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The Genetic Origins of the Relationship between Psychological Traits and Social Trust

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Recent studies have shown that trusting attitudes and behavior are biologically influenced. Focusing on the classic trust game, it has been demonstrated that oxytocin increases trust and that humans are endowed with genetic variation that influences their behavior in the game. Moreover, several studies have shown that a large share of the variation in survey responses to trust items is accounted for by an additive genetic component. Against this backdrop, this article makes two important contributions. First, utilizing a unique sample of more than 2,000 complete Swedish twin pairs, we provide further evidence of the heritability of social trust. Our estimates of the additive genetic component in social trust were consistent across the sexes — .33 for males and .39 for females — and are similar to the results reported in earlier studies. Secondly, we show that social trust is phenotypically related to three psychological traits — extraversion, personal control, and intelligence — and that genetic factors account for most of these correlations. Jointly, these psychological factors share around 30% of the genetic influence on social trust both for males and females. Future studies should further explore the possible causal pathways between genes and trust using panel data on both psychological traits and social trust.

■ **Keywords:** social trust, personality, behavior genetics

Social trust — or the default expectation of other people's trustworthiness (Rotter, 1980) — has been suggested as the root cause of much of what is valued in today's societies. A large body of research has shown that high levels of social trust have wide-ranging, positive societal and individual effects; when people trust each other, democratic stability is promoted, society is more inclusive and open, economic development is furthered, and feelings of wellbeing flourish (Putnam, 1993; Rothstein & Uslaner, 2005; Uslaner, 2002; Zak & Knack, 2001).

Much work has also been devoted to finding the origins of social trust. The main question in this long research tradition among social scientists has been whether trusting attitudes are predominantly formed and cemented early in childhood and adolescence through socialization (Dohmen, Falk, Huffman, & Sunde, 2008; Dinesen, 2010) or whether they are also subject to change later in life (Nannestad, 2008). However, the focus in this paper is on the genetic etiology of social trust. The argument and expectations of this study can be summarized briefly. We expect that, based on theory, social trust will be related to three psychological factors: extraversion, personal control, and social intelligence. In line with earlier empirical research, we also expect social trust and the three psychological traits to be heritable. Consequently, we investigate the extent to which the relationship between these variables is due to common genetic and environmental factors.

The basis for this conjecture is the so-called emancipation theory of trust as elaborated by Toshio Yamagishi and colleagues (Yamagishi, Kikuchi, & Kosugi, 1999; Yamagishi, 2001, Yamagishi & Yamagishi, 1994). The starting point of the theory is two different means of dealing with social uncertainty. One possibility is to restrict oneself to committed relationships with those familiar to us in order to reduce the risk of being cheated. However,

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the cost of such a restriction is the risk of missing out on better opportunities outside the current relationships.

As long as outside opportunities are scarce, commitment formation is an efficient means of dealing with social uncertainty. However, general trust in others might be a better response in a situation in which the opportunity costs of staying in secure and stable committed relationships are high. Thus, general trust emancipates individuals from the confines of stable and secure committed relationships and provides an advantage in a social environment full of opportunities.

Emancipation theory suggests several factors that should influence the level of trust observed in society. Levels of trust should be related to external conditions influencing the incentive structure of staying in committed relationships. Aspects of socioeconomic status, such as education or income, or an individual's real or perceived physical security have been shown to be good predictors of attitudes of trust or trusting behavior towards strangers (Alesina & Ferrara, 2002; Newton, 1999; Putnam, 2000; Whiteley, 1999). The prevailing institutional environment should also influence levels of trust. Previous studies have shown that impartial, uncorrupted, and equality-enhancing institutions help to generate relationships of trust (Cook, Hardin, & Levi, 2005; Delhey & Newton, 2003; North, 1990; Oskarsson, Svensson, & Öberg, 2009; Ostrom, 1990; Ostrom, 2000; Rothstein & Uslaner, 2005). A growing body of research has focused on the importance of local neighborhood conditions. This work has found a negative correlation between trust and ethnic and economic diversity (Delhey & Newton, 2005; Öberg, Oskarsson, & Svensson, 2011; Putnam, 2007; Stolle, Soroka, & Johnston, 2008).

However, the opportunity costs of restricting oneself to fewer and closer relationships are not only affected by external environmental conditions but also by one's internal environment. Thus, the emancipation theory of trust gives us reason to expect that trust also is rooted in basic psychological traits. More precisely, it has been shown that three traits are related to trust. First, the psychological trait extraversion, which is marked by sociability and an eagerness to engage with others and construct new social relationships, should increase the opportunities an individual has to benefit from higher social trust. Consequently, extraverted individuals have been found to be more trusting (Hiraishi, Yamagata, Shikishima, & Ando, 2008) and more inclined towards cooperative behavior (LePine & Van Dyne, 2001).

