

A Genetic Basis for Social Trust?

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Abstract A propensity to believe that fellow citizens will not act against our interests in social and economic transactions has been identified as key to the effective functioning of democratic polities. Yet the causes of this type of ‘generalized’ or ‘social’ trust are far from clear. To date, researchers within the social and political sciences have focused almost exclusively on social-developmental and political/institutional features of individuals and societies as the primary causal influences. In this paper we investigate the intriguing possibility that social trust might have a genetic, as well as an environmental basis. We use data collected from samples of monozygotic and dizygotic twins to estimate the additive genetic, shared environmental, and non-shared environmental components of trust. Our results show that the majority of the variance in a multi-item trust scale is accounted for by an additive genetic factor. On the other hand, the environmental influences experienced in common by sibling pairs have no discernable effect; the only environmental influences appear to be those that are unique to the individual. Our findings

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problematised the widely held view that the development of social trust occurs through a process of familial socialization at an early stage of the life course.

Keywords Social trust · Genes · Genetics · Twin studies · Social capital

Introduction

The much-studied phenomenon of human cooperation and trust is often cast as a puzzle, or enigma (cf. Nannestad 2008; Putnam 1996; Uslaner 2000). Through mechanisms which are not yet clearly understood, trust appears to enable independent actors to overcome collective action problems by providing a ‘first-mover’ incentive for cooperation in situations where there are returns to, and opportunities for, free-riding (Fehr and Gintis 2007). Through trust, it seems, we are able to improve the efficiency of social and economic transactions, by reducing monitoring costs and removing the need for coercive sanctions and contractual enforcement of reciprocal obligations (Coleman 1990; Mansbridge 1999). Societies which are able to foster and maintain collective beliefs about the good-will of the ‘generalized other’ can, therefore, reap the substantial collective and individual benefits of norms of reciprocity and cooperation (Fukuyama 1995; Putnam 2002). Yet, although there is much that remains uncertain about the nature and origins of trust, one thing that we know with some certainty is that some people are more likely to trust their fellow citizens than others and that this propensity is strongly correlated with a host of normatively benign outcomes, for both individuals and social groups (Delhey and Newton 2003; Inglehart 1999b).

At the individual level trust is highest among, *inter alia*, the better educated (Nie et al. 1996; Paxton 2007; Putnam 2000), those in professional occupations and higher income groups (Alesina and Ferrera 2002; Li et al. 2005) and lowest among divorcees (Patterson 1999), the unemployed (Brehm and Rahn 1997), ethnic minorities with a history of discrimination (Alesina and Ferrera 2000), and those in poorer health (Kawachi et al. 1999; Kawachi 1997). And at the country level, aggregate trust is correlated with economic development (Fukuyama 1995a, b; Knack and Keefer 1997; Putnam 1993; Whiteley 1999), lower levels of state corruption (La Porta et al. 1999; Rothstein and Uslaner 2006), income equality (Uslaner 2002), criminality, and juvenile delinquency (Halpern 2001; Sampson et al. 1997).

Theoretical accounts of modern democratic systems have also long advocated the notion of social trust as being consequential for political behavior and, therefore, the health and vitality of democratic systems. Almond and Verba’s seminal account of America’s civic culture, for instance, identified social trust as foundational, acting as a “a generalized resource that keeps a democratic polity operating” (Almond and Verba 1963, p. 356). While, in Robert Putnam’s highly influential theory of social capital, trust between citizens plays a central role in fostering civic engagement and facilitating the maintenance of the institutions of civil society which, in turn, enhance institutional performance (Putnam 1993, 2000). And, indeed, empirical investigations have shown ‘trustees’ to be considerably more likely to join political

organisations and civic associations (Brehm and Rahn 1997; Claibourn and Martin 2000; Uslander and Brown 2005), to have confidence in their institutions of government (Brehm and Rahn 1997; Zmerli and Newton 2008), to have more positive democratic attitudes (Inglehart 1999a), and to be more tolerant of minority groups (Uslander 2002). At the aggregate level, trust has been shown to be correlated with the total number of associational memberships (Paxton 2007) and indices of democratic governance at regional and national levels (Inglehart 1997; Knack 2002; Norris 2001).

Yet, while empirical evidence supporting the idea that trust is key to ‘health, wealth, and happiness’ continues to accumulate, the source of this individual difference remains far from clear (Nannestad 2008). The enigmatic allure of generalized trust as an object of study is lent further appeal by the fact that its behavioural manifestation in humans represents a paradigmatic challenge to rational choice frameworks in economics, political science, and psychology (Carpenter 2004; Elster 1993a, b). If humans are truly self-regarding utility-maximizers, then they should not exhibit the sorts of cooperative behaviour that experimental game-theorists have now repeatedly observed (Fehr and Fischbacher 2004; Gintis et al. 2003). Thus it is that the study of social trust now represents one of the few truly multi-disciplinary fields of investigation in the increasingly fragmented world of twenty-first century social science (Delhey and Newton 2003).

Yet, despite the multi-disciplinary nature of the study of trust, there is a surprising inconsistency between disciplines regarding its fundamental origins. For, while there is now near-complete consensus among personality theorists that trust is a genetically heritable component of personality (Bouchard and Loehlin 2001; Bouchard and McGue 2003), those within sociology and political science continue to regard the trusting disposition as being acquired entirely through processes of socialization. Our aim in this paper is to draw this anomaly to the attention of the community of trust-oriented social scientists and to raise the intriguing possibility that the kind of social trust in which they are interested might have a genetic as well as an environmental basis.

Trust From a Political Science Perspective

Scholars within political science who have set themselves the challenge of addressing the trust enigma have proposed a broad range of causal hypotheses, each with varying degrees of empirical support. For some, trust is a stable attitude or core value, that is formed through familial socialization at an early stage of the life-course (Stolle and Hooghe 2004; Uslander 2002). Others argue that trust emerges out of direct experience of social interaction in the context of both informal social networks and membership of voluntary associations (Bellah et al. 1985; Paxton 2007; Putnam 2000). Through direct experience of the social and economic returns to cooperative behaviour, people are gradually inculcated into norms of reciprocity and trust. And because such interaction appears to be facilitated within homogenous groups, urbanicity and ethnic diversity have also been proposed as underpinning generalized (dis)trust (Alesina and Ferrara 2004; Putnam 2007). Those of a more

institutionalist orientation, on the other hand, regard trust between individuals citizens as following from the trustworthiness of political institutions and their agents; societies with high levels of political corruption and economic inequality beget distrustful citizens (Rothstein 2004; Rothstein and Uslaner 2006).

