The nature of the relationships between personality and cognitive characteristics

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Abstract. In the current study we investigated the contribution of genetic and environmental factors to the relationship between the Big Five personality traits and nonverbal intelligence assessed with Raven's Standard Progressive Matrices. The sample included a total of 290 people: 59 monozygotic (MZ) and 86 dizygotic (DZ, 58 same-sex and 28 opposite-sex) twin pairs aged 14 to 20 years (mean age = 15.84, SD = 1.05). The phenotypic correlations between the traits and intelligence scores were non-significant, except for Openness. This relationship was largely explained by shared environmental influences (65%).

1 Introduction

The relationship between intelligence and personality traits has been of great interest to researchers since both of them are associated with the formation of individual differences in a range of lifetime achievements – from school to professional results [1-3]. Individual performance on tests of personality and intelligence (especially non-verbal intelligence) show considerable stability over the lifetime [2, 4]. On the one hand, there is a weak or zero correlation between personality traits and psychometric intelligence [5, 6]. On the other hand, more and more researchers have detected significant correlations between personality traits and intelligence, especially among the Big Five personality traits and nonverbal intelligence [5, 7-10]. Among the Big Five traits, Openness shows the strongest association with nonverbal intelligence [10, 11].

Analysis of the mechanisms underlying the relationship between personality traits and intelligence undertaken in recent years has proven the advantages of behavioral genetic approach. The first and so far few works show that the covariance of personality traits and intelligence is explained by common additive genetic factors [12, 13].

Structural equation modelling in multivariate methods gives an opportunity to investigate the mechanisms underlying the relationships and comorbidity between traits. For example, Kendler et al. [14] were using this method and found that comorbidity of depression and anxiety disorder was not accidental and not related to any other disorder, but was probably moderated by some correlating vulnerabilities to these disorders. The best fitting model explaining the association between depression and anxiety disorder included high genetic correlation between them and weak association with non-shared environment.

Therefore, anxiety disorder and depression are influenced by common genetic factors and different environmental factors.

Similar multivariate analysis was carried out for different measures of cognitive performance, such as working memory, verbal and spatial abilities. In general, these studies of a broad set of indicators on different cognitive sub-tests found genetic correlations above 0.50, and even approaching 1.00 (Deary, Spinath, & Bates, 2006). In other words, genetic correlations obtained suggest that a wide range of abilities are influenced by the same set of "universal" genes. The latter assumption is indicated in the current literature as the generalist gene hypothesis (Plomin & Kovas, 2005; Kovas & Plomin, 2007).

The aim of the current study was to analyse the role of genetic and environmental factors in personality traits and intelligence.

2 Methods

2.1 Participants

The sample included a total of 290 people: 59 monozygotic (MZ) and 86 dizygotic (DZ, 58 same-sex and 28 opposite-sex) twin pairs aged 14 to 20 years (mean age = 15.84, SD = 1.05).

2.2 Procedure

Nonverbal intelligence was assessed with the test 'Raven's Standard Progressive Matrices'. The test consists of 60 tasks with increasing complexity, grouped in 5 series (A to E).

Personality traits were measured with the Russian version of the questionnaire NEO-PI, which was

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Table 1. Within-pair correlations for NEO-PI and Raven's Standard Progressive Matrices.

Group	Neuroticism	Extraversion	Openness	Agreeableness	Conscientiousness	Raven
MZ	0.358 [0.109, 0.564]	0.374 [0.129, 0.577]	0.533 [0.318, 0.695]	0.591 [0.393, 0.737]	0.465 [0.234, 0.645]	0.809 [0.690, 0.886]
DZss	0.227 [-0.039, 0.462]	0.323 [0.066, 0.540]	0.426 [0.184, 0.620]	0.047 [-0.219, 0.306]	0.191 [-0.076, 0.432]	0.869 [0.781, 0.924]
DZos	0.283 [-0.101, 0.593]	0.441 [0.081, 0.699]	0.319 [-0.062, 0.618]	0.509 [0.168, 0.741]	0.506 [0.164, 0.740]	0.235 [-0.168, 0.570]

standardized on the Russian population. The questionnaire is based on the five-factor model of personality including five main dimensions – Neuroticism, Extraversion, Openness to experience, Agreeableness and Conscientiousness (Costa, McCrae, 1992).