Second, personal control — or the belief that one's fate and wellbeing are primarily the result of one's own making (Rotter, 1966) — should be positively related to trust. Individuals who believe they are the masters of their own fate should be more willing to trust strangers in order to reap the benefits of outside opportunities. Empirical tests indicated that personal control is positively related to trust in survey studies (Uslaner, 2002) and to expectations about cooperative behavior in Prisoner's Dilemma games (Hayashi, Ostrom, Walker, & Yamagishi, 1999).

Finally, when leaving secure relationships to explore better outside opportunities, one always runs the risk of being exploited. Thus, social intelligence — or a capacity to discern the trustworthiness of potential interaction partners — should be positively related to social trust. Yamagishi et al. (1999), Yamagishi (2001), and Hiraishi, Ando, and Ono (2004) showed that people high in general trust are more socially intelligent in the sense that they are more sensitive to information revealing lack of trustworthy behavior and are more accurate in judging the trustworthiness of others. Also, Sturgis, Read, and Allum (2010) reported a positive relationship between general intelligence (used as a proxy for social intelligence) and social trust.

Thus, we expect, based on these findings and the logic of the emancipation theory of trust, that extraversion, personal control, and social intelligence will be positively related to social trust. We also expect a significant share of this covariation between social trust and the psychological traits to be due to genetic influences. Previous research has shown that extraversion (Bouchard & Loehlin, 2001; Weiss, Bates, & Luciano, 2008), personal control (Bouchard & McGue, 2003; Goldsmith, 1983), and intelligence (Bouchard & McGue, 2003) are heritable. Moreover, recent studies by personality theorists and behavioral economists report that trusting attitudes and behavior are biologically influenced. In experiments using the classic trust game, it has been demonstrated that higher levels of the neuropeptide, oxytocin, are associated with increased trust (Kosfeld, Heinrichs, Zak, Fischbacher, & Fehr, 2005), and that individual differences in behavior in the trust game could be attributed to genetic variation (Cesarini et al., 2008). Also, several studies have shown that a moderate share of the variation in survey responses to trust items is accounted for by genetic variation (Hiraishi et al., 2008; Jang, McCrae, Angleitner, Riemann, & Livesley, 1998; Jang, Livesley, Angleitner, Riemann, & Vernon, 2002; Sturgis, Read, Hatemi, et al., 2010). Based on the classic twin design and samples drawn from Australian, Japanese, Canadian, and German registers, these studies have reported heritability estimates ranging between .3–.4 for the trust scale from the Revised NEO Personality Inventory (Costa & McCrae, 1995). When taking measurement error into account, the estimates increased to .5–.66 (Jang et al., 1998; Sturgis, Read, Hatemi, et al., 2010).

However, these studies do not investigate the degree to which social trust and psychological traits share the same genetic etiology. The only exception that we know of is a study based on a small Japanese sample that found that genetic factors explained most of the relationship between social trust and extraversion (Hiraishi et al., 2008). We suggest here that, apart from the relationship between social trust and extraversion, genetic influences also account

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for most of the phenotypic correlations between social trust and both personal control and social intelligence.

Methods and Measurement

We investigated our conjecture using data from the Swedish Twin Registry. The Swedish Twin Registry is the world's largest twin registry and it routinely administers surveys to Swedish twins (Lichtenstein et al., 2006). This paper uses data from the most recent of these surveys, called SALTY. The SALTY study is a collaborative effort between researchers in epidemiology, medicine, economics, and political science initiated in 2007. Data collection was completed in the summer of 2010.

In the beginning of 2009, SALTY was sent to 24,914 Swedish twins born between 1943 and 1958, and the final reminders were sent in the spring of 2010. The survey generated a total of 11,647 responses. Of these, 11,482 (98.6%) respondents gave informed consent to have their responses stored and analyzed. Zygosity was resolved either by questionnaire items with high reliability or, when available, by analysis of biosamples (Lichtenstein et al., 2006). In total, our sample is comprised of 1,169 monozygotic (MZ) pairs, 1,286 same-sex dizygotic (DZ) pairs, and 1,148 opposite-sex DZ pairs. The remaining responses were from individuals whose twin siblings failed to respond. All of our analysis utilizes data from same-sex twin pairs.

As part of SALTY, we administered batteries of questions designed to measure both social trust and psychological traits. Our measure of trust was the response to the standard survey research question "Generally speaking, would you say that most people can be trusted, or that you can't be too careful in dealing with people?" This has been the most common measure of social trust among political scientists and sociologists for more than half a century (Nannestad, 2008; Rosenberg, 1956). To get a more precise measure, we followed the recommendation of Zmerli, Newton, and Montaro (2007) and used a 10-point scale (1–10), instead of the original binary response alternatives.