While these dominant theoretical perspectives are certainly not mutually exclusive, neither do they represent a coherent and integrated causal narrative of the origins of social trust in modern democratic polities. And consensus among their various proponents appears some way off at present (Hardin 2006; Nannestad 2008). What unites these causal accounts, even if only implicitly, however, is that they all look to the environment, broadly defined, as the sole source of variability in trust. This, of course, is wholly appropriate for those whose analytic focus is on political institutions and government. Yet, even those adopting a value-based perspective have almost exclusively pointed to familial socialization as the mechanism of inter-generational transmission. According to Uslaner, a key proponent of the ‘trust as moral value’ perspective, for instance, “generalized trust stems from an optimistic view of the world that we initially learn from our parents” (Uslaner 2002, p. 76).

Other prominent scholars of social trust have also singled out home life and early-years socialization as the key to our understanding of adult trust (Dohmen et al. 2006; Stolle 2003; Stolle and Hooghe 2004). Yet it is well-known that the familial concordance upon which such conclusions have generally been based may have little or nothing to do with parenting style (Harris 1998). As it stands, then, this type of evidence is equally supportive of a genetic as it is a social transmission mechanism. Additional lines of evidence also suggest that trust might have a genetic as well as an environmental basis. For instance, a wealth of survey research shows trust is “sticky” in the sense that it changes only rather slowly at the societal and individual levels (Claibourn and Martin 2000; Nannestad 2008, p. 241; Sturgis et al. 2007; Uslaner 2008), just the pattern we should anticipate for a genetically heritable phenotype. Studies have also recently begun to report evidence of neuro-chemical causes of trusting and trustworthy behavior in iterated trust games (Kosfeld et al. 2005; Zak et al. 2005), lending further *prima facie* evidence to the notion of a biological underpinning to the trusting propensity.

Most importantly for our purposes here, however, is the finding that interpersonal trust is an important component of personality, with a strong genetically heritable component (Bouchard and Loehlin 2001). Within the so-called ‘big five’ dimensional classification of personality (Costa and McCrae 1992; Goldberg 1993), trust is one of the facets falling under the ‘agreeableness’ domain. It is a dispositional trait which denotes “trust in a generalized other—a person or group with whom one has not had a great deal of experience” (Rotter 1980, p. 2), a definition which bears a high degree of similarity to those provided by key commentators on trust within political science (see Delhey and Newton 2003; Putnam 2000; Uslaner 2002) (though see Hardin 2001 for a contrary view). Using classic twin designs a number of independent studies have found the trust facet of the Big Five to have heritabilities in the range 0.20–0.52 using samples drawn from US, German, Canadian, Swedish, Sardinian, and Japanese registers (Hiraishi et al. 2008; Jang et al. 1998, 2002; Pilia et al. 2006; Shikishima et al. 2006). Given the

definitional similarity between trust as measured by personality inventories and trust as conceptualised in surveys and behavioural economics, it would seem unlikely on *a priori* grounds for the results of these genetically informed investigations to have no generality for the measures of trust typically deployed within political science.

Behavioural measures of trust and reciprocity derived from experimental implementations of the trust game¹ have also been shown to have a substantial genetic component in Swedish and American populations (Cesarini et al. 2008). Although the correspondence between such ‘revealed preference’ measures of trust and the types of self-report item, that are our focus here, does not appear to be strong (Ermisch et al. 2009; Gächter et al. 2004; Glaeser et al. 2000), these findings add further *prima facie* plausibility to the idea that the survey measures of trust upon which political scientists have placed so much weight in recent years might have a genetic basis.

The remainder of the paper is structured as follows. First, we discuss the rationale of the twin design for disentangling genetic and environmental influences on human traits and behaviour. Next, we describe the data and measures to be used in the analysis, before setting out our descriptive and model-based results. We conclude with a consideration of the generality and potential limitations of our findings and a discussion of their implications for our understanding of the origins of social trust.

Decomposing Genetic and Environmental Effects

To study the relative strength of genetic and environmental influences on individual traits and behaviours, a range of methods have been developed based on the comparison of family members with varying degrees of genetic similarity. Any family members can be used in this type of analysis, although the most powerful design includes monozygotic (MZ) and dizygotic (DZ) twins. In this type of ‘twin study’, neither genes nor environment are directly measured but are, instead, inferred from the pattern of covariance on the phenotype across sibling pairs (Neale and Cardon 1992). The twin design derives its strength from the fact that MZ twins are genetically identical, while DZ twins share, on average, 50% of their segregating genes, the same as non-twin sibling pairs. Because neither zygosity nor being a twin are likely, *per se*, to have any direct influence on most phenotypic traits (Kendler et al. 1995), we can treat the difference in genetic similarity across MZ and DZ twin pairs as exogenously determined and, with some additional assumptions, identify equations which decompose trait variability into genetic and environmental components for the population from which the twin samples were drawn.

¹ The trust game has a number of variants but the basic design involves two anonymous participants, A and B, who are given equal amounts of money by an experimenter. A (the investor) is then asked to make a donation to B (the trustee). If A makes a donation and B reciprocates, the monetary return to both A and B is greater than if each acts selfishly by making no donation. While A has an incentive to cooperate because his return is greatest when both players donate, B has an incentive to defect because her return is at its maximum when A donates and she does not. Thus, in order to obtain his maximum return, A must *trust* that B will not act selfishly when she is asked to donate (see Ostrom and Walker (2004) for an overview of experimental approaches to trust).

The additional assumptions required for unbiased estimates of additive genetic and shared environmental influences are:

1. the shared environment is ‘equally equal’ for MZ and DZ twin pairs, the so-called ‘equal environments’ (EEA) assumption.
2. there is no assortative mating between parents of MZ and DZ twins, which is to say that partner choice is independent of the trust of the members of the mate-pair.
3. the effects of genes on trust are additive; genes do not interact with other genes, or with the environment in the expression of adult trust.