2.3 Analysis

The bivariate twin model (or a model of correlating factors, in accordance with Figure 1) was used to estimate the contribution of genetic and environmental components in the correlation between personality traits

Figure 1. Bivariate twin model.

and intelligence. The analysis evaluated the characteristics of five bivariate models including correlations between the scores for Raven's Standard Progressive Matrices and each of the NEO-PI scales.

Model fit was assessed by comparing the likelihood coefficients of the bivariate model and the saturated model. The saturated model includes the means, variances and covariance of the phenotypic variables without any restrictions. The bivariate model imposes restrictions on the means, variances and covariance hence its likelihood estimates are lower than those of the saturated model. Chi-square test is based on the difference in the likelihood coefficients and the difference of degrees of freedom allows us to take a decision on the statistical significance of the differences between the two models.

3 Results and discussion

Table 1 shows the descriptive statistics. According to the confidence intervals, within-pair correlations for same-sex (DZss) and opposite-sex dizygotic twins (DZos) did not differ significantly, except for Raven's test scores,

Table 2. Estimates of phenotypic variance components.

Scale	A [95% CI]	C [95% CI]	E [95% CI]
N	0.44 [0.00, 0.61]	0.01 [0.00, 0.37]	0.56 [0.39, 0.82]
E	0.00 [0.00, 0.55]	0.35 [0.00, 0.49]	0.65 [0.44, 0.80]
O	0.41 [0.00, 0.64]	0.15 [0.01, 0.49]	0.43 [0.30, 0.64]
A	0.56 [0.21, 0.70]	0.00 [0.00, 0.26]	0.44 [0.30, 0.62]
C	0.40 [0.00, 0.64]	0.08 [0.00, 0.44]	0.52 [0.36, 0.75]
Raven	0.34 [0.11, 0.61]	0.50 [0.24, 0.69]	0.16 [0.10, 0.25]

Note: N — Neuroticism, E — Extraversion, O — Openness, A — Agreeableness, C — Conscientiousness, Raven — Raven's Standard Progressive Matrices. A — additive genetic factors, C — shared environment, E — non-shared environment, 95% CI — 95% confidence interval.

therefore, it was decided to include the opposite-sex twin pairs in the analysis.

The chi-square test showed that all bivariate models demonstrate satisfactory likelihood statistics.

The estimates of phenotypic variance components (genetic factors, shared and non-shared environmental factors) are presented in Table 2. 50% of the phenotypic variance of intelligence is explained by shared environment, 34% - by genetic factors and 16% - by non-shared environment. The phenotypic variance of the NEO-PI scales is largely accounted for by non-shared environment (43-65%). Shared environment contribution is non-significant (0-15%), except for Extraversion (35%). The opposite pattern is observed for genetic factors (40-56%, 0% for Extraversion).

Table 3 presents the correlations between the NEO-PI scales and the scores for Raven's Standard Progressive Matrices. Overall, the phenotypic correlations between the variables are low (according to the confidence interval, the only significant correlation is observed between intelligence and Openness). Among the variance components, there are correlations between genetic factors of intelligence scores and Conscientiousness; and between shared environmental factors of intelligence scores and Openness.

Table 4 shows the contribution of genetic, shared environmental and non-shared environmental influences in the phenotypic correlations between NEO-PI scales

Table 3. Correlations between the components of variance of NEO-PI scales and Raven's Standard Progressive Matrices scores.

	$r_{\text{phenotypic}}$ [95% CI]	r_A [95% CI]	r_C [95% CI]	r_E [95% CI]
Neuroticism	0.04 [-0.09, 0.17]	0.28 [-1.00, 1.00]	-1.00 [-1.00, 1.00]	-0.03 [-0.30, 0.24]
Extraversion	0.01 [-0.12, 0.15]	-0.59 [-1.00, -0.43]	0.02 [0.96, -0.99]	0.03 [-0.24, 0.29]
Openness	0.17 [0.03, 0.30]	-0.34 [-1.00, 0.36]	0.99 [0.19, 1.00]	0.08 [-0.20, 0.34]
Agreeableness	0.11 [-0.03, 0.25]	0.12 [-0.51, 0.73]	1.00 [-1.00, 1.00]	0.06 [-0.22, 0.33]
Conscientiousness	0.06 [-0.07, 0.19]	0.23 [0.81, 1.00]	-0.25 [-1.00, 1.00]	0.08 [-0.19, 0.34]

Note: $r_{\text{phenotypic}}$ – phenotypic correlation, r_A – correlation explained by genetic factors, r_C – correlation explained by shared environment, r_E – correlation explained by non-shared environment, 95% CI – 95% confidence interval.

and the scores for Raven's Standard Progressive

Table 4. Contribution of genetic and environmental components to phenotypic correlation of NEO-PI and Raven Standard Progressive Matrices score.

