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Genetic analysis of IQ in young adulthood: a Russian twin study

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Abstract

The present study is an investigation of 80 like-sex, Russian twin pairs aged 16–28 years undertaken to replicate and extend the existent research literature on the heritability of cognitive ability in young adults. Up to date, no study examining cognitive abilities in Russian population adult twins has been carried out. The main objective of the present investigation is to analyze the genetic and environmental contributions to individual differences in general cognitive ability in a sample of young adult Russian twins. The Russian adaptation of the Wechsler Adult Intelligence Scale (WAIS; Wechsler, 1972) was administered separately to members of twin pairs during the single visit at their home by two testers. The model-fitting showed that a simple genetic model, including additive genetic and nonshared environmental effects, provided the adequate and most parsimonious description of verbal, performance and full-scale IQ data. Additive genetic influences accounted for approximately the same amount of variance in verbal, performance and full-scale IQ data—86%, 84% and 89%, respectively. The results are consistent with the reports from the majority of studies, suggesting an increased heritability and decreased shared environmental influences on IQ variability in adulthood compared to childhood.

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1. Introduction

Behavior genetics research has provided strong evidence for a substantial genetic contribution (around 50%) to individual differences in general cognitive ability (Bouchard & McGue, 1981;

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Chipuer, Rovine, & Plomin, 1990; Plomin, DeFries, McClearn, & McGuffin, 2000). However, most research investigating genetic and environmental contributions to variance in cognitive performance was conducted on children and adolescents and relatively few twin studies of general intelligence have included adults. Because the IQ heritability estimate of 50% is derived from samples of children and adolescents, its generalizability to adult population remains an open question. It is possible that the relative importance of genetic and environmental factors varies over the life span. More behavior genetics studies of adult samples are needed to clarify this question.

Two major reviews of behavior genetic investigations of intelligence (McCartney, Harris, & Bernieri, 1990; McGue, Bouchard, Iacono, & Lykken, 1993) suggested that the relative influence of genetic factors on cognitive ability may increase with age. McCartney et al. (1990) reported a correlation of 0.36 between age and estimates of the heritability of intelligence in their meta-analysis of twin studies. With a cross-sectional comparison of twin correlations, McGue et al. (1993) found that the dizygotic (DZ) twin correlation tended to decline with age, whereas the monozygotic (MZ) twin correlation remained stable. Thus, estimates of heritability rose from approximately 40% in childhood to more than 80% in adulthood, whereas estimates of the influence of the shared environment dropped from nearly 40% in childhood to zero in adulthood. Studies of adoptive siblings found a moderate correlation between adoptive siblings in childhood, suggesting that shared environmental factors account for 25% of IQ variance during this stage of life, and a near-zero correlation in adulthood, suggesting little enduring effect associated with shared environment (McGue et al., 1993).

Similarly, the major longitudinal studies suggest increasing genetic and decreasing shared environment influences on cognitive ability from childhood through adolescence to adulthood. The Louisville Twin Study (LTS; e.g., Matheny, 1990; Wilson, 1983) followed twins from birth to age 15 years with a follow-up visit at adulthood (somewhere between age 21 and 25) and found generally increasing heritability for cognitive performance, usually resulting from increasing MZ twin similarity. The most recent report from the Colorado Adoption Project (CAP; Plomin, Fulker, Corley, & DeFries, 1997) provided parent-offspring correlations from age 1 to 12 and at age 16, and found that, over time, the adopted children showed less and less resemblance to their adoptive parents in terms of IQ and increasing resemblance to their biological parents.

The findings of behavior genetic studies examining general cognitive ability in adulthood are consistent with the conclusion that heritability is higher in adulthood relative to childhood and adolescence. Studies of MZ twins reared apart, which almost exclusively involve adult twins (e.g., Pedersen, Plomin, Nesselroade, & McClearn, 1992) reported the heritability estimates around 75% (McGue et al., 1993). Longitudinal and cross-sectional studies suggest that after increasing in early adulthood heritability may reach a plateau in middle adulthood and may decline in late adulthood, finally approaching 54% (Finkel, Pedersen, McGue, & McClearn, 1995; Finkel, Pedersen, Plomin, & McClearn, 1998; Jarvik & Bank, 1983). Plomin, Pedersen, Lichtenstein, and McClearn (1994) found generally stable heritability over a 3-year period (around 80%) for cognitive performance in a sample of adult twins (mean age = 64; SD = 7.5). Similarly, in a cross-sectional study of cognitive abilities in adult twins, Finkel et al. (1995) found that heritability estimates of cognitive abilities could be equated across younger twins (aged 27–49 years) and middle-aged twins (aged 50–64 years) and constituted 81% for general cognitive ability. However, the analysis suggests significantly lower heritability estimates (54%) for cognitive abilities in very late adulthood (ages 65–85).

