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Title: Fluid insight moderates the relationship between psychoticism and crystallized intelligence

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Abstract: To elucidate potential relationships between personality and intelligence it is necessary to move beyond the ad hoc reporting of correlation coefficients and focus instead on testing deductions from well-established theories. To this end the present paper references Eysenck's (1995) theoretical work linking the dimension of psychoticism to both psychosis and creative genius. Drawing on this theory it was argued that the relationship between psychoticism and crystallized ability will be conditional on the level of fluid intelligence. Participants (N = 100) completed the Eysenck Personality Questionnaire - Revised (EPQ-R) and the Kaufman Brief Intelligence Test (K-BIT). Moderated multiple regression revealed a significant interaction effect. As expected crystallized ability (K-BIT vocabulary)was negatively related to psychoticism at low levels of fluid ability (K-BIT matrices) and positively related to psychoticism at high levels of fluid ability. These findings highlight the potential importance of psychoticism within GfGc investment theory.

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Intelligence lies in the cognitive domain, which is often treated as one of the 'two pillars' of differential psychology, the other being personality. In keeping with this view, Kline (1998) suggested that intelligence involves information processing and the solution of problems, as distinct from personality, which refers "to the way we do what we do" (p. 99). At the conceptual level, though, the distinction between intelligence and personality is seldom held to be absolute. Eysenck and Eysenck (1985), for example, argued for overlapping dimensional systems, in which, personality is seen as a superordinate construct that subsumes cognitive abilities. Even so, there are marked differences, both in the way these two constructs are routinely measured, as well as the practical contexts in which these measures are applied (Chamorro-Premuzic & Furnham, 2005). As a consequence, those studying intelligence and personality have tended to follow quite separate research paths.

In the sphere of intelligence research, Spearman (1927) used a statistical test known as the 'tetrad differences' criterion to confirm the presence of common variance across a range of diverse tests of cognitive ability. This general intelligence factor (*g*) was specifically linked to two eductive operations; the eduction of *relations*, and subsequent to that, the eduction of the *correlative idea* (i.e., an analogy). Spearman's pioneering method of factor analysis did not, however, permit the identification of factors related to subsets of cognitive variables (Robinson, 2009). Following advances in factor analytic methods, Cattell (1971) was able to show that non-verbal tests and verbal tests each had their own unique subset variance, a finding that underpinned his concepts of fluid and crystallized intelligence.

Prior to Cattell's factor analytic studies, earlier work in Spearman's laboratories had suggested that the perceptual versions of such tests as classification, matrices, and analogies provided the most 'saturated'

measures of *g* (Cattell, 1971). According to Cattell these 'content free' tests require a relation-educing ability that can be fluidly directed to any new or unfamiliar task. This fluid intelligence (*Gf*) was understood to be a 'native wit' that depends on the efficient functioning of cortical neurons. Crystallized intelligence (*Gc*), in contrast, represents the *investment* of fluid intelligence in the learning of judgmental skills, particularly those associated with the "more abstract features of the school curriculum" (Cattell, 1971, p. 128). Crystallized intelligence then depends not only on one's level of *fluid insight*, but also on one's level of education and acculturation. As education in Western cultures is predominantly verbal the prototypical tests that define crystallized intelligence are verbal tests such as vocabulary, general information, and comprehension (Kline, 1998). Apart from these two *relations-perceiving* intelligence factors, Cattell (1971) identified several additional broad factors including cognitive speed and retrieval capacity. But these additional factors were considered lower level cognitive processes, lacking the eductive properties that define general intelligence (Cattell, 1971).

The general structure of cognitive abilities, outlined by Cattell (1971, see also Cattell, 1987) has subsequently received strong endorsement (e.g., Carroll, 1993; Kline, 1998). When it comes to the structure of personality, though, there has been far less consensus. As with research in the intelligence sphere, factor analytic descriptions of personality cluster a multitude of primary factors, into a limited number of second-order dimensions. Debate, however, is ongoing as to the exact number and nature of these second-order personality dimensions (Zuckerman, 2005). The present discussion will focus on the 3 second-order personality dimensions identified in Eysenck's (Eysenck & Eysenck, 1985) influential model. One advantage of this model, over others, is that it provides a taxonomic framework for a number of causal theories of personality (e.g., Eysenck & Eysenck, 1985; Gray & McNaughton, 2000; Robinson, 2009).