It is important to be clear that these assumptions are not uncontroversial and there is a considerable body of literature, examining their theoretical and empirical plausibility, that we shall turn to in the discussion section of this article. At this juncture we note that, in our view, none of the objections raised against the twin design to date are of sufficient weight to seriously under-cut its core rationale—that differences in within-twin concordances across MZ and DZ populations are mostly accounted for by genetic differences.

In standard behavioural genetics models, the total variance of a phenotype is decomposed into genetic and environmental components. Genetic components are usually specified as additive effects (denoted ‘A’). An additive genetic effect represents the sum of all independent genetic effects. Because, in this model, total phenotypic variability must be due to either genetic or environmental effects, all non-genetically determined variance may be attributed to environmental causes. Environmental causes can be further sub-divided into ‘shared’ or ‘common environmental’ influences (denoted by ‘C’) and ‘non-shared’ or ‘unique environmental’ influences (denoted by ‘E’). Shared-environmental effects include all experiences that are shared within the twin pair such as: the family home, parental income, and family size. Unique-environmental effects include all those experiences that are unique to each individual twin, such as spousal influence, employment history, and differential parental treatment. It is important to note that estimates of unique-environmental effects for phenotypes measured by a single outcome also include errors of measurement (Bouchard and Loehlin 2001).

Using the components and assumptions mentioned above, the total phenotypic variance (V_t) is a sum of variances due to additive genetic, shared environmental and non-shared environmental effects :

$$(V)_t = a^2 + c^2 + e^2 \quad (1)$$

Because MZ twins share all their genes and, by definition, all of their shared environment and none of their unique environment, the covariance for the MZ twin pairs can be defined as:

$$(COV)_{MZ} = a^2 + c^2 \quad (2)$$

The members of a DZ twin pair, on the other hand, share half of their genes, all their shared environment and none of the unique environment. Thus the covariance for the DZ twin pair is:

$$(\text{COV})_{\text{DZ}} = 1/2 a^2 + c^2 \quad (3)$$

The logic of the twin design, then, is to partition the relative contributions of A, C, and E to phenotypic variability in terms of variance components. There are a number different statistical approaches that can be used for this purpose, though contemporary state of the art employs structural equation models (SEM) which, within a maximum likelihood framework, use latent variables and restrictions on the variance–covariance matrix of the observed scores for the trait in order to estimate the ACE components (Falconer and Mackay 1996; Neale 1997) (see also Eaves and Erkanli (2003) and Fowler et al. (2008) for a Bayesian approach to the same decomposition).

Data and Measures

In order to maximize the sample size available for analysis, we combine samples that were actually collected as two independent studies. Sample I included 559 individual Australian twins (329 females, 230 males) aged 17–26 years (mean 20.0 and SD 2.0). The twins in this sample were part of the study Genetics of Laterality, Smell, Taste and Reading (Wright and Martin 2004). These twins have participated or registered in the adolescent Twin Moles or Cognition (MAPS) studies. The data collection started in August 2002. In this sample, there were 91 MZ pairs (55 female, 36 male) and 135 DZ pairs (42 female, 28 male, 65 pairs of opposite sex). There were also 101 single twins.

Sample II included 690 individual twins (391 females, 299 males) aged 18–33 years (mean age = 23.1, SD = 3.7). These twins participated in a study on borderline personality disorder (Distel et al. 2007). The study started in July 2003. The target sample was entirely unselected for any phenotype. Twins could complete the survey online, or as a conventional mailed questionnaire. About 60% chose the online option. Zygosity of the twin pairs was determined by DNA marker test for nine pairs and for the remaining same-sex pairs conventional items on twin similarity and mistaken recognition.

The full sample comprised 280 complete pairs and 130 single twins (incomplete pairs). The latter are retained in the full information maximum likelihood (FIML) analysis of the raw data since they augment information about means, variances and sampling bias (Neale and Cardon 1992). Zygosity information was entirely lacking for nine pairs. These 18 individuals were added to the sample of singles. Of those whom zygosity could be assigned, there were 133 MZ pairs (83 female, 50 male) and 138 DZ pairs (47 female, 29 male, 62 pairs of opposite sex). Full details of the sample can be found in Distel et al. (2007). Pooling these two samples yielded 224 MZ pairs (138 female, 86 male), 273 DZ pairs (89 female, 57 male and 127 pairs of opposite sex) and 249 singles.

The Social Trust Measure

As we noted earlier, trust as a facet of ‘agreeableness’ has already been shown to have a strong genetically heritable component using the NEO-PI-R personality inventory (Hiraishi et al. 2008; Jang et al. 1998; Jang et al. 2002; Pilia et al. 2006; Shikishima et al. 2006). A reasonable objection to the conclusion that this implies equivalent origins for the kind of trust conceptualized within political science is that the measurement instruments are tapping different latent variables—personality inventories measure ‘personality’, while survey questions measure ‘attitudes’ or ‘values’. In survey research, social trust is usually measured with the long-standing item taken from Rosenberg’s misanthropy scale (Rosenberg 1956) in which respondents are asked to choose whether they think that ‘most people can be trusted’ or ‘you can’t be too careful in dealing with people’.

In the NEO-PI-R, the trust facet is derived from a total of eight Likert-type items. And, indeed, in terms of face validity, not all of these items represent a good match for social trust as it has been measured in the social and political sciences (see Glaeser et al. 2000; Sturgis and Smith (in press) for a review). Full wordings for the NEO-PI-R trust items are provided in the [Appendix](#). For the purpose of the present study, then, four items were selected which most closely match the definitions of social trust in the existing literature. These were the following:

I believe that most people are basically well-intentioned.

I believe that most people will take advantage of you if you let them.

I think that most of the people I deal with are honest and trustworthy.

My first reaction is to trust people.

Each item was measured on a five point response scale ranging from ‘strongly agree’ to ‘strongly disagree’. The negatively worded item (item 2) was reverse coded prior to analysis. The means and standard deviations and correlations between the items are presented in [Table 1](#). The Cronbach’s alpha for the four items was 0.76 in Sample I and 0.79 in Sample II.

In order to be confident that this scale really does tap the same construct as the standard generalized trust question, we took one further precautionary step using independent data collected on a general population sample in Great Britain. We included the four trust items from the NEO-PI-R alongside the Rosenberg question in the Ipsos-MORI monthly omnibus survey of adults in Britain.² A principal components analysis of these five items revealed a strong one factor solution (first eigenvalue = 2.3; second eigenvalues = 0.82) with a factor loading of 0.74 for the Rosenberg item. Clearly then, the subset of items we use in this analysis is tapping the same latent trust construct as the standard measure of trust used in the social and political sciences.