Thus, for the most part, evidence from twin and adoption studies has suggested that heritability and the effects of non-shared environment increase up to a certain point during the life span, while the importance of shared environment decreases. One should keep in mind, that this conclusion was derived from genetic research of cognitive abilities that was conducted on American and European samples. Meanwhile, the balance of genetic and environmental influences found in any one population is specific to that population. The genetic control of a particular behavior depends on a population's genetic structure. Also, culture unique to a particular population could potentially produce differences in the heritability and environmentality estimates in different human populations. Therefore, the findings obtained on a particular population cannot be generalized to other ones. To check the universality (or uniqueness) of the identified trends, similar studies employing samples from different populations are to be carried out.

Up to date, no study examining cognitive abilities in Russian population adult twins has been carried out. Studies addressing the heritability of IQ in a Russian population employed samples of children and adolescents (e.g., Egorova et al., 1996; Grigorenko, LaBuda, Michele C, & Carter, 1992; Halperin, Rao, & Morton, 1975; Kantonistowa, 1978; Luria, 1934/2002; Ravich-Shcherbo, Maryutina, Trubnikov, Belova, & Kiriakidi, 1996). Thus, Luria (1934/2002) showed an increasing genetic influence across 3–5-, 6–8- and 9–11- twin cohorts in a sample of 46 MZ and 54 DZ pairs. The results of a small cross-sectional study of 61 MZ and 57 DZ twin pairs suggested that the heritability may decline from childhood to adolescence (Kantonistowa, 1978). The genetic influences increased from 58.3% to 66.6% between ages 7–10 and 11–13 and decreased to 25% at ages 14–16. The shared environmental influences underlying individual differences in IQ increased across age cohorts studied (Kantonistowa, 1978). In a longitudinal study, Egorova et al. (1996) compared the IQ heritability estimates obtained in 6-, 7-, 10- and 14-year old twins and found an increasing genetic influence on cognitive abilities as subjects aged. A lower estimate of IQ heritability (0.29) than generally found worldwide was reported by Grigorenko et al. (1992) who examined data on five tests of general and specific cognitive abilities, cognitive styles, and creativity, obtained from members of 60 identical and 63 fraternal Russian 16-year-old twin pairs.

The present study is an investigation of 80 like-sex, Russian twin pairs aged 16–28 years undertaken to replicate and extend the existent research literature on the heritability of cognitive ability in young adults. The main objective of this study is to analyze the genetic and environmental contributions to individual differences in general cognitive ability in a sample of adult Russian twins. Obviously, Russian culture differs much from American and European cultures. Meanwhile, the educational level of people from Russia, America and Europe is rather similar. This fact allows us to compare the genetic and environmental sources of cognitive abilities between these populations.

2. Method

2.1. *Participants and measures*¹

The final sample included a total of 40 MZ twins (20 male, 20 female) and 40 pairs of same-sex DZ twins (20 male, 20 female). The sample was ascertained through voluntary participation of

¹ The data for this study was collected by N.V. Iskoldsky in 1985–1986.

individuals from a city-wide, population-based twin registry maintained by the Developmental Behavior Genetic Laboratory of the Institute of Psychology of the Russian Academy of Education. All twin pairs included in this analysis were raised in Russian-speaking, predominantly middle-class homes, and ranged in age from 16 to 28 years, with a mean age of 21.65 years ($SD = 3.3$). Zygosity determination was based upon a combination of the information obtained from a Russian translation of a twin diagnostic questionnaire (Cohen, Dibble, Grawe, & Pollin, 1973) based upon reported physical similarity and degree of mistaken identity at the time of assessment and a direct examination of physical similarity. Only twin pairs in which zygosity was assigned with confidence were included in the analysis.