The three second-order dimensions identified by Eysenck (Eysenck & Eysenck, 1985) are: psychoticism (P), extraversion (E), and neuroticism (N). Psychoticism is defined by a cluster of inter-correlated traits which include impulsivity, aggression, poor socialization and poor behavioural control. At its extreme, this dimension is associated with a disposition towards psychotic syndromes including psychopathy, schizotypy, manic-depressive illness, and schizophrenia. The Eysenckian dimension of extraversion subsumes a range of inter-related traits that include sociability, warmth, dominance, and activity. Finally, the dimension of neuroticism is associated with such traits as anxiety, depressed feelings, low self-esteem and moodiness.

In simple bivariate analysis, few sizable correlations, have been reported between measures of intelligence and second-order personality dimensions. Ackerman and Heggestad's (1997) meta-analytic study provides the most comprehensive review to date. Their population estimates for the three superfactors are based on total aggregate sample sizes ranging between 2,699 and 24,280. Both fluid and crystallized abilities were found to be negatively correlated with neuroticism (Gf = –.09; Gc = –.08) and psychoticism (Gf = –.15; Gc = –.17), and positively correlated with extraversion (Gf = +.06; Gc = +.11). Although all population estimates were significant, the effect sizes were universally small. Furthermore, later research has simply served to highlight the difficulties in replicating such weak associations (e.g., Wolf & Ackerman, 2005).

When considering the empirical associations that have been reported between personality and intelligence it may be tempting to conclude that personality is not related to intelligence in any

meaningful way. However, as Eysenck (1993) observed much of the research in this area has simply correlated "… any old IQ test that comes to hand with any old personality test that happens to be available" (p. 176). To elucidate potential relationships between personality and intelligence it is necessary to move beyond examining patterns of inter-correlations in an ad hoc manner and focus, instead, on testing deductions from well-established theories. To this end the present discussion will turn to theories linking personality to intelligence with particular reference to the theoretical links Eysenck (1995) has drawn between psychoticism, psychoses and creative genius.

In Cattell's (1971) *Gf-Gc* theory the successful crystallization of fluid abilities depends, not only on educational opportunity, but also on the influence of personality characteristics. For Cattell then, it is crystallized rather than fluid abilities that will be most strongly associated with personality. From the Eysenckian perspective the personality dimension most likely to regulate the successful development of crystallized abilities is the dimension of psychoticism. According to Eysenck (1995), psychoticism, psychosis and creative genius are all linked to the phenomena of latent inhibition. Latent inhibition is shown when non-reinforced pre-exposure of a CS (conditioned stimulus) subsequently retards conditioning when the CS and a US (unconditioned stimulus) are paired (Macintosh, 1975). Mackintosh (1975) has suggested that during the pre-exposure phase the organism learns that the conditioned stimulus is unrelated to any reinforcing event. The to-be CS is then deemed irrelevant and ignored, thus retarding the capacity to develop subsequent predictive associations with the US during the conditioning phase. In Mackintosh's (1975) model, the latent inhibitory effect is likened to a filtering mechanism which allows the organism to ignore stimuli that are "poorly correlated with reinforcement".

According to Eysenck, failure of the latent inhibitory process to limit associationist spreading, would promote exactly the kind of "overinclusive" style of thinking that characterizes schizophrenics. In detailing this argument Eysenck (1995) suggests that discrimination learning provides that basis for abstract concept formation. When a child hears a word in a certain context for the first time "the word is associated with the entire situation (stimulus compound). As the word is heard again and again, only certain aspects of the stimulus compound are reinforced. Gradually the extraneous elements cease to evoke the response (the word), having become 'inhibited' through lack of 'reinforcement" (Eysenck, 1995, pp 246-247). Eysenck (1995) argues that due to their weak levels of latent inhibition, psychotic individuals are unable to maintain appropriate conceptual boundaries and instead overgeneralize to include in their concepts, elements that do not strictly belong. In keeping with this view and consistent with the notion of a psychosis continuum, a weakness in latent inhibition has been linked to schizophrenia (Baruch, Hemsley, & Gray, 1988a; Gray, Pilowsky, Gray & Kerwin, 1995; Lubow, Kaplan, Abramovich, Rudnick, & Laor, 2000); psychometrically defined schizotypy (Allan, Williams, Wellman & Tonin, 1995; Baruch, Hemsley, & Gray, 1988b; Lipp & Vaitl, 1992; Shrira & Tsakanikos, 2009); and high P scores (Baruch, et al., 1988b; Lipp & Vaitl, 1992; Gibbons & Rammsayer, 1999; Kumari et al., 1999).