² Data were collected 14–21 July 2008, $n = 1964$. The sample design was not random but placed quota controls to match the sample to population marginals drawn from the 2001 census. Full details of the sample design and analysis are available from the corresponding author upon request.

Table 1 Correlations, means and standard deviations of the trust variables in monozygotic twins (MZ) (*n* of pairs = 184–185) presented above the diagonal, and dizygotic twins (DZ) presented below the diagonal (*n* of pairs = 220–222). The intraclass correlations for the same item are in bold.

	Twin A				Twin B				MZ Mean (SD)
	Well-int	Advantage	Trust	Honest	Well-int	Advantage	Trust	Honest	
	Twin A	Well-int	0.28 (0.13-0.42)	0.35 (0.20-0.50)	0.53 (0.38-0.68)	0.22 (0.07-0.37)	0.10 (-0.05-0.29)	0.23 (0.08-0.38)	
	Advantage	0.31 (0.18-0.44)	0.32 (0.17-0.47)	0.25 (0.10-0.40)	0.18 (0.03-0.34)	0.45 (0.30-0.60)	0.28 (0.13-0.43)	0.32 (0.18-0.46)	3.00 (1.09)
	Trust	0.44 (0.31-0.57)	0.35 (0.21-0.48)	0.41 (0.26-0.56)	0.28 (0.13-0.43)	0.18 (0.03-0.33)	0.38 (0.23-0.53)	0.36 (0.21-0.51)	3.34 (0.89)
	Honest	0.55 (0.42-0.68)	0.39 (0.26-0.52)	0.43 (0.30-0.56)	0.20 (0.05-0.35)	0.10 (-0.05-0.25)	0.20 (0.05-0.35)	0.37 (0.22-0.52)	3.70 (0.74)
Twin B	Well-int	0.18 (0.05-0.31)	-0.03 (-0.16-0.10)	0.07 (-0.06-0.20)	0.08 (-0.05-0.21)	0.23 (0.08-0.38)	0.35 (0.20-0.49)	0.47 (0.32-0.62)	3.65 (0.72)
	Advantage	0.11 (-0.02-0.24)	0.32 (0.19-0.45)	0.12 (-0.10-0.25)	0.26 (0.13-0.39)	0.32 (0.19-0.45)	0.32 (0.17-0.47)	0.30 (0.15-0.45)	3.00 (1.11)
	Trust	0.13 (0.00-0.26)	0.06 (-0.07-0.19)	0.18 (0.05-0.31)	0.18 (0.05-0.31)	0.30 (0.17-0.43)	0.45 (0.30-0.59)	0.45 (0.30-0.59)	3.33 (0.88)
	Honest	0.16 (0.03-0.29)	0.15 (0.02-0.28)	0.16 (0.03-0.30)	0.16 (0.03-0.29)	0.36 (0.23-0.49)	0.36 (0.23-0.49)	3.61 (0.82)	3.67 (0.82)
DZ Mean (SD)		3.61 (0.77)	2.93 (1.05)	3.28 (0.92)	3.60 (0.74)	2.93 (1.04)	3.18 (0.89)	3.61 (0.73)	

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Well-intentioned = most people well-intentioned; advantage = most people take advantage; trust = first reaction to trust people; honest = most people honest and trustworthy

Analysis

Structural equation modelling (SEM) was used to decompose the total variance in the trust scale into genetic and environmental components. Analyses were conducted using the Mx software package (Neale 1997). The raw data full information maximum likelihood (FIML) approach was used to fit the models to the data (Neale and Cardon 1992). Zygosity groups were separated by sex. Age and sex are included as covariates in the model.

Because we have multiple indicators of trust, it is possible to partition the variance of the ACE components into that which is common across all items and that which is specific to each item. This has the advantage of clarifying the interpretation of the unique environment (E_c) component. Where there is only a single indicator of a phenotype, the E component incorporates both the effects of the unique environment and measurement error (Bouchard and Loehlin 2001). This makes the interpretation of E ambiguous. Where multiple indicators of the phenotype are available, it is possible to estimate the contribution of the unique environment, net of errors of measurement in each individual item.

Compared to a factor model based on a sample of individual respondents, a genetic factor model fitted to twin data has twice the number of observed and latent variables because twin pairs are modeled as two separate groups in a multiple group model (Hayduk 1987). However, the model yields a single estimate of the ACE components because the variances and factor loadings of the latent factors are constrained to be equal within twin pairs (Falconer and Mackay 1996).

Two alternative factor models can be used for this partitioning: the independent pathway model and the common pathway model. Path diagrams for both models are shown in Fig. 1. Both models contain three common latent variables for additive genetic, shared environmental and non-shared environmental effects (A_c , C_c and E_c , respectively) and three specific latent variables for additive genetic, shared environmental and non-shared environmental effects (A_s , C_s , and E_s , respectively).

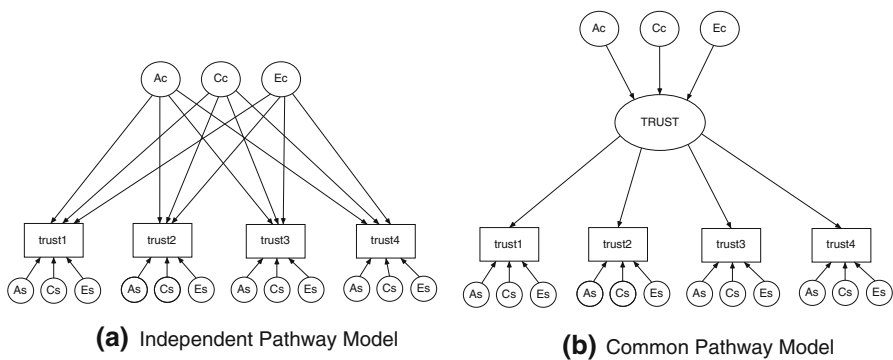


Fig. 1 **a** Independent pathway model **b** common pathway model. A_c common additive genetic effect, C_c common shared environmental effect, E_c common non-shared environmental effect, A_s specific additive genetic effect, C_s specific shared environmental effect, E_s specific non-shared environmental effect

The independent pathway model specifies a directional path between each of the ACE latent variables and each observed variable. The common pathway model specifies directional paths between each ACE latent factor and a single latent variable for the trait, with no direct effects between the ACE components and the observed variables, such that all genetic and environmental effects on the observed variables are mediated through the common latent factor (Neale and Cardon 1992). The greater parsimony of the common pathway model means that it should be preferred unless it provides a significantly worse fit to the data. Additionally, the common pathway model is to be preferred on theoretical grounds, as our interest here is in the latent construct ‘trust’ as opposed to the variance that is captured by these four particular items.