This question has been criticized for being ambiguous because it does not ask the respondent to choose between trust and distrust (Glaeser, Laibson, Scheinkman, & Soutter, 2000; Sturgis & Smith, 2010). Rather, respondents are prompted to choose between trust and caution (Miller & Mitamura, 2003). However, compared to other available trust indicators, this question has been shown to more clearly tap into a dispositional, as opposed to a situational, dimension of trust (Soroka, Helliwell, & Johnston, 2006; Uslaner, 2002).

To measure extraversion, we employed the so-called Adult Measure of Behavioral Inhibition (AMBI). This 16-item instrument was developed in order to measure subjective reports of contemporaneous trait inhibition (Gladstone & Parker, 2005). The AMBI is a subjective measure of behavior involving withdrawal, avoidance, fear of the unfamiliar, and a propensity to react to both social and nonsocial novelty with inhibition (Shatz, 2005). High scorers on the AMBI indicator are characterized by proneness for social avoidance and introversion. The correlation between AMBI and the extraversion–introversion scale from the Eysenck Personality Questionnaire-Revised (EPQ-R) is –.75 (Gladstone & Parker, 2005). We reversed the coding of the AMBI indicator so that high scores reflect extraversion.

Personal control refers to the extent to which individuals believe they can control events affecting them (Rotter, 1966). At the upper end of this dimension are individuals with a high internal locus of control, meaning that they believe events result first and foremost from their own actions and behavior. At the lower end of the dimension are individuals with a high external locus of control, which implies a belief that others, chance, or fate determine events. We measured locus of control using a 12-item version of Rotter's (1966) locus of control scale (LOC). Items included and response alternatives for both the AMBI and the LOC measures are presented in the Appendix.

Measuring social intelligence is somewhat more complex. The use of respondent self-report batteries to tap social intelligence has been widely criticized (Sturgis, Read, & Allum, 2010). Moreover, to collect independent observations of verifiably socially intelligent behavior for the large SALTY sample would be prohibitively expensive and time consuming. However, although empirically distinct, social and general intelligence have been found to correlate quite strongly (Jones & Day, 1997). Therefore, this study follows Sturgis, Read, and Allum (2010) and employs a measure of general intelligence as a proxy for social intelligence. We used social security numbers to match the men in the SALTY sample to conscription data provided by the Swedish National Service Administration. All men in our sample were required by law to participate in military conscription around the age of 18 years. We were able to successfully match 95% of male twins to the information in the military archives. The male SALTY respondents studied in this paper took four subtests (logical, verbal, spatial, and technical). Because there were minor changes to the test during our study period, we do not use the raw scores as our measure of cognitive ability. Instead, we transformed the subjects' test scores to percentile rank, separately by birth year, using a standardization sample of all twins for whom data was available (not just SALTY respondents).

Table 1 lists mean values by sex and correlations with age for all four variables discussed above. Significant differences between sexes and/or across age were found for all indicators except general intelligence. Some of these differences are small in magnitude and reflect the large sample sizes. We include age as a covariate influencing the mean values of the traits in the SEM-models and present the results separately by sex.

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TABLE 1

Descriptive Statistics

Variable	Male (SD)	Female (SD)	t_{sex}	r_{age}
Social trust	6.77 (2.19)	6.86 (2.21)	2.04*	–.03*
Personal control	17.36 (2.26)	17.82 (2.23)	10.75*	–.03*
Extraversion	33.51 (4.93)	33.24 (5.07)	–2.88*	–.06*
General intelligence	0.19 (0.94)			0.02

Note: SD = standard deviation; t = mean differences.

* $p < 0.05$, two-tailed tests.

Univariate Results

As a first step in the analysis, Table 2 presents within-twin-pair correlations for the measure of social trust and the three psychological traits. Correlations are significantly higher among MZ twins than for DZ twins in all traits, and for both males and females. Thus, as expected, social trust, extraversion, personal control, and cognitive ability seem to have a heritable component. Moreover, in many cases, the MZ correlations approach or even surpass twice the size of the DZ correlations, implying a very limited influence of the common environment.

Results from univariate structural equation models including additive genetic, shared, and nonshared environmental sources of variance are presented in Table 3. Easily accessible introductions to the univariate twin methodology are available in Fowler, Baker, and Dawes (2008) and Medland and Hatemi (2009). All results are obtained using maximum likelihood estimation on raw data in Mx (Neale, Boker, Xie, & Maes, 2004).

The point estimate for the C component is close to, or at, zero and is insignificant in all models. Accordingly, the fit statistics and model comparisons indicate that AE models fit best in all cases. That is, according to these estimates, the shared environment does not contribute to the resemblance regarding social trust or personalities within twin pairs.

The heritability estimates are significantly different from zero in all cases. The estimates for extraversion, personal control, and cognitive ability are similar to those reported in earlier studies (Bouchard & Loehlin, 2001; Bouchard & McGue, 2003; Goldsmith, 1983). Based on a sex limitation model, the genetic influence on extraversion is larger among females than males. More specifically, constraining the genetic effect to be equal across males and females significantly impairs the fit ($\Delta\chi^2 = 6.59$, $p = .01$).

