitive aspects of creativity. Chamorro-Premuzic and Furnham (2006) pointed out that the psychology of intelligence and the psychology of personality developed from different traditions in differential psychology, and only recently have psychologists considered them jointly. Understanding how cognitive abilities and personality traits collectively influence creative abilities is an important goal for future research.

The findings of the present study ought to be viewed in light of the occasionally weak reliability of the measures or constructs. The brief openness scale designed by Gosling, Rentfrow, and Swann (2003) had surprisingly poor internal consistency, even for a 2-item scale. Some of the latent constructs, such as the latent higher-order creativity and intelligence variables, had relatively weak H values. Each latent factor was defined by widely-used tasks or scales, so it is unlikely that the models are severely mis-specified. These low H values are probably due to having only 2 or 3 indicators for most of the factors; all else equal, H increases as the number of indicators increases (Gagné & Hancock, 2006). Future work can enhance the construct reliability of creativity by including more indicators, such as by administering more creativity tasks and having more raters score each task.

This study used divergent thinking to represent individual differences in creativity. Divergent thinking tasks are among the oldest and most popular tasks in scientific research on creativity (e.g., Wilson, Guilford, & Christensen, 1953), but they are controversial (see Kaufman & Baer, 2005). Several researchers — particularly researchers from traditions that view creativity in terms of problem solving (Weisberg, 2006) and sociocultural factors (Sawyer, 2006) — are skeptical of the value of divergent thinking specifically and of the notion of individual differences in creativity more generally. It's worth noting that most of the foundational research on individual differences in divergent thinking was conducted prior to the development of advanced psychometric and multivariate methods (Runco, 2007). Given the strengths of contemporary methods, modern research may reveal stronger evidence for the validity of divergent thinking (Silvia et al., in press). Regardless, this debate cannot be settled by any single study; only the accumulation of research will reveal whether divergent thinking is a fruitful scientific construct.

Acknowledgements
These data are from the Creativity and Cognition project, which was first described in Silvia et al. (in press). Chris Barona, Josh Cram, Karl Hess, Jenna Martinez, and Crystal Richard deserve thanks for collecting and scoring the data. Researchers can obtain the data files from the author's web page.

References
Bousfield and Sedgewick, 1944 W.A. Bousfield and C.H.W. Sedgewick, An analysis of sequences of restricted associative responses, *Journal of General Psychology* 30 (1944), pp. 149–165.
Carroll, 1993 J.B. Carroll, Human cognitive abilities: A survey of factor-analytic studies, Cambridge University Press, NY (1993).
Chamorro-Premuzic and Furnham, 2006 T. Chamorro-Premuzic and A. Furnham, Intellectual competence and the intelligent personality: A third way in differential psychology, *Review of General Psychology* 10 (2006), pp. 251–267.