Testing of alternate models was done by means of likelihood-ratio difference tests, in which the log-likelihood of the more restricted model is subtracted from the log-likelihood of the more general model. This yields a statistic that is distributed as Chi-square, with degrees of freedom equal to the difference in the number of free parameters in the two models. A non-significant Chi-square ($p \geq 0.05$) indicates that the more restrictive model does not significantly worsen the fit of the model and so should be preferred on the grounds of parsimony (Bollen 1989). Akaike’s Information Criterion (AIC) (Akaike 1987) was also used to evaluate the fit of alternative models. Lower values of AIC are taken as indicative of superior fit in comparisons of alternative, non-nested models.

Results

Before estimation of the ACE components, it was first necessary to test for equality of variances, covariances and means across MZ and DZ groups and across the two independent samples on the four trust items. Without equality of these parameters across the zygosity groups and samples, the assumption that they are drawn from the same population would be violated. For all four trust items, likelihood ratio difference tests indicated that the model which constrained the means, variances, and covariances to be equal across samples and zygosity groups did not provide a worse fit to the data than the model in which they were allowed to be different in each group.

Additionally, the sex control suggested that a sex-limitation model, in which the components for male and female twin pairs are estimated separately, was not necessary, and the males and females in the MZ and DZ groups could be pooled for the full model. It should be noted, however, that due to the relatively small sample size, the power to reject the need for a sex limitation model was low. The pattern of within-twin correlations indicated that a sex difference might be apparent, with heritabilities greater for females than for males. Due to the large number of nested model comparisons which show only non-significant test statistics, these are not presented here but are available from the corresponding author upon request.

Before presenting the results of the model-fitting, we first set out some descriptive results for the within and between item correlations for the MZ and DZ twin pairs. Retaining the restrictions of equal standard deviations for males and

females and equal correlations for MZ males and MZ females and across DZ males, DZ females and opposite-sex DZ twins, the estimated cross-twin and cross-item correlations are presented in Table 1.

The correlations between the trust items for both MZ and DZ twin pairs are of moderate magnitude (mean = 0.37; range = 0.23–0.53) suggesting that a single common factor is a reasonable assumption. The twin1–twin2 correlations for the DZ pairs are, on average, just under half those observed for the MZ twin pairs. The magnitudes of twin correlations are low to moderate and are in a similar range to those reported in previous genetically-informed analyses of social and political attitudes (e.g., Martin et al. 1986).

When MZ within-twin correlations are substantially larger than for DZ twins an additive genetic effect is indicated. If the variance of the individual items is due to shared environmental factors alone, the DZ pairs will resemble each other to the same extent as the MZ pairs. Thus, these coefficients indicate that the familial similarity observed may also be due, at least partially, to shared environmental factors. The fact that the within-twin correlations are well below 1 indicates that most of the variation in these items is due to non-shared environmental factors.

Model Fitting

We now present the findings of the structural equation models, which are presented initially in the form of fit statistics for alternative models in Table 2. The first comparison is between the full independent pathway model (depicted in Fig. 1a) and the more stringent common pathway model (depicted in Fig. 1b). Because these models are not nested, we use the AIC as our sole measure of model fit. The more restrictive common pathway model has a slightly lower AIC and is, therefore, preferred on the grounds of statistical and theoretical parsimony.

Having established the common pathway model as our preferred specification, we proceed to test, via a series of nested model comparisons, whether each of the causal paths running from the 10 A and C latent variables to the latent and observed trust variables is non-zero. Note that this test cannot be done for the E latent variables as these are, in effect, error terms of the equations in which the A and C factors are the independent variables. We begin by considering the genetic and environmental influences on the variance which is common to all four trust items. First, we restrict the common additive genetic (A_C) effect to be zero (model 2.1 in Table 2). We then place the same restriction on the common shared environmental effect (C_C) (Model 2.2 in Table 2). Finally, the coefficients for the effect of both A_C and C_C on the latent trust variable are restricted to zero (Model 2.3 in Table 2). These comparisons indicate that there is a non-zero additive genetic effect on the latent trust variable. However, we could not reject the null hypothesis that the shared environment has no effect on latent trust at the 95% level of confidence. With respect to the trust latent variable, then, we find evidence only of additive genetic and unique environmental effects.

Next, the same steps were taken for the unique variance in each item. First, all specific additive genetic effects (A_S) were constrained to zero (Model 2.4 in Table 2). Then all specific shared environmental (C_S) effects were set to zero

Table 2 Comparison of nested independent pathway models for variance decomposition

Model	Common factors	Specific factors	-2LL	N of parameters	AIC	Model comparison	$\Delta\chi^2$ (df)
1. Full independent pathway	ACE	ACE	9412.40	36	1448	–	–
2. Full common pathway	ACE	ACE	9418.94	31	1443	2 vs. 1	6.54 (5) <i>ns</i>
2.1 $A_C = 0$	CE	ACE	9429.30	30	1451	2.1 vs. 2	10.36 (1)***
2.2 $C_C = 0$	AE	ACE	9418.94	30	1441	2.2 vs. 2	0 (1) <i>ns</i>
2.3 A_C and $C_C = 0$	E	ACE	9469.38	29	1489	2.3 vs. 2	50.44 (2)***
2.4 $A_S = 0$	ACE	CE	9420.23	26	1434	2.4 vs. 2.2	1.29 (4) <i>ns</i>
2.5 $C_S = 0$	ACE	AE	9425.58	26	1440	2.5 vs. 2.2	6.64 (4) <i>ns</i>
2.6 A_S and $C_S = 0$	ACE	E	9478.77	22	1485	2.6 vs. 2.2	59.83 (8) ***
2.7 Individual non-significant A_S and C_S paths = 0	AE	ACE	9421.81	24	1432	2.7 vs. 2.2	2.07 (6) <i>ns</i>