Turning to social trust, the heritability estimates are consistent across sexes. Moreover, the magnitudes of the estimates are similar to the ones reported in studies on samples of twins from Australia (Sturgis, Read, Hatemi, et al., 2010), Japan (Hiraishi et al., 2008), Canada (Jang et al., 1998; Jang et al., 2002), and Germany (Jang et al., 1998; Jang et al., 2002). Thus, our results, which are based on a sample drawn from a different cultural and institutional context, provide confirmation of earlier studies on the heritability of trust.

Bivariate Results

We conjecture that social trust should be related to extraversion, personal control, and social intelligence and that most of these correlations should be accounted for by genetic influences. As an initial step in testing this conjecture, Table 4 presents the phenotypic correlations between

TABLE 2

Twin Correlations

Variable	MZ twins	DZ twins	p (difference)	NMZ	NDZ
FEMALES					
Social trust	.37 [.31, .44]	.19 [.12, .26]	< .001	667	725
Extraversion	.53 [.48, .58]	.17 [.10, .24]	< .001	675	724
Personal control	.30 [.23, .36]	.14 [.06, .21]	< .01	652	693
MALES					
Social trust	.35 [.28, .43]	.19 [.10, .28]	< .05	463	495
Extraversion	.39 [.30, .46]	.22 [.13, .30]	< .01	460	499
Personal control	.29 [.21, .37]	.08 [–.01, .17]	< .01	453	487
General intelligence	.78 [.74, .82]	.46 [.39, .53]	< .001	429	461

Note: [95% confidence interval]; MZ = monozygotic; DZ = dizygotic.

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TABLE 3

Univariate Results

Variable	Heritability A	Common env. C	Unique env. E	−2LL	p ($\Delta\chi^2$)
Females					
Social trust	.39 [.24, .44]	.00 [.00, .11]	.61 [.56, .68]	12,236.37	
	.39 [.33, .44]	— —	.61 [.56, .67]	12,236.37	1.00
Extraversion	.50 [.43, .55]	.00 [.00, .05]	.50 [.45, .55]	16,912.53	
	.50 [.45, .55]	— —	.50 [.45, .55]	16,912.53	1.00
Personal control	.29 [.13, .36]	.00 [.00, .13]	.71 [.64, .77]	12,178.23	
	.29 [.23, .36]	— —	.71 [.64, .77]	12,178.23	1.00
Males					
Social trust	.33 [.10, .42]	.03 [.00, .20]	.65 [.58, .73]	8,335.78	
	.35 [.28, .42]	— —	.65 [.58, .73]	8,335.84	.81
Extraversion	.34 [.12, .45]	.04 [.00, .22]	.62 [.55, .70]	11,524.77	
	.39 [.32, .46]	— —	.61 [.54, .68]	11,524.96	.66
Personal control	.26 [.11, .34]	.00 [.00, .11]	.74 [.66, .81]	8,509.17	
	.26 [.19, .34]	— —	.74 [.66, .81]	8,509.17	1.00
General intelligence	.68 [.54, .81]	.12 [.00, .25]	.21 [.18, .24]	4,320.34	
	.80 [.76, .82]	— —	.20 [.18, .24]	4,322.94	.11

Note: [95% confidence interval]. –2LL = –2*Log Likelihood for the full model and a model in which the c-path is dropped. The p-value is associated with a hypothesis test of the difference in likelihoods (χ^2 with one degree of freedom).

social trust and the three psychological traits. Our expectations are borne out by the results in Table 4.

The correlations range between .19 and .32 and are statistically significant. For both men and women, individuals scoring high on personal control and extraversion are more trusting. Also, among men, there is a clear positive relationship between general intelligence and trusting attitudes. These results render support for earlier studies showing a link between social trust and extraversion (Hiraishi et al., 2008), personal control (Uslaner, 2002), and general intelligence (Sturgis, Read, & Allum, 2010), respectively. Among these three studies, only Hiraishi et al. (2008) reports correlation coefficients that are directly comparable to the estimates in Table 4. Hiraishi et al. (2008) found that the correlation between extraversion and the trust facet from the agreeableness factor amounted to .36.

To further investigate the relationship between the three psychological traits and social trust, we need to decompose these phenotypic correlations into their genetic and environmental components. We employ bivariate Cholesky decomposition in order to estimate the amount of covariation between social trust and the psychological traits that can be accounted for by a common genetic source (Evans, Gillespie, & Martin, 2002; Loehlin, 1996; Medland & Hatemi, 2009; Neale et al., 2004). A schematic example of a bivariate Cholesky decomposition is provided in Figure 1. Because we want to estimate the amount of variation in social trust that can be accounted for by the psychological traits, we treat trust as the outcome variable in the models.