The Russian adaptation of the Wechsler Adult Intelligence Scale (WAIS; Wechsler, 1972)² was administered separately to members of twin pairs during the single visit at their home by two testers. The reliability of this instrument is 0.85. It is used to assess the cognitive abilities of individuals aged 16 years and older and consists of 11 subtests. Six subtests (information, comprehension, arithmetic, similarities, vocabulary, digit span) provide scores for the verbal scale and five subtests (picture completion, picture arrangement, block design, object assembly, digit symbol) provide scores for the performance scale. Three total indices are calculated based on the WAIS data: Verbal (VIQ), Performance (PIQ) and Full Scale (FSIQ) IQ.

2.2. Genetic analysis

For the present study, a structural equation model was fitted to VIQ, PIQ and FSIQ data from MZ and DZ twin pairs obtained in the sample. Accordingly to the basic principles of structural modeling, covariances matrices obtained in the sample are compared to the theoretically computed models, which are described by the equations of theoretically predicted covariances. The following sources of variation were considered: additive genetic (A), shared environmental (C), and nonshared environmental (E) effects. In this model, the additive genetic correlation for MZ twins is 1 (because they are genetically identical), and 0.5 in DZ twins. The shared environmental correlation is assumed to be 1 for both MZ and DZ twins, and non-shared environmental influences are uncorrelated between members of twin pairs.

Model parameters of interest were determined on the base of the maximum likelihood method. In our case, its formulation is equivalent to an optimization problem with the following fitting function to be minimized:

$$F = [\ln |\Sigma| - \ln |S| + \text{tr}(S\Sigma^{-1}) - p](N - 1),$$

where, S is the observed covariance matrix; Σ , expected covariance matrix expressed via observed parameters to be estimated; $|\Sigma|$ and $|S|$, determinants of matrices Σ and S ; $\text{tr}(S\Sigma^{-1})$, trace of matrices ($S\Sigma^{-1}$); N , sampling size used for calculation of matrix S ; p , order of matrix S .

The minimum of this function, which results from optimization of the problem solution, shows whether the model fits the observed data. Large values correspond to bad fit and small values-to good fit. Under certain conditions (Bollen, 1989), this goodness-of-fit measure is distributed as a chi-square (χ^2) distribution. That is why the χ^2 -statistic is used to clarify if the fit is adequate or not. The same statistic makes it possible to compare alternative models, thus a goodness-of-fit

² Adapted and standardized in Russia by Baranova and Dvoryashina (1976).

measure for the full model may be compared with the corresponding characteristics of reduced models in which some of the parameters are equated to zero. Since the difference in χ^2 -statistics for the full and reduced models is distributed as a chi-square, it may be used to ascertain whether the parameters dropped are significant or not (Loehlin, 1987).

To obtain an acceptable number of statistics, characteristics of interest were estimated for both monozygotic (MZ) and dizygotic (DZ) twin pairs (each twin type had its own expected and observed matrices of dimension 2 by 2). The sum of corresponding functions F_{MZ} and F_{DZ} for MZ and DZ pairs was used as a criterion to be minimized. The procedure of numerical non-linear optimization called Generalized Reduced Gradient developed by Leon Lasdon (University of Texas at Austin) and Allan Waren (Cleveland State University) was used for calculations.

Genetic and environmental parameters were estimated by fitting both full and reduced models. The overall fit of the models to the data was evaluated using χ^2 statistic; however, Akaike's information criterion ($AIC = \chi^2 - 2df$; Akaike, 1987) reflecting the degree of the model's simplicity was also employed, with lower Akaike's values representing better fitting models (Neale & Cardon, 1992).

Four models were analyzed by using model-fitting procedures. Initially, a "null model" that tests whether correlations between MZ and DZ twins are due to chance and measurement error was fitted to data for each cognitive ability, which involved 3 degrees of freedom (observations minus three estimated parameters). Then, the full model (ACE; model I) that includes all three parameters (additive genetic, shared environmental and nonshared environmental components) was fitted to the observed data. Two reduced models were then fitted to assess the significance of the omitted parameters. In the simple genetic model (AE; model II) similarity between twins is attributed only to the additive genetic effects, while shared environmental effects are dropped out. Finally, the environmental model (CE; model III) tests the significance of genetic factors and implies that any covariance between twins is due to shared environment.