Assuming that associative learning provides the basis for abstract concept formation, individual differences in latent inhibition will have implications, not just for the way words are nuanced, but for the learning of crystallized abilities in general. If Eysenck's argument concerning the role of latent inhibition in psychoses has relevance for the domain of personality, one might anticipate that high P scorers, with a tendency to overgeneralize, will be less effective when it comes to investing their fluid intelligence in such abstract crystallized abilities as vocabulary or comprehension.

A second line of enquiry has implicated elevations in psychoticism with creative genius. P scores have been positively associated with both psychometric creativity test scores (e.g., Woody & Claridge, 1977; Stavridou & Furnham, 1996; Batey & Furnham, 2009; Eysenck & Furnham, 1993) as well as creative achievements (e.g., Gotz & Gotz, 1979; Rushton, 1990; Stephen, 2008; Booker, Fearn & Francis, 2001). Eysenck (1995) suggests that, like psychotic individuals, creative individuals possess weak latent inhibition and consequently have "wide associative horizons" which allow them to perceive connections that others do not see. This notion has found some support in the literature. Dellas and Gaier (1970), for example, reported that creative individuals are less likely to screen out supposedly irrelevant details. Furthermore, a study of Harvard University students, found that weak latent inhibition was associated with greater creative achievements (Carson, Peterson, & Higgins, 2003).

So why might weak latent inhibition lead to a maladaptive overinclusive cognitive style in psychotic individuals; but to a controlled usefulness in creative individuals? According to Eysenck (1995) and others (e.g., Carson et al., 2003; Kaufman, 2009), the principal factor that distinguishes the "word salad" of the schizophrenic from the "utterances of the poet" is intelligence. Schizophrenic individuals are thought to have impaired intelligence and so are less able to reject any unusable associations. In keeping with this argument a number of studies highlight the importance of intelligence in the neuropsychology of schizophrenia; both as a pre-existing illness vulnerability factor and as an indicator of the degree of functional impairment (Potter & Nestor, 2010).

Aims and hypothesis

It is clear that from its inception, general intelligence has been aligned more closely with fluid abilities than crystallized abilities. According to Spearman (1927, p. 352) "The genuinely experiential form of learning, far from constituting as alleged the whole domain of intelligence, would appear to be precisely that form which has the least obvious claims to the name". For Spearman, general intelligence has more to do with the two "*non-experiential*" principles of eduction that were alluded to earlier. Adopting this perspective it is argued here, that when fluid intelligence is low, the wide associative horizon of the high P individual will be detrimental to the development of abstract crystallized abilities. High P individuals, in this case, will lack the higher-order eductive powers required to disentangle a vast array of both relevant and irrelevant associations. In contrast, when fluid intelligence is high, the ability to educe relations and correlates will serve as a protective factor. Indeed, amongst individuals possessing an innate fluid insightfulness, a wide associative horizon might prove abnormally useful in providing a more abstract and holistic understanding of experience; one that is conducive to the development of crystallized abilities. Following this argument it is predicted that fluid intelligence will moderate the relationship between P and Gc.

Method

Participants and procedure

A total of 100 undergraduate students (59 females and 41 males) participated in this study. Most did so as partial fulfilment of the research participation option in their introductory psychology course. The remaining participants were recruited through advertisements placed around the university campus. All participants were native English speakers aged between 18 and 29 years of age (M = 21.09; *SD* = *3.09*).