Christensen et al., 1957 P.R. Christensen, J.P. Guilford and R.C. Wilson, Relations of creative responses to working time and instructions, *Journal of Experimental Psychology* 53 (1957), pp. 82–88.
Coffman and MacCallum, 2005 D.L. Coffman and R.C. MacCallum, Using parcels to convert path analysis models into latent variable models, *Multivariate Behavioral Research* 40 (2005), pp. 235–259.
Costa and McCrae, 1992 Costa, P. T., Jr., & McCrae, R. R. (1992). *Revised NEO personality inventory (NEO-PI-R) and NEO five-factor inventory (NEO-FFI) professional manual*. Odessa, FL: Psychological Assessment Resources.
De Raad, 1994 B. De Raad, An expedition in search of a fifth universal factor: Key issues in the lexical approach, *European Journal of Personality* 8 (1994), pp. 229–250.
DeYoung et al., 2005 C.G. DeYoung, J.B. Peterson and D.M. Higgins, Sources of openness/intellect: Neuropsychological correlates of the fifth factor of personality, *Journal of Personality* 73 (2005), pp. 825–858.
Drewes, 2000 D.W. Drewes, Beyond the Spearman-Brown: A structural approach to maximal reliability, *Psychological Methods* 5 (2000), pp. 214–227.
Ekstrom et al., 1976 R.B. Ekstrom, J.W. French, H.H. Harman and D. Dermen, Manual for kit of factor-referenced cognitive tests, Educational Testing Service, Princeton, NJ (1976).
Feist, 1998 G.J. Feist, A meta-analysis of personality in scientific and artistic creativity, *Personality and Social Psychology Review* 2 (1998), pp. 290–309.
Feist, 2006 G.J. Feist, The psychology of science and the origins of the scientific mind, Yale University Press, New Haven, CT (2006).
Gagné and Hancock, 2006 P. Gagné and G.R. Hancock, Measurement model quality, sample size, and solution propriety in confirmatory factor models, *Multivariate Behavioral Research* 41 (2006), pp. 65–83.
Getzels and Jackson, 1962 J.W. Getzels and P.W. Jackson, Creativity and intelligence: Explorations with gifted students, Wiley, NY (1962).
Goldberg et al., 2006 L.R. Goldberg, J.A. Johnson, H.W. Eber, R. Hogan, M.C. Ashton, C.R. Cloninger and H.G. Gough, The international personality item pool and the future of public-domain personality assessment, *Journal of Research in Personality* 40 (2006), pp. 84–96.
Gosling et al., 2003 S.D. Gosling, P.J. Rentfrow and W.B. Swann Jr., A very brief measure of the big-five personality domains, *Journal of Research in Personality* 37 (2003), pp. 504–528.
Guilford, 1950 J.P. Guilford, Creativity, *American Psychologist* 5 (1950), pp. 444–454.
Guilford, 1967 J.P. Guilford, The nature of human intelligence, McGraw-Hill, NY (1967).
Harrington, 1975 D.M. Harrington, Effects of explicit instructions to "be creative" on the psychological meaning of divergent thinking test scores, *Journal of Personality* 43 (1975), pp. 434–454.
Kaufman and Baer, 2005 In: J.C. Kaufman and J. Baer, Editors, *Creativity across domains: Faces of the muse*, Lawrence Erlbaum Associates, Mahwah, NJ (2005).
Kim, 2005 K.H. Kim, Can only intelligent people be creative?, *Journal of Secondary Gifted Education* 16 (2005), pp. 57–66.
King et al., 1996 L.A. King, L.M. Walker and S.J. Broyles, Creativity and the five-factor model, *Journal of Research in Personality* 30 (1996), pp. 189–203.
Kline, 2005 Kline, R. B. (2005). *Principles and practice of structural equation modeling* (2nd ed.). NY: Guilford.
Loehlin, 2004 J.C. Loehlin, Latent variable models: An introduction to factor, path, and structural equation analysis (4th ed.), Lawrence Erlbaum Associates, Mahwah, NJ (2004).
McCrae, 1987 R.R. McCrae, Creativity, divergent thinking, and openness to experience, *Journal of Personality and Social Psychology* 52 (1987), pp. 1258–1265.
Michael and Wright, 1989 W.B. Michael and C.R. Wright, Psychometric issues in the assessment of creativity. In: J.A. Glover, R.R. Ronning and C.R. Reynolds, Editors, *Handbook of creativity*, Plenum, NY (1989), pp. 33–52.
Phillips, 1999 L.H. Phillips, Age and individual differences in letter fluency, *Developmental Neuropsychology* 15 (1999), pp. 249–267. View Record in Scopus | Cited By in Scopus (19)
Preckel et al., 2006 F. Preckel, H. Holling and M. Wiese, Relationship of intelligence and creativity in gifted and non-gifted students: An investigation of threshold theory, *Personality and Individual Differences* 40 (2006), pp. 159–170.

Runco, 2007 M.A. Runco, Creativity, Elsevier, Amsterdam (2007).
Runco et al., 2005 M.A. Runco, J.J. Illies and R. Eisenman, Creativity, originality, and appropriateness: What do explicit instructions tell us about their relationships?, *Journal of Creative Behavior* 39 (2005), pp. 137–148.
Sawyer, 2006 R.K. Sawyer, Explaining creativity: The science of human innovation, Oxford University Press, NY (2006).
Silvia, in press Silvia, P.J. (in press). Creativity and intelligence revisited: A latent variable analysis of Wallach and Kogan (1965). *Creativity Research Journal*.
Silvia et al., in press Silvia, P.J., Winterstein, B.P., Willse, J.T., Barona, C.M., Cram, J.T., Hess, K.I., et al (in press). Assessing creativity with divergent thinking tasks: Exploring the reliability and validity of new subjective scoring methods. *Psychology of Aesthetics, Creativity, and the Arts*.
Sligh et al., 2005 A.C. Sligh, F.A. Conners and B. Roskos-Ewoldsen, Relation of creativity to fluid and crystallized intelligence, *Journal of Creative Behavior* 39 (2005), pp. 123–136.
Sternberg and O'Hara, 1999 R.J. Sternberg and L.A. O'Hara, Creativity and intelligence. In: R.J. Sternberg, Editor, *Handbook of creativity*, Cambridge University Press, NY (1999), pp. 251–272.
Troyer et al., 1997 A.K. Troyer, M. Moscovitch and G. Winocur, Clustering and switching as two components of verbal fluency: Evidence from younger and older healthy adults, *Neuropsychology* 11 (1997), pp. 138–146.
Wallach and Kogan, 1965 M.A. Wallach and N. Kogan, Modes of thinking in young children: A study of the creativity–intelligence distinction, Holt, Rinehart, & Winston, NY (1965).
Weisberg, 2006 R.W. Weisberg, Creativity: Understanding innovation in problem solving, science, invention, and the arts, Wiley, Hoboken, NJ (2006).
Wilson et al., 1953 R.C. Wilson, J.P. Guilford and P.R. Christensen, The measurement of individual differences in originality, *Psychological Bulletin* 50 (1953), pp. 362–370.