3. Results

Descriptive statistics for the VIQ, PIQ and FSIQ data are presented in Table 1. The sample's IQ means and variances are remarkably similar to those reported in other twin studies (e.g., Rijdsdijk, Vernon, & Boomsma, 2002). Compared to DZ twins, MZ twins have slightly higher average VIQ, PIQ and FSIQ scores. To determine the significance of these differences, mean VIQ, PIQ and FSIQ scores were computed for each twin pair. These pair means were then subjected to a one-way analysis of variance that included zygosity as an independent variable. Results from this

Table 1
Descriptive statistics for verbal, performance and full-scale IQ data

Trait	Mean		Variance		VR s^2_{mz}/s^2_{dz}
	MZ	DZ	MZ	DZ	
VIQ	116.80	110.75	159.07	158.64	1.00
PIQ	103.54	100.15	122.01	95.72	1.28
FSIQ	111.81	107.94	134.66	168.91	0.80

analysis yielded a significant difference between the groups of MZ and DZ twins for VIQ ($F = 4.608$, $p = 0.035$), but the effect for zygosity was not significant for PIQ ($F = 2.108$, $p = 0.151$) and FSIQ ($F = 1.979$, $p = 0.164$).

Variance ratios (MZ variance divided by DZ variance) were also computed for VIQ, PIQ and FSIQ to test the significance of any zygosity difference in the variances. Although the MZ twins' variance is higher for VIQ and PIQ and smaller for FSIQ, these differences are not significant.

Covariance matrices estimated on the basis of VIQ, PIQ, and FSIQ scores were entered in the program. Two matrices, one for MZ and one for DZ twins, were obtained and used to calculate the intraclass correlations for the groups of MZ and DZ twins. Table 2 presents the twin correlations for the VIQ, PIQ and FSIQ data. As shown, the MZ twin correlations are substantially greater than the DZ twin correlations, indicating that individual differences in general cognitive ability are due at least in part to heritable influences (Bouchard & McGue, 1981; Chipuer et al., 1990).

Results of the model fitting procedure conducted for VIQ, PIQ and FSIQ scores are presented in Tables 3–5, correspondingly. A “null model” that tests whether correlations between MZ and DZ twins are due to measurement error or nonsystematic influences can be rejected because the model does not fit the data. This conclusion holds true for VIQ ($\chi^2_{(3)} = 12.50$; $p = 0.01$), PIQ ($\chi^2_{(3)} = 15.27$; $p = 0.00$), as well as for FSIQ ($\chi^2_{(3)} = 17.94$; $p = 0.00$) data. The full model (ACE model) that includes all three parameters: additive genetic, shared environmental and nonshared environmental effects fits the observed data well for VIQ ($\chi^2_{(3)} = 0.44$, $p = 0.93$, AIC = -5.56), for PIQ ($\chi^2_{(3)} = 2.70$, $p = 0.44$, AIC = -3.30) and FSIQ ($\chi^2_{(3)} = 0.20$, $p = 0.98$, AIC = -5.80).

At the following stage, the reduced model AE was fitted to assess the significance of the omitted parameter of shared environment. A nonsignificant reduction of fit from the full to the reduced model resulted for the VIQ ($\chi^2_{(3)} = 1.461$, $p = 0.24$), PIQ ($\Delta\chi^2_{(3)} = 0.061$, $p = 0.49$), and FSIQ

Table 2
Correlation coefficients for verbal, performance and full-scale IQ data of twin pairs

Zygosity	Verbal IQ	Performance IQ	Full Scale IQ
MZ	0.870***	0.861***	0.909***
DZ	0.598***	0.474**	0.351*

* $p = 0.013$.

** $p = 0.001$.

*** Correlation is significant at level $p < 0.001$.

Table 3
Model comparisons for verbal IQ data of twin pairs

Model	Description	Model fit				Change statistic ^a		
		χ^2	Df	P	AIC	$\Delta\chi^2$	df	p
0	Null hypothesis	12.50	3	0.01	6.50	–	–	–
I	a, c, e—ACE	0.44	3	0.93	-5.56	–	–	–
II	A, e—AE	1.91	4	0.75	-6.09	1.461	1	0.24
III	C, e—CE	12.57	4	0.01	4.57	12.128	1	0.00

^a Models II and III are compared to the Full Model—Model I.