Psychological testing took place in a quiet room on campus. All tests were individually administered in the following order: after completing a demographics questionnaire (age, sex) each participant was administered a brief Gf-Gc intelligence test followed by a self-report questionnaire measure of the Big Three personality factors.

Materials

Intelligence Measures

Matrices and vocabulary are widely thought to provide the single best indicators of fluid and crystallized abilities respectively (Kline, 1998). In the current study the Kaufman Brief Intelligence Test (K-BIT, Kaufman & Kaufman, 1990) was used to assess performance in these two areas. The K-BIT takes 10-30 minutes to complete and was developed for individuals aged 4- to 90-years of age. It consists of two subtests: a matrices subtest and a vocabulary subtest (comprising Part A, *Expressive vocabulary* and Part B, *Definitions*). The matrices subtest measures the ability to solve new problems by assessing a person's ability to perceive relationships and to complete perceptual analogies. The vocabulary subtest measures verbal, school-related skills by assessing a person's word knowledge and verbal concept formation. The K-BIT was administered in accordance with the standardised procedures detailed in the K-BIT manual (Kaufman & Kaufman, 1990). Raw score totals for the vocabulary subtest and the matrices subtest were the only measures extracted from the K-BIT. Standardised IQ scores were not calculated as the norms for the K-BIT are now more than 20-years old. Chronbach's alpha for both the K-BIT matrices subtest (.80) and the K-BIT vocabulary subtest (.86) equalled or exceeded .80 the generally accepted bench mark for good reliability (Henson, 2001).

Personality measures

Participants completed the Eysenck Personality Questionnaire – Revised (EPQ-R; Eysenck & Eysenck, 1991); a test consisting of 106 dichotomously scored items which measure the personality dimensions of extraversion (E), neuroticism (N) and psychoticism (P). The EPQ-R also contains a lie (L) scale for measuring dissimulation. The EPQ-R takes approximately 20-25 minutes to complete. Cronbach's alpha was calculated for each of the 3 personality scales and the lie scale. E (.86), N (.87) and P (.82) all showed good internal consistency. Chronbach's alpha for the L (.76) scale was adequate.

Results

Table 1 provides means, standard deviations (*SD*) and zero-order correlations for the relevant study variables. Skewness and kurtosis statistics indicated that the assumption of normality was violated for the psychoticism dimension only. The P distribution was normalized through a logarithmic transformation and all analyses were conducted twice, once with log-transformed, and once with untransformed, P values. The differences between these two sets of analyses were minor and did not impact in any way on the interpretation of findings. For this reason only the data for the untransformed P scores will be discussed.

Insert Table 1 about here

In simple bivariate correlation two significant relationships were found between cognitive ability and personality: a weak negative correlation between vocabulary and extraversion ($r = -.20$, $p < .05$) and a moderately strong positive correlation between matrices and psychoticism ($r = .32$, $p < .01$). Matrices was also found to be negatively correlated with the Lie scale ($r = -.24$, $p < .05$). In line with Spearman's (1927) notion of a general intelligence factor, scores for the vocabulary and matrices subtests were positively correlated ($r = .36$, $p < .01$).

To determine whether the relationship between psychoticism and vocabulary is conditional on matrices, a hierarchical regression analysis was conducted. In the first step vocabulary was regressed on the demographic variables of sex and age. In the second step, psychoticism and matrices were entered. In the third step, the interaction between psychoticism and matrices was entered. To avoid issues associated with non-essential multi-colinearity, psychoticism and matrices values were centred before being employed in the regression analysis (Cohen, Cohen, West, & Aiken, 2003).

Results from the hierarchical regression are presented in Table 2. In the first step, age was a significant predictor of vocabulary, $\beta = .32$, $t(97) = 3.32$, $p < .01$, a finding consistent with the observation that crystallized abilities increase with age (Cattell, 1971). Sex, on the other hand was not significantly related to vocabulary ($\beta = -.10$, $t(97) = -1.08$, $p = .28$). In the second step, psychoticism and matrices significantly added to the model, $\Delta R^2 = .10$, $p < .01$: psychoticism, $\beta = .04$, $t(95) = .46$, $p = .65$, and matrices $\beta = .30$, $t(95) = 3.11$, $p < .01$. The addition of the interaction term, in the third step, also significantly added to

the model, $\Delta R^2 = .05$, $p < .05$: $\beta = .27$, $t(94) = 2.46$, $p < .05$. Overall, the final model accounted for 25.8% of the variance in vocabulary scores.

