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Intelligence and personality as predictors of divergent thinking: The role of general, fluid and crystallised intelligence

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ABSTRACT

Two studies examined the relationships between measures of intelligence, personality and divergent thinking (DT) in student samples. Study one investigated the incremental validity of measures of IQ and fluid intelligence with the Big Five Personality Inventory with regards to DT. Significant relationships of DT to fluid intelligence, Extraversion and Disagreeableness were observed. Study two investigated the incremental validity of measures of fluid and crystallised intelligence (as assessed by a test of general knowledge) with the Big Five Personality Inventory with regards to DT. Hierarchical regression analyses revealed a significant relationship between crystallised intelligence and DT. The nature of the relationships of IQ, fluid and crystallised intelligence, in addition to personality traits to tests of DT were considered.

The psychological study of creativity has intrigued researchers for decades (Runco, 2004). One of the most popular research methodologies is to investigate intellectual or personality traits with reference to creativity (c.f. Batey & Furnham, 2006 for a review). However, researchers have traditionally tended to study *either* intelligence *or* personality in relation to creativity. More studies that use multiple predictor variables for normative samples are required (Mumford, 2003). This paper reports two studies of the relationships of IQ, fluid and crystallised intelligence, with a measure of personality to divergent thinking (DT) test performance. The aim of the two studies was to investigate the extent to which IQ, fluid and crystallised intelligence, in addition to a measure of the five factor model (FFM) of personality could account for performance on tests of DT.

DT tests "require individuals to produce several responses to a specific prompt" (Plucker & Renzulli, 1999. p.38). The analysis of longitudinal creative achievement data by Plucker (1999) indicates that DT abilities are an important factor for real-world achievement. In this paper DT was assessed by a measure of fluency, as other forms of scoring have been demonstrated to be unreliable (Carroll, 1993; Harvey, Hoffmeister, Coates, & White, 1970; Hocevar, 1979; Plass, Michael, & Michael, 1974; Runco, 1986). The use of DT fluency has become popular (Furnham & Bachtiar, 2008; Furnham, Batey, Anand, & Manfield, 2008; Holling & Kuhn, 2008) as has word fluency (Tsakanikos & Claridge, 2005).

Most theories of intelligence trace their roots back to the hierarchical model first proposed by Spearman (1904) who suggested intelligence to consist of a general factor (IQ) in addition to a set of specific factors (*s*). Cattell (1971) posited there to be a distinction between fluid (*gf*) and crystallised (*gc*) intelligence: *gf* represents reasoning ability. Conversely, *gc*

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represents abilities used in the organisation and conceptualisation of information. Measures of intelligence have been found to predict DT (Batey & Furnham, 2006). Torrance (1967), conducted an early meta-analysis of 388 correlations between intelligence measures and the Torrance Tests of Creative Thinking (TTCT; Torrance, 1974). He found a median correlation between the verbal DT tests and IQ of $r = 0.21$. In a large study, Richards (1976) administered elements of both Guilford's (1967) and Wallach and Kogan (1965) DT tests to almost 500 naval officers. Data were available for three types of IQ test. The mean correlation between the battery of creativity tests and IQ tests was $r = 0.27$. In a recent study Silvia (2008) found DT to be substantially related ($\beta = .43$) to a higher-order intelligence factor. An explanation for the relation between creativity and intelligence may reside in the neurophysiology of intellect. It is likely that the efficient neural basis of intelligence (e.g. Eysenck & Barrett, 1985; Jensen, 1993) explains some of the variance in DT test scores. DT tests are timed, therefore under these conditions, neural efficiency contributes to an increase in DT performance. First, speed of retrieval of information from memory will allow a participant to consider more ideas in a short period of time. Second, *gf* will allow for rapid manipulation of ideas to produce fitting responses to the DT items. Lastly, a rich store of knowledge that is effectively organised (*gc*) will be required in order to combine ideas to produce responses to the DT test items.

Recent studies have examined the relationship of the five factor model of personality (FFM: Costa & McCrae, 1992) to DT, which is comprised of Neuroticism (N), Extraversion (E), Openness to Experience (O), Agreeableness (A) and Conscientiousness (C). Most studies of the FFM and DT have found a positive relationship with Extraversion, Openness to Experience and some negative relationships to Agreeableness (c.f. Batey & Furnham, 2006 for a review).

However, very few studies have investigated the incremental validity of the FFM of personality over ability (e.g. Furnham et al., 2008). McRae (1987) found that DT was consistently associated with self-reports and peer ratings of Openness. King, Walker, and Broyles (1996) examined the relations between creative ability, creative accomplishments, and personality. The Pearson correlations indicated that verbal creativity was significantly correlated with Extraversion and Openness. A negative relationship between Agreeableness and creative accomplishments was also observed. In a recent study, Furnham et al. (2008) found that DT was predicted Extraversion and negative Agreeableness. Lastly, Furnham, Crump, Batey, and Chamorro-Premuzic (2009) found that the Consequences DT test (Christensen, Merrifield, & Guilford, 1953) was predicted by Emotional Stability, Extraversion, Openness and negative Agreeableness. It may be hypothesised that Extraversion confers an advantage in DT tests in that Extraverts would use the test-taking scenario as an opportunity to raise arousal and would benefit from the group administration of the test (Batey & Furnham, 2006). The role of Openness may be explained with reference to the greater propensity towards imagination and openness to new ideas (Costa & McCrae, 1992), as well as the links to reduced cognitive inhibition (Peterson & Carson, 2000; Peterson, Smith, & Carson, 2002). It may be hypothesised that negative Agreeableness is related to DT performance, in that disagreeable individuals are less likely to be concerned about providing socially acceptable responses (which would increase the number provided) and possess the self-confidence to provide responses that might not be immediately obvious.