*** $p < 0.001$ m ** $p < 0.01$, *ns* non-significant. Full ACE includes all common and specific additive genetic, shared environmental and non-shared environmental effects. A_C common additive genetic effect, C_C common shared environmental effect, A_S specific additive genetic effect, C_S specific shared environmental effect

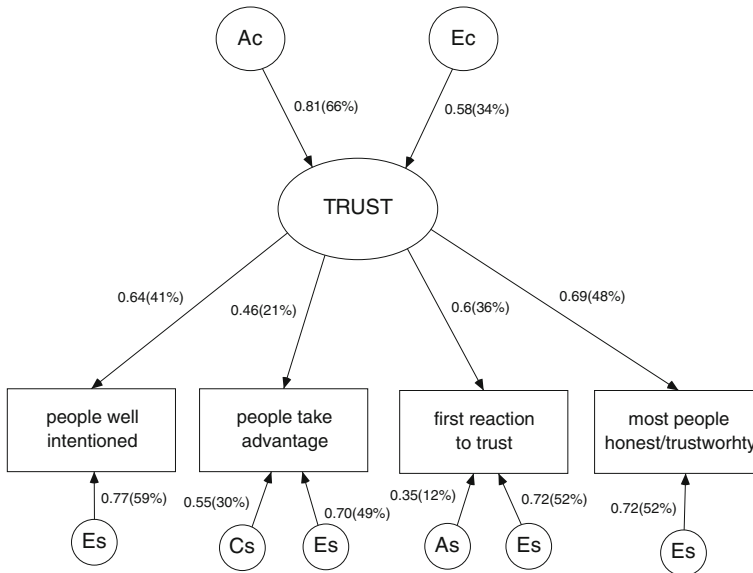


Fig. 2 Final common pathway model with significant path coefficients. A_C common additive genetic effect, C_C common shared environmental effect, E_C common non-shared environmental effect, A_S specific additive genetic effect, C_S specific shared environmental effect, E_S specific non-shared environmental effect

(Model 2.5 in Table 2). The comparison of the nested models indicated that these components could be set to zero without significantly increasing the log-likelihood of the model. However, when all specific additive genetic and shared environmental components were dropped simultaneously the fit of the model worsened significantly (Model 2.6 in Table 2). We therefore looked at each coefficient in isolation and set all non-significant specific additive genetic and shared environmental components to zero (Model 2.7 in Table 2). This final model did not significantly worsen the fit of the model relative to model 2.2.³

Figure 2 displays the coefficient estimates for the best fitting model (Model 2.7). These are standardized regression weights, so summing and squaring yields the percentage of total variance explained by each exogenous variable in each endogenous variable it predicts. These percentages are presented in parentheses on the path diagram in Fig. 2. Parameters that were constrained to zero in the model-fitting stage are not displayed on the path diagram. In terms of the latent trust variable, the additive genetic factor explains two-thirds of the variance that is common across all four items, the shared environment has no effect at all, while the unique environment explains the residual third.

³ To ensure that none of the paths was incorrectly set to zero due to the simultaneous dropping of multiple components, each non-significant component was also dropped one by one from the model, starting with the components with the lowest estimates. This step-by-step approach yielded the same result as the simultaneous constraints approach.

Table 3 Percentages (95% CI) of genetic and environmental effects on the four trust items in the final model

Item	A_C	A_S	C_C	C_S	E_C	E_S
Most people well intentioned	27% (16–38%)	0%	0%	0%	14% (3–25%)	59% (49–70%)
People take advantage	14% (7–21%)	0%	0%	30% (23–38%)	7% (1–15%)	49% (41–56%)
First reaction is to trust	24% (14–33%)	12% (3–21%)	0%	0%	12% (3–21%)	52% (43–61%)
Most people are honest/ trustworthy	31% (21–42%)	0%	0%	0%	16% (6–27%)	52% 42–62%

A_C common additive genetic effect, C_C common shared environmental effect, E_C common non-shared environmental effect, A_S specific additive genetic effect, C_S specific shared environmental effect, E_S specific non-shared environmental effect

These proportions relate only to the variance which is shared between the four items. Also presented in Fig. 2 are the coefficients for the ACE components for the variance that is unique to each item. This residual variance can be considered as measurement error because it represents the variance that remains after conditioning on the latent trust variable (Bollen 1989). For two of the items (‘people are well intentioned’ and ‘most people are honest and trustworthy’), only unique environmental effects are apparent. For ‘people take advantage’ additive genetic effects account for around a third of the residual variance, while for ‘my first reaction is to trust people’ shared environmental factors contribute around 12% of the variance unaccounted for by the latent factor.

Finally, Table 3 presents the proportion of the total variance explained in each item by each latent factor. Approximately half the total variance in each item is unique to the item in question and is accounted for by environmental factors that are not shared between sibling pairs. Approximately a quarter of the total variance in each item can be attributed to additive genetic effects. Shared environmental influences contribute just 12% of total variance in one item and nothing at all in the other three.

Discussion

Our analysis leads to two primary substantive conclusions, both of which are likely to prove controversial and difficult to integrate with existing theoretical perspectives within political science. First, we find that social trust, as measured in surveys throughout the world for the past 50 years, has a substantial genetic component. Second, while our results also confirm an important role for environmental factors, these influences were limited to those that are unique to each sibling; shared environmental influences, including all those relating to the family and home-life, do not contribute to individual differences in the sample of adolescents and young adults we have used here. While it is inappropriate to directly equate the ‘shared

environment' variance component in a twin design to 'parents' (Rowe 1994), our results nonetheless corroborate those of Cesarini et al. (2008) in questioning the dominant theoretical framework within political science, which views the acquisition of a trusting disposition as proceeding through processes of familial socialization (Stolle and Hooghe 2004; Uslander 2002; Uslander 2008).