Insert Table 2 about here

The nature of the interaction between psychoticism and matrices is clarified in Figure 1. In accord with the research hypothesis the simple slope relating psychoticism to vocabulary is negative when matrices scores are low (1.5 standard deviation below the mean) and positive when matrices scores are high (1.5 standard deviation above the mean). Post-hoc analyses indicated that the simple slopes depicted in Figure 1 were both significantly different from zero [Low matrices: $\beta = -.547$, $t(94) = -2.12$, $p < .05$. High matrices: $\beta = .310$, $t(94) = 2.17$, $p < .05$].

Insert Figure 1 about here

Given that extraversion showed a significant bivariate correlation with vocabulary it was added to the hierarchical regression analysis as a fourth and final step. The addition of extraversion did not, however, add significantly to the model, $\Delta R^2 = .03$, $p = .06$: $\beta = -.17$, $t(93) = -1.89$, $p = .06$.

Discussion

Results from the present study support the hypothesis that matrices (fluid ability) moderates the relationship between psychoticism and vocabulary (crystallized ability). At lower levels of matrices, psychoticism was found to be negatively correlated with vocabulary while at higher levels of matrices the relationship was reversed. The hypothesis for this study was derived from theoretical and empirical work linking the dimension of psychoticism to the phenomenon of latent inhibition (e.g., Eysenck, 1995; Baruch, et al., 1988b). Eysenck (1995) argued that individuals high on psychoticism have weak latent inhibition and therefore possess a wide associative horizon (i.e., they incorporate into a given concept, elements which may have been associated with the concept, but are not necessarily integral to it). This argument would seem to have clear implications for the development of complex abstract concepts, the kind required for the acquisition of crystallized cultural knowledge. It was suggested here that amongst individuals with low fluid ability, high psychoticism would be detrimental to the elaboration of crystallized abilities. High P individuals, in this case, would lack the higher-order eductive powers required to disentangle a vast array of both relevant and irrelevant associations. When fluid intelligence is high, however, the ability to educe relations and correlates would serve as a protective factor. In fact, the combination of enhanced eductive powers and a wide associative horizon, might furnish high P individuals with the necessary associations with which to elaborate superior crystallized concepts.

Two significant bivariate correlations were found between cognitive ability and personality: a weak negative correlation between vocabulary and extraversion ($r = -.20$, $p < .05$) and a moderately strong positive correlation between matrices and psychoticism ($r = .32$, $p < .01$). The direction of the correlation between extraversion and vocabulary (crystallized intelligence) is consistent with that found in a number of recent publications reviewed by Wolf and Ackerman's (2005). Their meta-analytic study revealed that extraversion-intelligence correlations have tended to change direction since 2000, from positive to slightly negative. Wolf and Ackerman (2005) suggest that this shift in the extraversion-intelligence relationship may have something to do with changes in the way extraversion is measured. For instance the change from the EPI to the EPQ involved significant revisions to the extraversion scale. The positive correlation between matrices (fluid intelligence) and psychoticism is at odds with Ackerman and Heggestad's (1997) population estimate for these two constructs (–.15). This inconsistency may have something to do with changes in the operational definition of psychoticism (see Eysenck & Eysenck, 1991), or perhaps the lack of representativeness of participants employed in the present study.

Limitations and Future Research

The present study has certain limitations that bear on the generalizability of the results. As participants in the study were all university students there is likely to have been considerable restriction in the range of fluid ability, particularly at the lower end of the ability spectrum. Additional research is needed to determine whether the moderated relationship reported here will hold when participants with extremely high and low fluid ability are included. A further limitation of the present research is the narrow age range of participants. The years from 18 to 29 approximate the age range in which fluid abilities are at their peak (Cattell, 1971). In contrast crystallised abilities tend to keep increasing with age

until much later in life (Cattell, 1971). These age related trends in fluid and crystallized intelligence are likely to impact on the moderated relationship found here between psychoticism and vocabulary. Finally the present study was limited in terms of the range of subtests used to measure fluid (K-BIT matrices) and crystallized (K-BIT vocabulary) ability. The use of a number of different measures of fluid and crystallized ability – such as the subtests that define the WAIS-IV (Wechsler, Coalson & Raiford, 2008) perceptual reasoning and verbal comprehension indices – would allow for a more robust test of the theory outlined in this paper.