1. Study 1. Intelligence and personality as predictors of DT fluency: the role of IQ and fluid intelligence

The primary aim of this first study was to investigate the ability of IQ and fluid intelligence, alongside the FFM of personality traits to predict performance on a test of DT fluency. The study was conducted to test several hypotheses. The hypotheses related to the role of intelligence and personality in predicting DT fluency test scores.

Previous studies have demonstrated relationships between intelligence and DT (Batey & Furnham, 2006). This indicates that both IQ (a mixture of fluid and crystallised intelligence) and fluid intelligence should be found to positively and significantly relate to DT fluency. It was hypothesised that both IQ (H1a) and fluid intelligence (H1b) would be positively and significantly correlated with DT fluency. It was expected that the magnitude of the correlation between fluid intelligence and DT fluency would be greater than that observed for IQ (H1c).

Prior research has demonstrated relationships between the FFM of personality and DT (e.g. King et al., 1996). This suggests that personality traits will be found to be significantly related both positively and negatively to DT fluency. It was hypothesised that Extraversion (H2a) and Openness to Experience (H2b) would be positively and significantly correlated with DT fluency, whilst Agreeableness was expected to be negatively and significantly correlated with DT fluency (H2c).

1.1. Method

1.1.1. Participants

A total of 82 undergraduate students from University College London took part in this study. The large majority were British and all participants possessed a high degree of English language proficiency. There were 71 females and 11 males with ages ranging from 17 to 40 ($M = 19.88$, S.D. = 3.42).

1.1.2. Measures

(a) *Divergent thinking* (*DT*): was measured by a variant of Guilford's (1967) *Uses* test. Unusual Uses were sought for six different items (brick, a tin of polish, mobile phone, balloon, safety pin and laptop computer) the reliability of these measures was acceptable ($\alpha = .74$). Participants were given 2 min for each item to provide as many unusual uses as they

Table 1
Descriptive statistics and inter-correlations for all measures.

	M (S.D.)	1	2	3	4	5	6	7	8
1. Total DT fluency	31.6 (7.5)		.34**	.43**	.01	.23*	−.07	−.06	.01
2. (IQ) WPT	27.9 (5.7)			.65**	−.11	−.10	.00	.14	−.08
3. (*gf*) BRT	31.5 (12.2)				.12	−.12	−.08	.09	−.07
4. Neuroticism	144.7 (8.8)					.34**	.33**	.15	.37**
5. Extraversion	148.6 (8.3)						.35**	.43**	.23*
6. Openness	147.4 (8.6)							.35**	.40**
7. Agreeableness	151.4 (7.5)								.29**
8. Conscientiousness	156.0 (10.4)								

Note: $N = 82$. WPT = Wonderlic Personnel Test, BRT = Baddeley Reasoning Test, *gf* = fluid intelligence.
* $p < .05$.
** $p < .01$.

could. In accordance with the recommendations of Hocevar (1979) DT responses were scored for fluency and summed to produce a Total DT fluency score.

(b) *IQ*: was measured through the *Wonderlic Personnel Test* (WPT: Wonderlic, 1992). This 50-item test can be administered in 12 min. Items include word and number comparisons, disarranged sentences, serial analysis of geometric figures and story problems that require mathematical and logical solutions. The mean score for this sample was 27.94 (S.D. = 5.69). The test has comprehensive norms and correlates very highly ($r = 0.92$) with the WAIS-R (Wonderlic, 1992).

(c) *Fluid intelligence* (*gf*): was measured through the *Baddeley Reasoning Test* (BRT: Baddeley, 1968). This 64-item test is administered in 3 min and measures fluid intelligence through logical reasoning. Each item is presented in the form of a grammatical transformation that has to be answered with "true"/"false", e.g. "A precedes B–AB" (true) or "A does not follow B–BA" (false). The mean score for the present sample was 31.55 (S.D. = 12.23). Studies have reported the validity and reliability indicators for this measure (e.g. Furnham, Chamorro-Premuzic, & Moutafi, 2005).

(d) *Personality*: was assessed through the *NEO-PI-R* (Costa & McCrae, 1992), which is a well-established and widely used 240-item, non-timed questionnaire that assesses the Big Five personality traits, namely, Neuroticism, Extraversion, Openness to Experience, Agreeableness, and Conscientiousness, as well as the 30 underlying sub-facets. Items involve questions about typical behaviors and are answered on a five-point Likert-type scale ("strongly disagree", "disagree", "neutral", "agree", and "strongly agree"). The manual provides extensive data regarding reliability and validity (Costa & McCrae, 1992).

1.1.3. Procedure

Data were collected as part of an introductory class on personality psychology, students had no previous formal background in psychology and participants were debriefed, which included feedback on their scores. Tests were administered by three experimenters in a large and quiet lecture theatre. Participants completed the ability measures first with an interval of 30 min between measures, followed by the self-report scales of personality. Lastly, the DT tests were administered in a separate session to avoid fatigue effects.

1.2. Results and discussion

1.2.1. Correlations

Descriptive statistics and inter-correlations for all measures are reported in Table 1. As can be seen, Total DT fluency was significantly and positively related to the two measures of intelligence, confirming H1a and H1b. The magnitude of the observed correlations was greater for fluid rather than IQ, confirming H1c. There were no significant correlations between intelligence and personality. Total DT fluency was correlated with Extraversion, confirming H2a, but not Openness or Agreeableness, failing to confirm H2b and H2c (Table 2).