This is not to say parents play no role, beyond transmission of genes, in the development of trust in their offspring. Rather, we find that in adolescence and early adulthood, individual differences are accounted for by genetic and non-shared environmental influences alone. It is, however, essential to explicitly acknowledge the contingent nature of our findings and several notes of caution are in order. First, the sample we have used consists of Australian twins aged 15–33, with the majority in their early 20s. The data were collected in 2002–2006. The sample is representative of this section of the Australian population at this point in time across a broad range of demographic characteristics (Wright and Martin 2004). Although our estimates are similar to, while somewhat higher than, those of previous investigations of trust as a personality dimension using US, Japanese, Canadian, and Scandinavia samples, it is possible that the estimated ACE components in other samples will vary depending on how, where, and when twin samples are selected (see Turkheimer 2004). Among an older sample of twins in a different geographical location, it is plausible that the estimated ACE components could be quite different from those we have found here. Thus, it is essential not to reify these estimates of the relative contributions of genes and environment into fixed, or static entities but to treat them as one small piece in a much larger (uncompleted) puzzle. That being said, however, we believe our results suggest a genetic basis for social trust that is likely to generalize to most, if not all, socio-political contexts.

Another limitation of our analysis relates to sample size. Because large sample sizes are required for the separation of A and C effects in the same model (Visscher 2004), our power to reject the null hypothesis of zero shared environmental influence with 497 twin pairs is low, if the magnitude of C is small. In the case of this study, our best estimate for the common C in the final model was actually zero. However, if in reality, the shared environment has a non-zero but small effect on trust, a variance component of say 8%, we would have limited power to detect it.⁴ The comparatively small sample also means that the power to detect sex differences in the models we fitted was low. Some of the descriptive analyses we presented indicated the possibility of differential heritabilities in trust for men and women but parametric tests did not lead to the rejection of the null hypothesis of zero sex difference. Future research into the genetic basis of trust could, therefore, usefully further investigate such differential sex effects.

Thus, we emphasize again, that while our results are suggestive of a limited influence of shared environmental factors, they are far from definitive. With a larger sample size and in a different context, this variance component might well prove

⁴ While perhaps unlikely, estimates within this range are certainly plausible, with 95% confidence intervals around the variance components for the unrestricted model (model 2) in table 2 having upper bounds in the range 7%–10% across the 4 items in the trust scale (estimates available from corresponding author upon request).

significantly different from zero. On the other hand, the pattern of within-twin correlations showed no strong evidence of a shared environmental effect and our sample design does afford sufficient power to detect shared environmental effects of even moderate magnitude (e.g., 12% or above). The relatively young average age of the twins in our sample is also relevant in this regard. Younger twin samples should tend toward finding shared environmental effects, insofar as these are likely to dissipate as the twins leave home and spend less time with one another as they age (Hatemi et al. 2009a). So, while we must be cautious about concluding that shared environment has no effect at all, we can be quite confident that these data do not support a strong influence of the shared environment.

We anticipate that a further line of objection to our conclusions will focus on our measure of social trust. While the survey data upon which much of the evidence base on social trust is founded uses the Rosenberg generalized trust question (GTQ), or some variant thereof, we have had to rely on a subset of items from a facet of the NEO-PI-R. Although we have shown, in a separate study, that these items are highly correlated with the GTQ, one might reasonably object that all we have shown in our main analysis is that trust is an aspect of personality and personality is genetically heritable. This can hardly be considered revelatory, at least to a psychologist (Bouchard and Loehlin 2001; Jang et al. 1998). But such a criticism would largely miss the point of our analysis. For our motivation in this paper has been to show that what political scientists refer to as social trust is, in large part at least, the same construct referred to by psychologists. And while political scientists continue to adhere to a model of complete environmental determinism, psychologists have accepted for some time that the propensity to trust has a substantial genetically heritable component (Hiraishi et al. 2008; Jang et al. 1998, 2002; Pilia et al. 2006; Shikishima et al. 2006).

Perhaps the key and most controversial aspect of the twin study design is the equal environments assumption (EEA). If the imposed environments of MZ twins are more similar than those of DZ twins, we might wrongly attribute differences in the magnitudes of covariance on the phenotype as being due to genes rather than environment. This might happen, for instance, if parents intentionally or unintentionally provide more similar environments for MZ pairs due to a belief that this is the most appropriate way to rear identical twins. Empirical investigations, however, have shown this to be an unlikely contingency. Because large numbers of parents are mistaken about the zygosity of their twins, it is possible to compare concordances on phenotypes according to perceived and actual zygosity. It transpires that perceived zygosity makes no difference—DZ twins believed by their parents to be MZ are no more similar than those correctly classified as DZ, and vice versa (Bouchard and McGue 2003).

Similarly, twins that have been reared apart are just as similar as twins raised together (Bouchard 1998 (though see methodological criticisms of studies of twins reared apart reviewed in Charney (2008))). Additionally, in this regard, Hatemi et al. (2009c) find no difference in concordance of political attitudes in a sample of MZ and DZ twins aged 9.5–18 but a large difference in political attitudes in adult twins who no longer live at home. The change in concordance was due to a decrease in the DZ correlations rather than an increase between MZs. This is the *opposite* of what

we would expect if differences in concordance are due to parents deliberately or unintentionally creating more similar environments for DZ than MZ pairs during the time the twins are resident within the family home.

It may, however, not be *perceived* zygosity that is important in this regard. It is often pointed out (Charney 2008; Mischel 1986) that MZ twins might have more similar environments than DZs because they look and behave more similarly to one another than do DZs. Thus, people they encounter throughout their lives will treat them more similarly than they would if they were DZ, because they are equally physically attractive and have more similar personalities and temperaments. This, though, is a highly circular argument. If MZ twins are treated more similarly because they are biologically more alike, this can hardly be considered a violation of the EEA. For the reason that MZ environments are more similar than DZ environments (if indeed they are) is *because of the initial difference in genetic predispositions* (Alford et al. 2008; Bouchard and Loehlin 2001).

Even if we accept the rather tortuous logic that attributes differences in shared environments to environmental causes, however, we must also still believe that these differences in shared environment are themselves able to fully explain differences in the concordance on the phenotype in question. It is not sufficient to demonstrate that MZ twins are dressed more similarly by their parents in childhood than DZ twins. One must also show (or accept) that dressing more similarly in childhood is the cause of differences in concordance between MZs and DZs on the specific phenotype under investigation. For some phenotypes, say, preference for smart or causal clothes in adulthood, this may be plausible. For others, such as alcoholism or schizophrenia, it makes little sense, if any. In our view, the sorts of differences between the environments of MZ and DZ twins that have been demonstrated to date (see, for example, Evans and Martin 2000; Scarr and Carter-Saltzman 1979) cannot plausibly account for the large difference in concordance in social trust that we have found here.