Concluding Comments

It was argued that the associative connections of high P individuals are likely to be more numerous and include many relevant and irrelevant associations. It was further argued that the level of ones eductive powers will determine whether or not such a wide associative horizon is useful for the development of abstract crystallized concepts. The relevance of psychoticism to the elaboration of crystallized abilities was first identified, albeit indirectly, in Cattell's own writings. Two personality traits singled out by Cattell (1971) as having an important role in the development of crystallized abilities were superego strength, and self-sentiment. Both of Cattell's primaries have been found to load highly on a second order factor labelled "socialization" which resembles the obverse of psychoticism (Matthews, 1988). Results from the present study justify a continued focus on the role of psychoticism within GfGc investment theory.

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Table 1

Descriptive statistics and correlation coefficients[a] for study variables (N = 100)

	Mean	*SD*	Matrices	Vocab	P	E	N	L
Matrices	38.50	*4.45*	.795	.360**	.317**	-.033	-.127	-.245*
Vocab	65.41	*6.13*		.858	.138	-.197*	-.005	-.045
P	7.93	*5.00*			.822	.184	-.264**	-.477**
E	14.86	*5.25*				.863	-.229*	-.186
N	12.06	*5.74*					.870	.021
L	5.99	*3.66*						.761

* $p < .05$, two tailed

** $p < .01$, two tailed

[a]Cronbach's alpha is entered on the diagonal

Table 2

Hierarchical regression results for vocabulary regressed on matrices and psychoticism with the interaction effect (N=100)

	Model 1		Model 2		Model 3	
Variable	β	*t*	β	*t*	β	*t*
Step 1: Control variables						
Sex[a]	-.104	-1.084	-.092	-1.008	-.105	-1.179
Age	.319	3.325**	.275	2.975**	.305	3.364**
Step 2: First order effects						
P			.044	.458	-.118	-1.030
Matrices			.303	3.110**	.388	3.840**
Step 3: Interaction effect						
P x Matrices					.273	2.463*
df		(2, 97)		(4, 95)		(5, 94)
F		6.010**		6.328**		6.546**
R^2		.110		.210		.258
ΔR^2				.100		.048

* p < .05, two tailed

** p < .01, two tailed

[a]Coded 1 = male, 2 = female

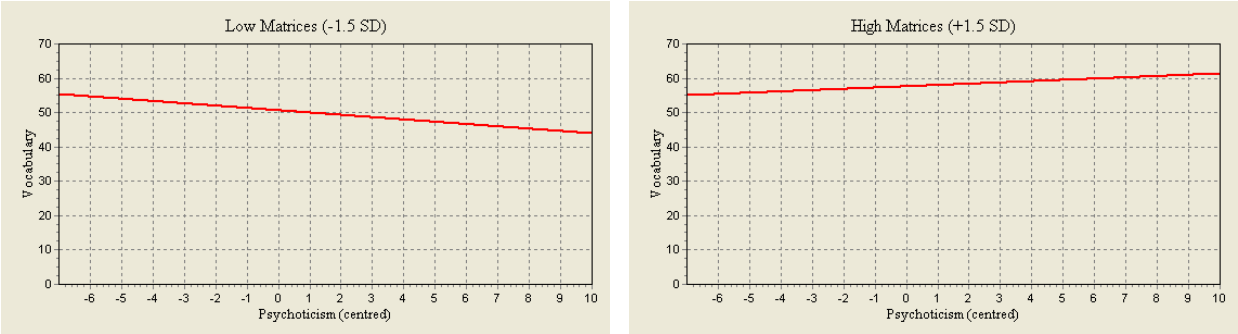

Figure 1. Vocabulary regressed on psychoticism (centred) at two different levels of matrices