1.2.2. Multiple regressions

Next, a series of hierarchical regressions were performed on the data to test the extent to which IQ, fluid intelligence and personality, could predict differences in Total DT fluency. The results of this analysis are presented in Table 3. In the final regression model, of the two intelligence tests, only *gf* was significantly related ($\beta = 0.44$, $t = 3.42$, $p < .05$) confirming H1a and partially confirming H1c. Extraversion was found to be significantly positively related to Total DT fluency ($\beta = 0.49$, $t = 4.44$, $p < .01$). This result was in accordance with H2a. A significant relationship was observed between DT fluency and Agreeableness ($\beta = -0.30$, $t = -2.74$, $p < .05$) which confirmed H2c. Each model of the regression was able to significantly predict variance in Total DT fluency, with the personality variables able to explain an additional 14% of the variance over and above the intelligence scores.

In order to investigate whether facet scores of the FFM factors had differential relations to DT fluency scores. Regressions were performed where the criterion variable was DT fluency, whilst the predictor variables were all the facet scores for N, E, O, A and C. The results of these five independent analyses are reported in Table 3.

Table 2
Hierarchical regression: general, fluid intelligence and personality as predictors of Total DT fluency.

Model	St.β #1	St.β #2	St.β #3	t
#1				
IQ (WPT)	.34			3.27*
$F(1, 80) = 10.72$*	$Adj.R^2 = .11$			
#2				
IQ (WPT)		.12		.89
gf (BRT)		.35		2.63*
$F(2, 79) = 9.21$**		$Adj.R^2 = .17$		
#3				
IQ (WPT)			.14	1.11
gf (BRT)			.44	3.42*
Neuroticism			−.17	−1.51
Extraversion			.49	4.44**
Openness			−.09	−.83
Agreeableness			−.30	−2.74*
Conscientiousness			.12	1.12
$F(7, 74) = 6.29$**			$Adj.R^2 = .31$	

Note: $N = 82$. BRT = Baddeley Reasoning Test, WPT = Wonderlic Personnel Test, *gf* = fluid intelligence.
* $p < .05$.
** $p < .01$.

Lastly, the NEO-PI-R facets found to significantly relate to DT fluency were, in a separate analysis, regressed against DT fluency. The results of that analysis are presented in Table 4.

The regression with selected facets of the NEO-PI-R was able to account for 19% of the variance in DT fluency scores. It was found that three facet scores from the NEO-PI-R were able to explain approximately an additional 5% of the variance in Total DT fluency scores over and above the superordinate five factors. There were positive relationships with N6: Vulnerability ($\beta = 0.27$, $t = 2.59$, $p < .05$) and O3: Feelings ($\beta = 0.22$, $t = 2.06$, $p < .05$). A negative relationship was observed with O4: Actions ($\beta = -0.36$, $t = -3.35$, $p < .01$).

This study demonstrated, as predicted that intelligence and personality traits were systematically related to creativity as manifested in DT fluency test scores. Indeed, taken together intellectual and personality variables were able to account for a little under a third of the variance in DT fluency.

The hypotheses that intelligence would be positively and significantly correlated with DT fluency were supported. Both IQ and fluid intelligence revealed first order correlations with DT fluency. The third part of the first hypothesis (H1c), that the correlation between fluid intelligence and DT fluency would be greater than that observed for IQ was supported. In the correlational analysis, the magnitude of the relationship between fluid intelligence and DT fluency was greater than that observed for IQ. The regressional analyses utilising the superordinate five factors revealed that, taken together, only fluid intelligence significantly predicted DT fluency test scores.

These results indicate that the relationship between components of intelligence and creativity to be relatively complex. Earlier studies (e.g. Getzels & Jackson, 1962; Wallach & Kogan, 1965) demonstrated there to be a relationship between IQ and creativity on the order of approximately $r = 0.10$ to 0.40. However, these studies were unable to ascertain as to whether this relationship was founded upon IQ, or more specifically aspects of fluid intelligence. Such findings would be important for applied issues with regards to the understanding of creativity. If knowledge is found to be a significant predictor of DT fluency scores, then efforts to stimulate and teach creativity skills could look to enhance levels of general and specific knowledge. Should fluid intelligence be found to be the most significant predictor of DT scores, then this would suggest that the trainability of DT skills would be limited. This study clearly demonstrated that both IQ and fluid intelligence correlate with creativity as assessed via DT test fluency scores, but when both variables are taken together, it is fluid intelligence which explains the "lions' share" of the variance. This implies that the production of divergent responses over a short period of time is highly reliant upon processing speed. Given that the DT tests were administered in only 2 min, this finding is not surprising. Speed of processing would be key for the rapid retrieval and manipulation of salient ideas to fit task constraints. This finding also suggests that a significant proportion of the relationship between IQ and creativity may be explained with reference to fluid intelligence (which all tests of IQ assess to some degree).

The hypotheses for the relationships between personality variables and DT fluency scores were partially supported. Extraversion was found to correlate with DT fluency scores (H2a) as did negative Agreeableness (H2c). No relationship was observed between DT fluency scores and Openness in either the correlations or regressions.

These findings indicate that the addition of personality variables over and above intellectual variables is able to explain some of the basis for DT fluency test scores. In particular, Extraverts were found to perform well. The likelihood is that there are three related, but not identical explanations for this finding. Firstly, Extraverts have been suggested to possess a greater desire for sensation-seeking and stimulation (Costa & McCrae, 1992; Eysenck & Eysenck, 1985). It may be argued that the DT test scenario provides an opportunity for these traits to be rewarded. Secondly, Extraverts are considered to be more impulsive. Again, this heightened impulsivity may favour DT test performance. In that, the impulsive person would be less

Table 3
Hierarchical regression: facets of the NEO-PI-R as predictors of Total DT fluency.