We will use the estimates from the bivariate models to investigate the links between genes, social trust, and psy-

TABLE 4

Phenotypic Correlations: Psychological Traits and Social Trust

	Females	Males
Extraversion	.32*	.27*
Personal control	.19*	.20*
General intelligence	—	.25*

Note: *p < .01, two-tailed tests.

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chological traits in three ways. First, using bivariate Cholesky decomposition (panel (i) in Figure 1), we can estimate the extent to which the variance in social trust can be accounted for by the same genetic (A), common environmental (C), and unique environmental factors (E) influencing other psychological measures. Thus, A_1 in Figure 1 is the sole genetic cause of Trait 1 via path a_{11} and a partial cause of Trait 2 via path a_{21}. A_2, then, represents the genetic variance in Trait 2 via path a_{22} independent of A_1. Similarly, C_1 and E_1 represent the common and unique environmental causes of Trait 1 via paths c_{11} and e_{11}, and the corresponding partial causes of Trait 2 via paths c_{21} and e_{21}, whereas C_2 and E_2 are the common and unique environmental causes of Trait 2 via path c_{22} and e_{22}, independent of C_1 and E_1. Consequently, large and significant estimates of a_{21} suggest that the first genetic factor (A_1) influences both the psychological trait in focus and social trust.

The parameter estimates generated by this initial Cholesky decomposition can also be used to construct other quantities of interest represented by a so-called correlated factors model (panel (ii) in Figure 1). Above all, estimates of the correlations across the latent components

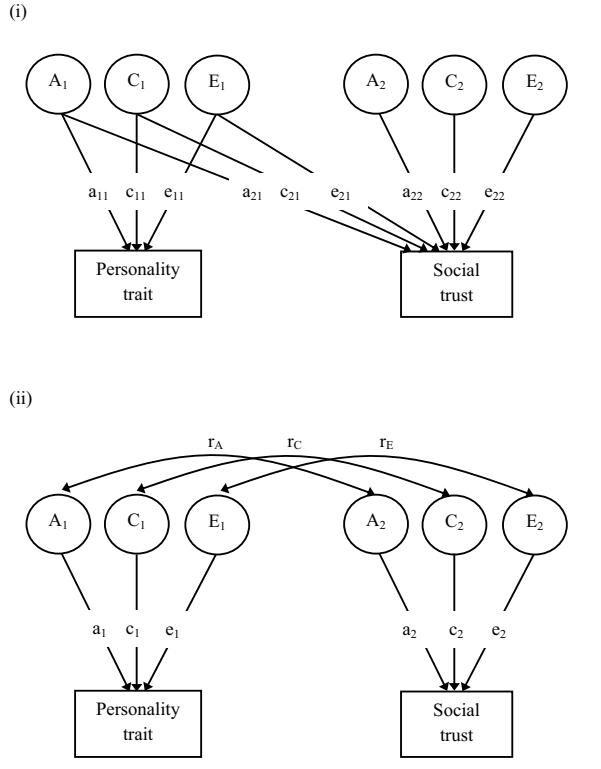

FIGURE 1

Bivariate Cholesky decomposition and the correlated factors model. Note the two alternative bivariate behavior genetic models, (i) Cholesky, and (ii), correlated factors. In the squares are the two observed variables; in the circles are the three latent variance components, additive genetic (A), common environment (C), and unique environment (E).

(r_A, r_C, and r_E) are provided. The genetic correlation (r_A) is a measure of the degree to which the genetic endowments of two traits covary and is obtained by dividing the genetic covariance between the two traits by the square root of the product of their genetic variances (r_C and r_E are defined analogously):

$$r_A = \frac{a_{11}a_{21}}{\sqrt{a_{11}^2(a_{21}^2 + a_{22}^2)}} \quad (1)$$

The square of the genetic correlation ($R^2_A = r^2_A$) can be interpreted as the R^2 from a regression of the genetic endowment of social trust on the genetic endowment of a psychological trait (extraversion, personal control, or general intelligence). Thus, the square of the genetic correlation is a direct measure of the genetic overlap between social trust and the psychological trait. A squared genetic correlation equal to zero means that the two traits are influenced by completely different genes, whereas a squared correlation of 1 implies that the same genetic endowment influences both traits.

A third quantity of interest is the share of the total phenotypic correlation accounted for by genetic factors. Similar to the univariate case in which we decompose the phenotypic variance, we can also decompose the covariation between two traits into additive genetic, shared environmental, and unique environmental components. This measure provides the share, or proportion, of this covariation that can be explained by additive genetic factors ($prop_A$). The share of the total phenotypic correlation accounted for by genetic factors is defined as:

$$prop_A = \frac{r_A\sqrt{a_{11}^2(a_{21}^2 + a_{22}^2)}}{r} \quad (2)$$

where the phenotypic correlation (r) can be written as:

$$r = r_A\sqrt{a_{11}^2(a_{21}^2 + a_{22}^2)} + r_C\sqrt{c_{11}^2(c_{21}^2 + c_{22}^2)} + r_E\sqrt{c_{11}^2(c_{21}^2 + c_{22}^2)} \quad (3)$$

Large estimates of $prop_A$ tell us that the covariation between a particular psychological trait and social trust is mainly driven by genetic factors.