Table 4
Model comparisons for performance IQ data of twin pairs

Model	Description	Model fit				Change statistic ^a		
		χ^2	Df	<i>P</i>	AIC	$\Delta\chi^2$	df	<i>P</i>
0	Null Hypothesis	15.27	3	0.00	9.27	–	–	–
I	a, c, e—ACE	2.70	3	0.44	–3.30	–	–	–
II	A, e—AE	2.76	4	0.60	–5.24	0.061	1	0.49
III	C, e—CE	17.10	4	0.00	9.10	14.401	1	0.00

^a Models II and III are compared to the Full Model—Model I.

Table 5
Model comparisons for full scale IQ data of twin pairs

Model	Description	Model fit				Change statistic ^a		
		χ^2	Df	<i>P</i>	AIC	$\Delta\chi^2$	df	<i>P</i>
0	Null hypothesis	17.94	3	0.00	11.94	–	–	–
I	a, c, e—ACE	0.20	3	0.98	–5.80	–	–	–
II	A, e—AE	1.27	4	0.87	–6.73	1.069	1	0.30
III	C, e—CE	18.06	4	0.00	10.06	17.857	1	0.00

^a Models II and III are compared to the Full Model—Model I.

($\Delta\chi^2_{(3)} = 1.069, p = 0.30$) data, indicating that the latent factor of shared environment is not significant. The AE model provided an adequate and more parsimonious description of the VIQ ($\chi^2_{(4)} = 1.91; p = 0.75; AIC = -6.09$), PIQ ($\chi^2_{(4)} = 2.76; p = 0.60; AIC = -5.24$) and FSIQ ($\chi^2_{(4)} = 1.27; p = 0.87; AIC = -6.73$) data than ACE model.

Then, the CE model, in which the genetic parameter was equated to zero, was fitted. The CE model does not fit either VIQ ($\chi^2_{(4)} = 12.57; p = 0.01; AIC = 4.57$), PIQ ($\chi^2_{(4)} = 17.10; p = 0.00; AIC = 9.10$), nor FSIQ ($\chi^2_{(4)} = 18.06; p = 0.00; AIC = 10.06$) data and yields significantly worse goodness-of-fit measures than the full model for VIQ ($\Delta\chi^2_{(4)} = 12.128, p = 0.00$), PIQ ($\Delta\chi^2_{(4)} = 14.401, p = 0.00$) and FSIQ ($\Delta\chi^2_{(4)} = 17.875, p = 0.00$) data. These results indicate that genetic effects significantly influence verbal, performance, and general cognitive ability and are required to explain twin resemblances in VIQ, PIQ and FSIQ.

Results of these model comparisons indicate that the AE model, in which the additive genetic and non-shared environmental effects are included, and in which shared environmental

Table 6
Genetic, shared environmental, and non-shared environmental standardized parameter estimates obtained from full and best-fitting model to verbal, performance and full-scale IQ data

Variance component	Verbal IQ		Performance IQ		Full scale IQ	
	Full model	Preferred model	Full model	Preferred model	Full model	Preferred model
a ²	0.59	0.86	0.78	0.84	0.66	0.89
c ²	0.27	–	0.06	–	0.23	–
e ²	0.14	0.14	0.16	0.16	0.11	0.11

coefficients are dropped from the model, provides the best fit to the VIQ, PIQ and FSIQ data. The resulting standardized parameter estimates from the best-fitting (AE) model are presented in Table 6.

4. Discussion

The question addressed in this genetic analysis concerns the origins of individual differences in the VIQ, PIQ and FSIQ in a Russian adult twin sample. The twin correlations were fairly comparable to figures from other countries and cultures. The model-fitting showed that a simple genetic model, including additive genetic and nonshared environmental effects, provided the adequate and the most parsimonious description of VIQ, PIQ and FSIQ data. Under this model, additive genetic influences accounted for approximately the same amount of variance in VIQ, PIQ and FSIQ data—86%, 84% and 89%, respectively. Non-shared environmental effects explained the rest 14%, 16% and 11% of total variance in VIQ, PIQ and FSIQ, respectively.