	St.β	t
N1: Anxiety	−.18	−1.34
N2: Angry hostility	−.08	−.60
N3: Depression	−.06	−.48
N4: Self-consciousness	−.06	−.49
N5: Impulsiveness	−.08	−.70
N6: Vulnerability	.36	2.40*
$F(6, 75) = 1.28$	$Adj.R^2 = .02$	
E1: Warmth	.19	1.54
E2: Gregariousness	.09	.74
E3: Assertiveness	.08	.66
E4: Activity	−.01	−.10
E5: Excitement-seeking	.14	1.15
E6: Positive emotions	.04	.35
$F(6, 75) = .99$	$Adj.R^2 = .00$	
O1: Fantasy	−.19	−1.65
O2: Aesthetics	.00	.04
O3: Feelings	.24	2.15*
O4: Actions	.28	−2.43*
O5: Ideas	.18	1.74
O6: Values	.02	.20
$F(6, 75) = 2.62$*	$Adj.R^2 = .11$	
A1: Trust	.21	1.78
A2: Straightforwardness	−.09	−.72
A3: Altruism	−.20	−1.67
A4: Compliance	.02	.16
A5: Modesty	.01	.11
A6: Tender-mindedness	−.08	−.72
$F(6, 75) = 1.36$	$Adj.R^2 = .03$	
C1: Competence	−.04	−.35
C2: Order	.04	.28
C3: Dutifulness	−.05	−.39
C4: Achievement striving	.04	.28
C5: Self-discipline	.13	.93
C6: Deliberation	−.12	−.95
$F(6, 75) = .38$	$Adj.R^2 = -.05$	

Note: $N = 82$.
* $p < .05$.

likely to self-censor and thereby would be more likely to offer responses, leading to increased fluency. Lastly, Extraverts may have preferred the social setting of the group administration of DT tests over Introverts.

A relationship between Disagreeableness and DT test fluency scores was also observed. This finding is not as common in the literature as the relationship of DT to Extraversion, but has been reported nonetheless (King et al., 1996). It is likely that Disagreeableness is able to predict higher DT test fluency scores (when the effects of intellect have been controlled) with regards to the role of non-conformity and self-confidence. Agreeable people may be characterised by their desire to maintain harmony and avoid confrontation. Alternatively Disagreeable people will be more likely to be non-conformist, thereby less concerned about offering responses that conform to common perceptions. Second, Disagreeable individuals

Table 4
Hierarchical regression: selected facets of the NEO-PI-R as predictors of Total DT fluency.

	St.β	t
Vulnerability (N6)	.27	2.59*
Feelings (O3)	.22	2.06*
Actions (O4)	−.36	−3.35**
$F(6, 75) = 6.06$**	$Adj.R^2 = .19$	

Note: $N = 82$.
* $p < .05$.
** $p < .01$.

are more inclined to perceive themselves as immodest (Costa & McCrae, 1992). This self-confidence would result in a greater propensity to proffer suggestions that less-confident people would assume to be irrelevant, thereby resulting in great fluency.

No relationship between Openness to Experience and DT test scores was observed. It is not uncommon for creativity investigations to fail to reveal a relationship between Openness and creativity (Martindale & Dailey, 1996). It is likely that the failure to yield a significant relationship between these two constructs is largely related to the method of assessing DT scores, in this case fluency alone. A measure of fluency leaves no room for an assessment of originality, flexibility or elaboration. Therefore, the Open individual's tendency to provide ideas from a wider frame of reference is not assessed. Given that participants were allowed 2 min for each DT test item, it may be that Open individuals, who would be more likely to search for remote answers may have been disadvantaged by this form of creativity assessment. Similarly, Open individuals may have been more interested in providing answers high in quality and unusualness (as opposed to quantity), which would result in a decrease in fluency, because remote associates take longer to produce (Mednick, 1962).

The analysis of facet scores for the NEO-PI-R in relation to DT fluency scores revealed equivocal results. The role of emotions was implicated, in that high DT scorers reported themselves to be more vulnerable to stressful emotions and also more open to feelings. This finding supports the idea of the creator as more emotionally labile (Feist, 1998), though such a finding would normally be associated with an artistic population (Gotz & Gotz, 1979). An explanation for this involves the notion that emotionally variable individuals utilise their emotional reactions to events to generate ideas and responses. Therefore, the facet analysis was able to provide some insight into potential processes by which people provide answers on a DT test. The finding that there was a negative relationship of Openness to Actions and DT scores was more problematic. It may be argued that individuals particularly Open to Actions prefer a wide range of stimulating, *physically oriented* activities (where they are able to perform new actions) rather than DT tests, which may be hypothesised to be a rather poor scenario for the opportunity to try new actions and activities. An alternative explanation would be that individuals high in Openness are also likely to possess less-restrictive attentional inhibition mechanisms (Peterson & Carson, 2000; Peterson et al., 2002). Which in turn, suggests that such individuals would find fluent performance under strict timed conditions difficult, as they would be more likely to be inundated with irrelevant ideas thereby decreasing their fluency. However, the finding that the two significant facets of Openness were positively and negatively related to DT scores may explain why at the superordinate level, Openness was not found to be significantly related to DT fluency scores.

Overall, this study indicated that fluent divergent thinkers possess high levels of fluid intelligence and are Extraverted and Disagreeable. The next study will examine DT fluency in a similar manner, but with the use of a test of general knowledge (*gc*) instead of IQ.

2. Study 2. Intelligence and personality as predictors of divergent thinking fluency: the role of fluid and crystallised intelligence

The previous study demonstrated, as predicted that intelligence and personality traits were systematically related to creativity as manifested in DT test fluency scores.

The primary aim of this study was to investigate the ability of fluid and crystallised intelligence, alongside the FFM of personality traits to predict performance on a test of DT. This allowed a closer examination of the role of crystallised intelligence in DT fluency. The study was conducted to test several hypotheses. The hypotheses related to the role of fluid and crystallised intelligence in addition to personality in predicting DT test scores.