Table 5 displays the standardized path coefficients, the share of the total phenotypic correlation accounted for by genetic factors, and the squared genetic correlation for females and males. Because the univariate results indicate that the shared environment exerts little or no influence on extraversion, personal control, general intelligence, and social trust, we have constrained the paths c_{11}, c_{21}, and c_{22} to zero. As is evident from the results presented in Table 6, this restriction did not significantly worsen the fit in any of the five models.

Looking first at the individual genetic path coefficients in Table 5, all of these are significantly different from zero, which indicates that the genetic sources of the psychologi-

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TABLE 5

Bivariate Cholesky Results for Psychological Traits and Social Trust

Model	a_{11} a_{21}	a_{22}	c_{11} c_{21}	c_{22}	e_{11} e_{21}	e_{22}	$prop_A$	R_A^2
Females								
Extraversion → Social trust	.71		—		.70		.70	.20
	[.67, .74]				[.67, .74]		[.56, .83]	[.12, .30]
	.28	.55	—	—	.12	.77		
	[.22, .34]	[.50, .60]			[.07, .18]	[.74, .81]		
Personal control → Social trust	.54		—		.84		.84	.24
	[.48, .60]				[.80, .88]		[.62, 1.07]	[.12, .40]
	.30	.54	—	—	.04	.78		
	[.21, .39]	[.47, .60]			[–.01, .09]	[.75, .82]		
Males								
Extraversion → Social trust	.62		—		.78		.38	.06
	[.56, .58]				[.74, .83]		[.15, .58]	[.01, .15]
	.15	.58	—	—	.19	.78		
	[.06, .23]	[.51, .63]			[.13, .26]	[.74, .82]		
Personal control → Social trust	.51		—		.86		.87	.24
	[.43, .58]				[.81, .90]		[.57, 1.20]	[.10, .47]
	.29	.52	—	—	.03	.80		
	[.19, .41]	[.41, .59]			[–.04, .29]	[.76, .85]		
General intelligence → Social trust	.89		—		.45		.88	.16
	[.87, .91]				[.42, .49]		[.75, 1.02]	[.09, .24]
	.24	.55	—	—	.06	.80		
	[.18, .30]	[.48, .61]			[–.01, .13]	[.75, .84]		

Note: [95% confidence interval]

cal traits also influence social trust. The results for the personal control–social trust models are consistent across sexes. The path coefficients (a_{21}) estimating the shared additive genetic component of the psychological trait to social trust are of similar size among men (0.29) and women (0.30). The same conclusion also holds for the unique environmental path e_{21}.

However, the social trust models indicate that the genetic covariation (a_{21}) between extraversion and social trust is almost twice as large for females (.28), compared to that for males (0.15). Constraining these path coefficients to be equal across sexes in a pooled model significantly weakens the model fit ($\Delta\chi^2 = 6.77$, $p = .009$).

The same pattern is evident when looking at the estimates of the proportion of covariation that can be explained by additive genetic factors ($prop_A$). The share of the phenotypic correlation attributable to genetic factors ranges from 70% to 90%. These estimates suggest that the relationships between social trust and the three psychological traits are largely driven by common genetic sources. The only exception is, once again, the relationship between extraversion and social trust among men, which, to a greater extent, can be explained by nonshared environmental factors (0.62), compared to genetic factors (0.38).

Further insight into the relationship between the three psychological traits and social trust is provided by the squared genetic correlation coefficient. The amount of genetic variance in social trust shared with the three psychological traits is large in magnitude and statistically significant across all five models. For both men and women, personal control accounts for 24% of the genetic variance in social trust. Among men, the social trust indicator shares 16% of its genetic variance with the measure of general intelligence. However, for extraversion, the results differ by sex. Whereas extraversion accounts for one-fifth of the genetic variance among women, the corresponding result for men is a meager 6%. The results for extraversion among women are consistent with the findings of Hiraishi et al. (2008).

Estimates of R_A^2 from bivariate models do not quantify how much of the total variation in social trust can be attributed to the combined influence of extraversion, personal control, and general intelligence. To estimate the amount of genetic variance jointly accounted for by these three traits, we utilize a multivariate model (results not shown). The ordering of the variables in a multivariate Cholesky model is crucial for the interpretation of the individual path coefficients and should be grounded in theoretical arguments. However, because this analysis focuses on the amount of variance shared by the three psychological factors and social trust rather than on estimating the specific path coefficients, the ordering of the variables is not of crucial importance. In the four-variate model for males (extraversion → personal control → general intelligence → social trust) the three psychological traits account for 30% of the genetic variance in social trust. In the trivariate model for females (extraversion → personal control → social trust), extraversion and personal control jointly account for 29% of the genetic influence on trust.