Compared to most previous findings (Bouchard & McGue, 1981; Chipuer et al., 1990), the influences of shared-family environment were nonsignificant and genetic influences were high. It may be due to social homogeneity in the Russian society at time of assessment, eliminating much of the environmental variance between families, or to a possible sample bias. However, these results could also reflect the developmental trends identified in the majority of studies (e.g., McGue et al., 1993), suggesting an increased heritability and decreased shared environmental influences on IQ variability in adulthood compared to childhood. In our study of 22-year old twins heritability of cognitive ability was much higher (exceeding 80%) than estimates typically found earlier in life (about 50%). Thus, the recent analyses of data obtained from the 16-year-old American and western European adolescents showed the heritability of around 57% for general IQ (Plomin et al., 1997; Rowe, Jacobson, & Van den Oord, 1999). Lower heritability estimates (less than 30%) were obtained in the samples of Russian 16-year old twins (Grigorenko et al., 1992; Kantonistowa, 1978).

Our results are similar to those recently reported in a sample of 194 18-year-old Dutch twin pairs (Rijsdijk et al., 2002). The AE model showed the best fit and heritabilities for VIQ, PIQ, and FSIQ were 84%, 68%, and 82%, respectively (Rijsdijk et al., 2002). Somewhat lower IQ heritability estimates were found in other studies that employed samples of twins of comparable age. Sundet, Tambs, Magnus, and Berg (1988) reported the heritability estimate of 68% in their sample of 757 identical and 1093 fraternal male twin pairs, all tested in their late teens or early twenties, from the files of the Norwegian Armed Forces. In the LTS, MZ and DZ twins' correlations in IQ at age 21–25 were 0.85 and 0.56 respectively, which indicates heritability about 58% (Matheny, 1990). The meta-analysis conducted by McGue et al. (1993) suggests an IQ heritability estimate of approximately 60% at ages 16–20. Our heritability estimates for IQ approach those found later in life (Pedersen et al., 1992; Tambs, Sundet, & Magnus, 1984).

While genetic factors contributed substantially to individual differences in IQ test performance, shared environmental factors did not significantly influence individual differences in IQ in our sample. This finding is consistent with the summaries of cross-sectional studies of intellectual performance (McCartney et al., 1990; McGue et al., 1993) as well as longitudinal studies (e.g., Loehlin, Horn, & Willerman, 1989; Plomin et al., 1997) indicating that the effects of shared family

environment may decrease to negligible levels by adolescence. This observation can be explained as a consequence of the changing relationship between genotype and environment (Scarr & McCartney, 1983). During adulthood, individuals tend to select environment, in part, inherited abilities, interests, and dispositions that reinforce existing genetic differences. The findings of significant nonshared environmental influences and nonsignificant shared environmental influences may relate to this type of genotype-environment interaction, given the ages (16–28 years) of the Russian twin sample used in the present analysis. At these ages, twins of the sample went through the stage of self-selection of experiences and changes in occupation and marital status and many of them separated and left their childhood homes.

It should be noted, however, that although tests of the shared twin environmental effects were nonsignificant in all of the scales (Tables 3–5), the power to detect such effects is relatively weak without large twin samples (Neale & Cardon, 1992). The estimates for VIQ and FSIQ are most likely to suffer from the lack of power because shared twin environmental effects, although nonsignificant, accounted for 27% and 23% of observed variation in VIQ and FSIQ, respectively, and inclusion of such effects in the model reduced the estimates of heritability from 0.86 to 0.59 for VIQ and 0.89 to 0.66 for FSIQ. If these effects retained their significance, then genetic factors would have approximately the same impact on individual differences in cognitive ability as reported for these ages in the literature (McGue et al., 1993; Sundet et al., 1988).

Analysis of the heritability of the specific scales suggested no pattern of differential heritability. Genetic influences appear strongest for general cognitive ability, although genetic influence is nonetheless substantial and not significantly different for verbal and performance IQ. Generally a similar pattern of results was reported by McGue et al. (1993) in the University of Minnesota cross-sectional study of reared-together twins and Plomin et al. (1997) for 16-year-olds from the CAP sample. Also, Bratko (1996) found approximately equal heritability estimates of around 55% for verbal and spatial abilities in a Croatian sample of 149 twin pairs aged 15–19 years. In contrast, in samples of Norwegian adult twins (Tambs et al., 1984) and Dutch twins (Rijsdijk et al., 2002) lower heritability estimates were reported for PIQ compared to VIQ and FSIQ data.

Considering some important limitations of the present study, including the small sample size and potential selection bias, our conclusions are necessarily tentative. The future analyses of data from this longitudinal study of Russian twins will help to clarify the roles of genetic and environmental influences on general cognitive ability across development.

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