Previous studies have demonstrated relationships between intelligence and DT (e.g. Barron & Harrington, 1981) as was the case for the first study in this paper. This indicates that fluid intelligence should be found to positively and significantly relate to DT fluency. The research of Mednick (1962) suggests that large stores of knowledge in the individual will correspond with a greater ability to produce creative solutions to problems. In that, in order to hypothesise about, for example, the uses of an item or the consequences to result from a hypothetical situation, the test taker must access what they already know about the DT test item or consequence and relate that to new scenarios, contexts or settings. This in turn will rely upon previously stored knowledge about the new settings. It may therefore be hypothesised, that the more knowledge an individual has, the greater the number of mental elements to be combined to produce responses fitting for the DT test requirements. Put in another way, if an individual knew of only one way in which an object could be used and only one possible scenario or context, then the total combination of responses that they could provide to a DT *Uses* test item would equal one. Therefore, with more knowledge of potential uses and a greater appreciation of context, the greater the number of possible combinations and as a result greater DT fluency.

Of particular interest in this study was the extent to which a test of general knowledge (*gc*) could explain variance in DT fluency scores over and above the contribution of fluid intelligence. It was hypothesised that both fluid (H1a) and crystallised intelligence (H1b) would be positively and significantly correlated with DT fluency.

Prior research has demonstrated relationships between the FFM of personality and DT (e.g. King et al., 1996). The previous study in this paper demonstrated a positive correlation between Extraversion and a negative correlation of Agreeableness to DT fluency, though not the expected relationship to Openness. It was hypothesised that the personality traits of Extraversion (H2a) and Openness to Experience (H2b) would be positively and significantly correlated with DT fluency. The final hypothesis was that Agreeableness would be negatively and significantly correlated with DT fluency (H2c).

2.1. Method

2.1.1. Participants

A total of 72 undergraduate students from University College London took part in this study. The large majority were British and all participants possessed a high degree of English language proficiency. There were 63 females and 9 males. Their ages ranged from 17 to 40 (M = 19.19, S.D. = 3.49).

2.1.2. Measures

(a) *Divergent thinking* (*DT*): was assessed via three different measures. First, by a variant of *Thurstone's Word Fluency Test* (TWF: Thurstone, 1938) where participants were asked to provide as many words beginning with the letter "B" as they could. This test has been used recently in investigations of creative thinking (Tsakanikos & Claridge, 2005). Second, a variant of Guilford's (1967) *Uses* test. Unusual Uses were sought for a brick. Thirdly, using a variant of Guilford's *Consequences* test (1967) where participants were asked to list as many consequences as they could for the event that everybody suddenly became deaf. Participants were given 3 min for each item to provide as many responses as they could. In accordance with the recommendations of Hocevar (1979) DT responses were scored for fluency and summed to produce a Total DT fluency score. The Pearson correlations between the three tests ranged from r = 0.35–0.50 (p < .05). The reliability of the DT fluency scores were found to be moderate (α = 0.52).

(b) *Fluid intelligence* (*gf*): was measured through the *Baddeley Reasoning Test* (BRT: Baddeley, 1968). The mean score for the present sample was 29.60 (S.D. = 13.27).

(c) *General knowledge* (*gc*): was measured using the *General Knowledge Test* (GKT: Irwing, Cammock, & Lynn, 2001). This 72 item questionnaire is administered in 20 min and assesses knowledge of 6 primary areas; literature, general science, medicine, games, fashion and finance. The mean score for the present sample was 29.74 (S.D. = 10.07). The psychometric properties of this test have been reported (Furnham & Chamorro-Premuzic, 2006).

(d) *Personality*: was assessed through the *NEO-PI-R* (Costa & McCrae, 1992).

2.1.3. Procedure

Data were collected as part of an introductory class on personality psychology, students had no previous formal background in psychology and participants were debriefed, which included feedback on their scores. Tests were administered by three experimenters in a large and quiet lecture theatre. Participants completed the ability measure first, followed by the self-report scales of personality. Lastly, the DT and general knowledge (*gc*) tests were administered in two separate sessions to avoid fatigue effects.

2.2. Results and discussion

2.2.1. Correlations

Descriptive statistics and inter-correlations for all measures are reported in Table 5. Total DT fluency was significantly related to the measure of general knowledge, confirming H1b. Total DT fluency was not related to fluid intelligence, failing to confirm H1a. There were no significant correlations between fluid intelligence and personality, but general knowledge was related to Openness. Total DT fluency was correlated with Extraversion, which accords with H2a. No significant relationships were observed between DT fluency and either Openness or Agreeableness. These results failed to confirm H2b and H2c. General knowledge was correlated with fluid intelligence (r = 0.40, p < .01).

2.2.2. Multiple regressions

Next, a series of hierarchical regressions were performed on the data to test the extent to which fluid intelligence, general knowledge and personality, could predict differences in Total DT fluency, the results of that analysis are presented in Table 6. In the final regression model only *gc* was significantly related to Total DT fluency (β = 0.28, t = 2.05, p < .05) confirming H1b.

Table 5
Descriptive statistics and inter-correlations for all measures.

	M (S.D.)	1	2	3	4	5	6	7	8
1. Total DT fluency	49.0 (10.9)		.21	.30**	−.03	.25*	.18	.21	.00
2. (*gf*) BRT	29.6 (13.3)			.40**	−.09	.10	.13	−.04	−.17
3. (*gc*) GKT	29.7 (10.1)				−.04	.12	.32**	−.05	−.25*
4. Neuroticism	96.2 (26.2)					−.19	.05	.08	−.03
5. Extraversion	117.1 (23.4)						.57**	.23	.36**
6. Openness	124.4 (22.9)							.32**	.22
7. Agreeableness	115.0 (22.8)								.36**
8. Conscientiousness	110.0 (20.3)								

Note: N = 72. BRT = Baddeley Reasoning Test, GKT = General Knowledge Test, *gf* = fluid intelligence, *gc* = crystallised intelligence.