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TABLE 6

Bivariate Model Fit Statistics

Model	–2LL ACE	–2LL cij=0	p ($\Delta\chi^2$)
Females			
Extraversion → Social trust	28,935.47	28,935.47	1.00
Personal control → Social trust	24,311.93	24,311.93	1.00
MALES			
Extraversion → Social trust	19,742.80	19,743.64	.84
Personal control → Social trust	16,784.33	16,784.82	.92
General intelligence → Social trust	12,555.17	12,560.79	.13

Note: –2LL = –2*Log Likelihood for the full model and a model in which all three c-paths are dropped. The -value is associated with a hypothesis test of the difference in likelihoods (χ^2 with three degrees of freedom).

Discussion

The empirical results of this study are consistent with the expectations outlined in the introduction. In line with previous results, we found that social trust is heritable. Our estimates of the additive genetic component in social trust were consistent across the sexes — 0.33 for males and 0.39 for females — and similar to the results reported in Jang et al. (1998), Jang et al. (2002), Hiraishi et al. (2008), and Sturgis, Read, Hatemi, et al. (2010). Thus, we provide further evidence, based on a new sample and national context, that trust is influenced both by environmental and genetic factors.

Our univariate results also improve on these earlier studies because we utilize a different measure of social trust. All the studies referred to above employ all, or a subset, of the eight items comprising the trust facet from the Revised NEO Personality Inventory (Costa & McCrae, 1995). The item used in this study has been included in countless surveys around the world since the mid 1950s and has served as the most common measure of social trust among social scientists. To the best of our knowledge, the results in Table 3 provide the first support for a heritable component of this well-known survey item.

The primary contribution of this study is to better understand the genetic and environmental roots of the relationship between social trust and psychological traits. We hypothesized, based on the emancipation theory of trust and earlier empirical findings, that three psychological traits — extraversion, personal control, and social intelligence — are related to social trust. We also found moderately strong phenotypic correlations between our three psychological traits and the social trust indicator. These results deserve highlighting in their own right because there are very few studies of the relationship between psychological traits and social trust.

Moreover, in all but one case (the relationship between extraversion and social trust for males), our results showed that genetic factors account for between 70% and 90% of the correlations between the psychological traits and trust. Thus, we find strong evidence that most of the relationship between the three traits and social trust can be explained by a common genetic factor. Further, extraversion, personal control, and general intelligence (only among men) jointly account for a substantial proportion (around 30%) of the total genetic influence on social trust.

Before concluding, we would like to point out some caveats regarding our analysis. It is important to note that we utilize cross-sectional data in this study and, therefore, cannot test for causal mechanisms mediating the effect of genes on social trust. Evidence of a common genetic source for the psychological traits and social trust is consistent with, but does not prove, causal mediation. Instead, significant estimates of the genetic correlation may be consistent with any of four different scenarios. First, it may be the case that genes influence the psychological traits, which, in turn, influence social trust. Second, the reverse may be true: genes influence social trust, which, in turn, affects the three psychological characteristics. The third possibility is reciprocal causation, in which the relationship between psychological traits and social trust has a nonrecursive causal structure. Finally, it is also possible that the same set of genes influences social trust and the psychological traits independently — a relationship known as pleiotropy.

These competing causal hypotheses can, in principle, be tested with cross-sectional twin data (Duffy & Martin, 1994; Gillespie, Zhu, Neale, Heath, & Martin, 2003; Heath et al., 1993). For instance, in a recent study, Verhulst, Hatemi, and Eaves (in press) employ a direction of causation (DOC) structural model to investigate the relationship between psychological traits and political ideology. The findings they report run counter to the assumed causal structure of psychological traits influencing political attitudes. Instead, their results suggest that the correlation between psychological traits and political attitudes, in some instances, is a function of reversed causality (attitudes causing traits) and, in other instances, reflects an innate common underlying genetic factor (pleiotropy).

However, the DOC model imposes restrictive assumptions. Above all, testing a causal hypothesis using cross-sectional data requires significantly different heritabilities in the variables (Gillespie et al., 2003). With the exception of general intelligence, our univariate model results suggest that both social trust and the psychological traits have quite similar heritabilities. Thus, the data we use do not permit a clear test of the direction of causality.

Another caveat is that some of the measures used in this study suffer from limitations. Above all, social intelligence is measured with scores from tests of cognitive ability. Although cognitive ability and social intelligence are positively correlated, they are still distinct constructs. Also, using a single item as a measure of social trust may be problematic. However, although the single item strategy precludes assessment of the reliability of the social trust indicator, the indicator we use is by far the most widely

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used measure of social trust among social scientists and, therefore, interesting in its own right.