Scales	r_A [95% CI]	r_C [95% CI]	r_E [95% CI]
N	0.63 [0.00, 1.00]	0.31 [0.00, 1.00]	0.06 [0.00, 1.00]
E	0.24 [0.00, 1.00]	0.38 [0.00, 1.00]	0.38 [0.00, 1.00]
O	0.30 [0.00, 0.46]	0.65 [0.43, 1.00]	0.05 [0.00, 0.29]
A	0.47 [0.00, 1.00]	0.38 [0.00, 1.00]	0.15 [0.00, 1.00]
C	0.54 [0.00, 1.00]	0.31 [0.00, 0.99]	0.15 [0.00, 1.00]

Note: N – Neuroticism, E – Extraversion, O – Openness, A – Agreeableness, C – Conscientiousness, r_A – phenotypic correlation explained by genetic factors, r_C – phenotypic correlation explained by shared environment, r_E – phenotypic correlation explained by non-shared environment, 95% CI – 95% confidence interval.

Matrices test. Non-shared environment influences vary from 6% to 15% (except for 38% for Extraversion). Shared environment influences vary from 31% to 38% (except for 65% for Openness). Genetic influences vary from 24% to 63%.

It is necessary to note that the sample size does not allow us to estimate the influences with high accuracy.

4 Conclusion

In the current study we investigated the contribution of genetic and environmental factors to the relationship between the Big Five personality traits and nonverbal intelligence assessed with Raven's Standard Progressive Matrices. The phenotypic correlations between the traits and intelligence scores were non-significant, except for Openness, which is consistent with previous studies [10, 11]. This relationship is largely explained by shared environmental influences (65%). Further research is needed on an extended sample for more accurate estimates of the relative role of genetic and environmental factors in the relationship of personality traits and nonverbal intelligence.

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References

1. T. Chamorro-Premuzic, A. Furnham, J. of Res. in Pers. **37**, 319 (2003)
2. L.S. Gottfredson, Hum. Perf., **15**, 25 (2002)
3. N.R. Kuncel, S.A. Hezlett, D.S. Ones, J. of Pers. and Soc. Psc., **86**, 148 (2004)
4. J.P.T. Costa, R.R. McCrae, Pers. and Ind. Dif., **13**, 653 (1992)
5. S.B. Malykh, T.N. Tikhomirova, Voprosy psikhologii [Psychological issues], **2**, 147 (2015)
6. J. Moutafi, A. Furnham, J. Crump, Eur. J. of Pers., **17**, 79 (2003)
7. P.L. Ackerman, E.D. Heggestad, Psc. bul., **121**, 219 (1997)
8. E.J. Austin, S.M. Hofer, I.J. Deary, H.W. Eber, Pers. and Ind. Dif., **29**, 405 (2000)
9. T. Chamorro-Premuzic, J. Moutafi, A. Furnham, Pers. and Ind. Dif., **38**, 1517 (2005)
10. A. Furnham, J. Moutafi, T. Chamorro-Premuzic, Int. J. of Sel. and Assessm., **13**, 11 (2005)
11. P.C.L. Heaven, J. Ciarrochi, Pers. & Soc. Psc. Bul., **34**, 451, (2008)
12. M. Luciano, M.J. Wright, D.L. Duffy, M.A. Wainwright, G. Zhu, D. M. Evans et al., Beh. Gen., **36**, 45 (2006)
13. J.L. Pincombe, M. Luciano, N.G. Martin, M.J. Wright, Twin Res. and Hum. Gen., **10**, 462 (2007)
14. K.S. Kendler, E.E. Walters, M.C. Neale, R.C. Kessler, A.C. Heath, L.J. Eaves, Arch. of gen. psc., **52**, 374 (1995).