* p < .05.

** p < .01.

Table 6
Hierarchical regression: general, fluid intelligence and personality as predictors of Total DT fluency.

Model	St.β #1	St.β #2	St.β #3	*t*
#1				
gf (BRT)	.21			1.77
$F(1, 70) = 3.14$	$Adj.R^2 = .03$			
#2				
gf (BRT)		.10		.82
gc (GKT)		.26		2.09*
$F(2, 69) = 3.84$*		$Adj.R^2 = .07$		
#3				
gf (BRT)			.08	.68
gc (GKT)			.28	2.05*
Neuroticism			−.00	−.01
Extraversion			.25	1.73
Openness			−.13	−.86
Agreeableness			.23	1.86
Conscientiousness			−.06	−.48
$F(7, 64) = 2.15$			$Adj.R^2 = .10$	

Note: $N = 72$. BRT = Baddeley Reasoning Test, GKT = General Knowledge Test, *gf* = fluid intelligence, *gc* = crystallised intelligence.
* $p < .05$.

The *F* change for the 3 models in the regression was found to be significant for the addition of the GKT only, indicating that *gc* was able to account for unique variance in DT test scores over and above *gf*.

This study indicated that general knowledge is able to predict DT fluency scores, confirming H1. In both the correlational and the regressional analyses general knowledge was found to be related to DT. This finding suggests that the ability to produce numerate ideas to a set stimulus over a short period of time is in part, reliant upon stores of knowledge. The fact that fluid intelligence was not found to significantly relate to DT was surprising, but would suggest that knowledge has a greater role to play in ideational fluency than speed of processing or abstract reasoning. This finding corresponds closely to Mednick's (1962) associative basis of the creative process, where he argued that creativity involves the concatenation of disparate concepts. As a caveat, it is important to note that the relationship of knowledge to creative endeavour may vary dependent upon domain. With *gc* far more important in historical and scientific fields, where a large body of knowledge is required. An alternative conclusion with regards to the role of *gc* in predicting creativity as DT fluency, would be that a measure of general knowledge incorporates aspects of fluid intelligence and personality traits. Cattell (1971) found *gc* and *gf* to be correlated. Equally, relationships have been observed between Openness and *gc* (Furnham & Chamorro-Premuzic, 2006). Therefore, the ability of general knowledge to account for variance in DT fluency scores, could be a result of *gc* being a mixture of fluid intelligence and Openness to Experience, two variables which have been found to relate to creativity. The failure to report a significant relationship between the fluid intelligence measure and DT in this study could be explained with reference to the small number of participants reducing the likelihood of revealing weak relationships and that significantly different DT tests were employed in Study 2 than for Study 1.

Extraversion was found to correlate with DT fluency, but did not explain unique variance over and above the measures of intellect, partially fulfilling the second hypothesis. This finding is at odds with most of the personality with regards to DT literature (e.g. King et al., 1996) but may in part, be explained through the small sample size. Were these analyses to be replicated with a larger sample it is likely that a significant role for Extraversion would be found.

No significant relationship was again revealed between Openness and DT fluency. It is likely that the failure to find a significant relationship between Openness and DT in the regression analysis may be traced to multicolinearity between Openness and general knowledge. It has been proposed that Open individuals are more likely to seek experiences (Costa & McCrae, 1992) and invest their fluid intelligence in the accretion of knowledge and skills (Cattell, 1971). Therefore, in the regression the effects of Openness may have been manifested in higher general knowledge scores.

The expectation that there would be a negative relationship between DT fluency scores and Agreeableness was not confirmed. However, this is not a particularly common finding in the literature. Again, the small sample size might have had a significant effect, lessening the chances of revealing weak relationships between variables.

The previous study demonstrated that intellectual and personality variables could account for approximately 17 and 14% of the variance in DT fluency scores respectively. This study found that in the regression, only general knowledge could significantly account for DT fluency scores.

2.3. General discussion

This paper reported on two studies of the relationships of IQ, fluid and crystallised intelligence, with the FFM of personality with regards to DT fluency scores. The results of the studies supported the hypothesis that DT fluency is a result of both intellectual and personality processes. Of greatest interest in the studies, was the extent to which IQ, fluid and crystallised intelligence contributed to DT fluency performance alongside the FFM of personality. The results of the analyses indicated

that of the three measures of ability, crystallised intelligence is the most powerful predictor of DT fluency. It is likely that the reason *gc* is able to explain variance in creativity scores so effectively, is that *gc* itself is comprised of several factors. First, *gc* has been repeatedly found to be positively correlated with *gf* (Furnham & Chamorro-Premuzic, 2006), which itself is a known correlate of DT, as demonstrated in the first study. Second, *gc* has been found to relate to Openness (Furnham & Chamorro-Premuzic, 2006), also a known correlate of DT (e.g. King et al., 1996). The combination of these personality traits is likely to lead to increased performance on tests of DT. Third, many researchers have argued that creativity involves the association of disparate concepts (Mednick, 1962; Koestler, 1964). This indicates that creators draw upon the resources of knowledge (*gc*) and then manipulate those ideas with their fluid reasoning ability (*gf*). The second study reported here provides some evidence for those assertions. Lastly, it may be contended that fluid and crystallised intelligence are both "located" in the prefrontal cortex (Robinson, 1996), such that inter-correlations between these traits are to be expected as both reflect executive control processes.

These results have important implications for the understanding of creativity. First, the ability to generate numerous ideas to a stimulus problem can be seen to relate largely to stored knowledge and experiences. The benefit of this finding is that it indicates that the ability to create can be augmented by learning and instruction. Had the results confirmed a role for *gf* only, this would suggest that attempts to train creativity would be problematic, as *gf* is considered to be largely a reflection of biological processes (Jensen, 1998). In turn, this suggests that efforts to increase the knowledge of the individual (or indeed organisation, as is the case for learning organisations) will result in increased levels of creative thinking.