The estimates presented in this article and the caveats discussed above also provide a departure point for future research. Above all, our study can only offer a first step in the search for the etiology of social trust. Future studies should employ different designs in order to unravel the causal pathways between the variables. To test the claim that psychological traits mediate the influence of genes on trust, these studies should include panel data on the variables of interest. Future work should also include better measures of some of the psychological traits in focus here. Extraversion is measured with a behavioral inhibition scale. Although highly correlated with well-known measures of extraversion, there is reason to suspect that the scale also is related to the neuroticism dimension (Shatz, 2005). More importantly, our proxy for social intelligence is less than ideal. We did succeed in replicating the positive relationship between general intelligence and social trust reported in Sturgis, Read, and Allum (2010). However, both that study and the analysis in this paper rely on the assumption that cognitive ability tests are an acceptable proxy for social intelligence.

Finally, we have only accounted for part of the heritable variation in social trust. According to our results, extraversion, personal control, and general intelligence share some 30% of the genetic component in social trust. Consequently, the remaining 70% constitutes a "black box". Part of this variation may be due to measurement errors. The fact that earlier studies have reported an increase in heritability estimates from 0.3–0.4 to 0.5–0.66 when measurement error was taken into account suggests there may be a substantial degree of measurement error in trust indicators (Jang et al., 1998; Sturgis, Read, Hatemi et al., 2010). However, it is also likely the case that the three psychological traits examined in this study do not exhaust the list of possible correlates of social trust. Additional correlates must be identified and included in future studies in order to better understand the causal pathways between genes and social trust.

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Appendix A

Items Included in the Indices — Locus of Control (LOC)

In the following 12 statements, mark the alternative best describing how you feel.

1. a. Many of the unhappy things in people's lives are partly due to bad luck.
1. b. People's misfortunes result from the mistakes they make.

2. a. One of the major reasons why we have wars is because people don't take enough interest in politics.
2. b. There will always be wars, no matter how hard people try to prevent them.

3. a. In the long run people get the respect they deserve in this world.
3. b. Unfortunately, an individual's worth often passes unrecognized no matter how hard he tries.

4. a. The idea that teachers are unfair to students is nonsense.
4. b. Most students don't realize the extent to which their grades are influenced by accidental happenings.

5. a. Without the right breaks, one cannot be an effective leader.
5. b. Capable people who fail to become leaders have not taken advantage of their opportunities.

6. a. No matter how hard you try, some people just don't like you.
6. b. People who can't get others to like them don't understand how to get along with others.

7. a. I have often found that what is going to happen will happen.
7. b. Trusting fate has never turned out as well for me as making a decision to take a definite course of action.

8. a. Becoming a success is a matter of hard work, luck has little or nothing to do with it.
8. b. Getting a good job depends mainly on being in the right place at the right time.

9. a. The average citizen can have an influence in government decisions.
9. b. This world is run by the few people in power, and there is not much the little guy can do about it.

10. a. When I make plans, I am almost certain that I can make them work.
10. b. It is not always wise to plan too far ahead because many things turn out to be a matter of good or bad fortune anyhow.

11. a. In my case getting what I want has little or nothing to do with luck.
11. b. Many times we might just as well decide what to do by flipping a coin.

12. a. What happens to me is my own doing.
12. b. Sometimes I feel that I don't have enough control over the direction my life is taking.

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Appendix B

Adult Measure of Behavioral Inhibition (AMBI)

Additive index based on the 16 items. The response alternatives are (1) 'Yes/most of the time', (2) 'Some of the time', and (3) 'No hardly ever'.

'When you enter a new or unfamiliar social situation or whenever you are faced with new and unfamiliar surroundings or people…'

1. Do you tend to become vigilant and wary of your surroundings?

2. Do you feel awkward when you are approached by someone new?

3. Do you tend to become quiet?

4. Do you tend to approach people whom you don't know and talk to them?

5. Do you tend to spend time observing strangers from a distance first, before being able to mix in?

6. Do you tend to be chatty in conversation when you are speaking to someone new?

7. Are you likely to spend most of your time next to a person whom you know well?

8. Do you tend to feel physically anxious (e.g. racing pulse, sweaty, butterflies)?

9. Do you tend to introduce yourself to new people?

10. Do you tend to keep a fair distance away from strangers?

11. Do you tend to withdraw and retreat from those around you?

12. Do you prefer your own company over the company of others?

13. Do you usually enjoy going to social events with large crowds of people?

14. Would you tend to choose solitary leisure activities over spending time with close friends?

15. Do you prefer to be surrounded by lively activity rather than a quiet gathering?

16. If physically able, would you enjoy adventure holidays with some element of risk?

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