An important research question posed by these studies was the extent to which DT is related to intellectual versus personality traits. The results indicate that overall, when creativity is measured using DT fluency, ability traits have a greater role to play than personality. In the first study the measures of intelligence accounted for approximately 17% of the variance in DT fluency, versus 14% for personality traits. In the second study the measures of intellect were able to account for over twice of the variance in DT fluency scores of that contributed by personality. However, it is important to note that overall, in the first study the variables accounted for 31% of variance in DT fluency, whilst the variables in study two accounted for only 10%. As will be discussed later, it is likely that this is a result of the types of DT tests administered and the time provided for administration.

The studies presented here also provided some evidence for the role of personality traits in predicting DT fluency. Overall, the personality trait most closely related to DT fluency was Extraversion. It is likely that this observed relationship between Extraversion and DT is a result of the three factors posited previously; sensation-seeking, impulsivity and the nature of the group administration of the DT tests. An interesting finding was that Openness to Experience was found to be largely unrelated to DT, it was proposed that this was an artefact of the way in which the DT tests were scored; in terms of fluency.

There are future avenues for exploration. The study utilised a relatively small, heterogeneous undergraduate sample. It is highly likely that the relationships between fluid intelligence, knowledge and personality would vary considerably dependent upon the domain of endeavour (e.g. Feist, 1998). It may be that knowledge-intensive domains (e.g. science or engineering) might be differentiated from less knowledge-intensive domains (e.g. art) on the basis of the utility of knowledge for creative achievement. The tests employed in this study were valid and reliable, but this investigation might be replicated using different measures for fluid intelligence (non-verbal fluid IQ) or knowledge (a science knowledge test for example).

This study combined the scores of several different DT tests. This is a common practice in creativity studies (e.g. Vincent, Decker, & Mumford, 2002). It was found that the DT test items all correlated significantly above the order of $r = 0.30$. However, the alpha reliability of the composite DT scores in study 2 was not particularly high ($\alpha = 0.52$). This indicates that these tests of DT could be measuring different aspects of ideational production. In turn, this means that the role of personality and intellect in predicting the different DT test scores could differ. Taken with the fact that the DT tests had different administration times (2 and 3 min for study one and two, respectively) and used different test items there is clearly a need to replicate these findings.

There are a number of limitations to this analysis of creativity as DT fluency in relation to fluid and crystallised intelligence and personality. First, the small sample consisted entirely of undergraduates, with a limited age range and few males. The sample sizes for the two studies conducted were sufficient to reveal strong effects (Miles & Shevlin, 2001), but not likely to reveal medium or small effects. This indicates that some potential underlying relationships between intellect, personality and DT fluency that may have been demonstrated in a large sample, may have not been revealed in these studies. Further, there is also the danger of type I errors in small sample sizes. However, given that the results of these studies were largely in accordance with the hypotheses and previous research, it is unlikely that this was the case. Second, creativity in this study was domain-general. It may be that for certain domains the need for extensive domain-specific knowledge is high (e.g. Amabile, 1996), but the requirement for general knowledge is low. Third, different measures of DT were used in study 1 and 2. Although, there is evidence that DT is a psychometrically sound construct (e.g. Carroll, 1993) there is not yet enough evidence to indicate that different tests of DT (e.g. *uses* versus *consequences*) measure precisely the same constructs. Fourth, DT tests are not measures of creativity per se, though they are predictive of real-world creative achievement (Plucker, 1999). It is likely that the relationship of both the intelligence test scores and the personality variables would vary with regards to the nature of the criterion of creativity employed.

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References

Amabile, T. M. (1996). *Creativity in context*. New York: Westview.

Baddeley, A. D. (1968). A 3 min reasoning test based on grammatical transformation. *Psychonomic Science*, *10*(10), 341–342.

Barron, F. X., & Harrington, D. M. (1981). Creativity, intelligence and personality. In *Annual review of psychology*. Palo Alto, CA: Annual Reviews., pp. 439–476.

Batey, M., & Furnham, A. (2006). Creativity, intelligence and personality: A critical review of the scattered literature. *Genetic, General and Social Psychology Monographs*, *132*, 355–429.

Carroll, J. B. (1993). *Human cognitive abilities: A survey of factor-analytical studies*. New York: Cambridge University Press.

Cattell, R. B. (1971). *Abilities: Their structure, growth and action*. Boston, MA: Houghton Mifflin.

Christensen, P. R., Merrifield, P. R., & Guilford, J. P. (1953). *Consequences form A-1*. Beverly Hills, CA: Sheridan Supply.

Costa, P. T., & McCrae, R. R. (1992). *Revised NEO personality inventory and NEO five-factor inventory professional manual*. Odessa, FL: Psychological Assessment Resources.

Eysenck, H. J., & Barrett, P. (1985). Psychophysiology and the measurement of intelligence. In C. R. Reynolds & P. C. Willson (Eds.), *Methodological and statistical advances in the study of individual differences* (pp. 1–49). New York: Plenum Press.

Eysenck, H. J., & Eysenck, M. W. (1985). *Personality and individual differences: A natural science approach*. New York: Plenum.

Feist, G. J. (1998). A meta-analysis of the impact of personality on scientific and artistic creativity. *Personality and Social Psychological Review*, *2*, 290–309.

Furnham, A. F., & Bachtiar, V. (2008). Personality and intelligence as predictors of creativity. *Personality and Individual Differences*, *45*, 613–617.

Furnham, A., Batey, M., Anand, K., & Manfield, J. (2008). Personality, hypomania, intelligence and creativity. *Personality and Individual Differences*, *44*, 1060–1069.

Furnham, A. F., & Chamorro-Premuzic, T. (2006). Personality, intelligence and general knowledge. *Learning and Individual Differences*, *16*, 79–90.

Furnham, A., Chamorro-Premuzic, T., & Moutafi, J. (2005). Personality and intelligence: Gender, the Big Five, self-estimated and psychometric intelligence. *International Journal of Selection and Assessment*, *13*, 11–24.

Furnham, A. F., Crump, J., Batey, M., & Chamorro-Premuzic, T. (2009). Personality and ability predictors of the "consequences" test of divergent thinking in a large non-student sample. *Personality and Individual Differences*, *46*, 536–540.

Getzels, J. W., & Jackson, P. W. (1962). *Creativity and intelligence: Explorations with gifted students*. Oxford, England: Wiley.

Gotz, K. O., & Gotz, K. (1979). Personality characteristics of successful artists. *Perceptual and Motor Skills*, *49*, 919–924.

Guilford, J. P. (1967). *The nature of human intelligence*. New York: McGraw-Hill.

Harvey, O. J., Hoffmeister, J. K., Coates, C., & White, B. J. (1970). A partial evaluation of Torrance's test of creativity. *American Educational Research Journal*, *7*, 359–372.

Hocevar, D. (1979). Ideational fluency as a confounding factor in the measurement of originality. *Journal of Educational Psychology*, *71*, 191–196.

Holling, H., & Kuhn, J. (2008). Does intellectual giftedness affect the factor structure of divergent thinking? Evidence from a MG-MACS analysis. *Psychology Science Quarterly*, *50*, 283–294.

Irwing, P., Cammock, T., & Lynn, R. (2001). Some evidence for the existence of a general factor of semantic memory and its components. *Personality and Individual Differences*, *30*, 857–871.

Jensen, A. R. (1993). Why is reaction time correlated with psychometric *g*? *Current Directions in Psychological Science*, *2*, 53–56.

Jensen, A. R. (1998). *The g factor: The science of mental ability*. Westport, CT: Praeger.

King, L., Walker, L., & Broyles, S. (1996). Creativity and the five factor model. *Journal of Research in Personality*, *30*, 189–203.

Koestler, A. (1964). *The act of creation*. New York: Macmillan.

Martindale, C., & Dailey, A. (1996). Creativity. Primary process cognition and personality. *Personality and Individual Differences*, *20*, 409–414.

Mednick, S. A. (1962). The associative basis of the creative process. *Psychological Review*, *3*, 220–232.

McRae, R. (1987). Creativity, divergent thinking and openness to experience. *Journal of Personality and Social Psychology*, *52*, 1258–1265.

Miles, J. N. V., & Shevlin, M. E. (2001). *Applying regression and correlation: A guide for students and researchers*. London: Sage Publications.

Mumford, M. D. (2003). Where have we been, where are we going? Taking stock in creativity research. *Creativity Research Journal*, *15*, 107–120.

Peterson, J. B., & Carson, S. (2000). Latent inhibition and openness to experience in a high-achieving student population. *Personality and Individual Differences*, *28*, 323–332.

Peterson, J. B., Smith, K. W., & Carson, S. H. (2002). Openness and extraversion are associated with reduced latent inhibition: Replication and commentary. *Personality and Individual Differences*, *33*, 1137–1147.

Plass, H., Michael, J., & Michael, W. (1974). The factorial validity of the Torrance Tests of Creative Thinking for a sample of 111 sixth grade children. *Educational and Psychological Measurement*, *34*, 413–414.

Plucker, J. A. (1999). Is the proof in the pudding? Reanalyses of Torrance's (1958 to present) longitudinal data. *Creativity Research Journal*, *12*, 103–114.

Plucker, J., & Renzulli, J. S. (1999). Psychometric approaches to the study of human creativity. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 35–60). New York: Cambridge University Press.

Richards, R. L. (1976). A comparison of selected Guilford and Wallach-Kogan Creative Thinking Tests in conjunction with measures of intelligence. *Journal of Creative Behavior*, *10*, 178–182.

Robinson, D. L. (1996). *Brain, mind, and behavior: A new perspective on human nature*. Westport CT and London: Praeger Press.

Runco, M. A. (1986). The discriminant validity of gifted children's divergent thinking test scores. *Gifted Child Quarterly*, *30*, 78–82.

Runco, M. A. (2004). Creativity. *Annual Review of Psychology*, *55*, 657–687.

Silvia, P. J. (2008). Another look at creativity and intelligence. Exploring higher order models and probable confounds. *Personality and Individual Differences*, *44*, 1012–1021.

Spearman, C. (1904). IQ, objectively determined and measured. *American Journal of Psychology*, *15*, 201–293.

Thurstone, L. L. (1938). *Primary mental abilities*. Chicago, USA: Chicago University Press.

Torrance, E. P. (1967). The Minnesota studies of creative behavior: National and international extensions. *Journal of Creative Behavior*, *1*, 137–154.

Torrance, E. P. (1974). *Torrance tests of creative thinking: Directions guide and scoring manual*. Massachusetts: Personal Press.

Tsakanikos, E., & Claridge, G. (2005). Less words, more words: Psychometric schizotype and verbal fluency. *Personality and Individual Differences*, *39*, 705–713.

Vincent, A. S., Decker, B. P., & Mumford, M. D. (2002). Divergent thinking, intelligence, and expertise: A test of alternative models. *Creativity Research Journal*, *14*, 163–178.

Wallach, M. A., & Kogan, N. (1965). *Modes of thinking in young children*. New York: Holt, Rinehart & Winston.

Wonderlic, E. F. (1992). *Wonderlic personnel test user's manual*. Libertyville, IL: E.F. Wonderlic.