A second assumption of the twin design we have used in this paper is that there is no assortative mating. If parents select one another as a function of a trait, however, they will be more genetically similar in terms of that trait, than a randomly chosen pair in the population (Medland and Hatemi 2009; Fowler et al. 2008). This genetic resemblance of parents can bias the estimates of the ACE components by reducing the genetic difference between MZ and DZ twin pairs (Falconer and Mackay 1996). It is certainly intuitively plausible that individuals might select partners on the basis of how trusting they are and, indeed, Dohmen et al. (2006) report a between-parent trust correlation of 0.32 in the German socio-economic panel. Because this analysis was restricted to couples married during the current or previous year, it suggests that it is assortative mating rather than spousal influence that gives rise to the association.

Clearly, then, it is possible that our estimates are biased due to assortative mating. Insofar as this bias might affect our main conclusions, however, it is crucial to note that the un-modeled effect of assortative mating will be to bias the estimate of the shared environment *upward* (Fowler et al. 2008). This is because assortative mating increases the genetic similarity between DZ twins but not between MZ twins, who already share 100% of their genes. Thus, if as seems likely, the ‘no

assortative mating' assumption is violated in these data, the result will be that we over-estimate the effect of the shared environment. Because we have estimated the shared environmental variance component to be zero, assortative mating is not a relevant concern.

Finally, the model we have employed assumes that the effects of genes on trust are additive. That is to say that there are no gene \times gene and no gene \times environment interactions. While a blanket assumption of no gene \times gene interactions may be highly unrealistic in terms of how a genotype actually manifests as a phenotype, in terms of decomposition into ACE components it is unproblematic, because the interaction effects will still be correctly allocated to the additive genetic component (Bouchard and Loehlin 2001; Falconer and Mackay 1996). In this sense, however, it is more appropriate to think of the A component as the 'total heritability', combining additive genetic and genetic dominance effects, rather than additive genetic effects only.

The assumption of no gene \times environment interactions is potentially more problematic. It might be the case, for instance, that the heritability of trust varies as a function of the socio-economic status of an individual's parents (e.g., Harden et al. 2007), or level of attendance at religious ceremonies and gatherings (Fowler and Dawes 2008). If such interactions are not directly modeled, they might be incorrectly partitioned into the unique environmental variance component, leading to under-estimates of both A and C (Falconer and Mackay 1996). The sensitivity of parameter estimates to these types of un-modelled gene \times environment interactions underlines the points made earlier about the malleability of the ACE components across time, place, and culture. Our results indicate that social trust has a genetic basis and that shared environmental influences are weak to non-existent. We should not, however, consider the point estimates of the variance components in these analyses as definitive values. Rather, by using the most transparent and simplest models, the genetic estimates reported here open the door for more complex familial models in future analyses to include parents and non twin siblings in the sample thus allowing for the effects of rGE, GxE, assortative mating and twin-only environmental variance to be addressed (Eaves and Hatemi 2008; Medland and Hatemi 2009).

Conclusion

If the origin of social trust is indeed a puzzle, standard survey and experimental approaches appear at present to be some considerable way from solving it (Hardin 2006). Our aim in this paper has been to investigate the possibility that part of the reason why the solution has remained so elusive is that we might not always have been looking in the right places. In his recent comprehensive review of theorizing and research on social trust in political science, Nannestad mentions, almost in passing, the possibility that trust might be "hard-wired into our brains by evolution" (Nannestad 2008, p. 413). This seemingly fanciful notion remains undeveloped, however, and the remainder of his article is devoted to synthesizing and critiquing the myriad publications that have adopted social-learning and political-institutional

frameworks to understand the origins of trust. This is no criticism of Nannestad's review, for its content is an accurate reflection of the current state of research on social trust within political science.

As we pointed out in the introductory section of this article, however, the evidence marshalled in support of the social-learning model is equally supportive of a biological transmission mechanism. If trust is 'sticky', why should we conclude—without evidence—that this property emanates from social and cultural processes alone? If personality and cognitive ability are accepted as having a genetically heritable component, as they now surely are, why not social trust? And, in light of the evidence we have presented here, it is difficult to maintain that the type of trust in which psychologists have long been interested is orthogonal to the notion of social trust developed within political science.

Part of the reason that biogenetic mechanisms have received so little attention within the social sciences is the general lack of data appropriate for the task, though this is now beginning to change (Alford et al. 2008). It also, no doubt, reflects the perceived moral and ethical quandaries that emanate from biological explanations of human traits and behaviour. Whatever one's view of the moral implications of biological explanations of social behaviour, however, it is no longer defensible for the social scientific community to simply ignore the growing body of empirical evidence which suggests that social attitudes and dispositions like trust have a genetic basis (Alford et al. 2005; Arvery et al. 1989; Bouchard et al. 2003; Eaves and Hatemi 2008; Eaves et al. 1989; Fowler et al. 2008; Hatemi et al. 2007, 2009a, b; Heath et al. 1985).

What, though, are the implications for our understanding of political attitudes and behavior if social trust and similar constructs have a genetic basis? First, and most obviously, theoretical and empirical accounts that fail to account for genetic factors are mis-specified at the outset (Alford and Hibbing 2008; Fowler and Dawes 2008). Second, such traits must be considered less malleable and less open to the influence of deliberate policy interventions relative to a phenotype which is completely environmentally determined. On the face of it, this throws up an apparent paradox; how can the notion of genetic heritability be reconciled with known empirical regularities, such as the wide cross-national variability (Newton and Delhey 2005) and the post-war decline in social trust in the United States? (Paxton 1999; Putnam 2000). While we do not seek to resolve such issues here, it is important to be clear that positing a genetic influence on social behaviour is not an assertion of biological determinism. Biological causes are no more deterministic than are environmental ones. The results we have presented here, like the vast majority of genetically informed analyses of human traits and behaviors, attribute a substantial causal role to 'the environment'. Additionally, the mechanisms linking genes to complex phenotypes like social and political attitudes are extremely complex, involving high dimensional interactions between and among genes, environments, and phenotypes, in ways which may ultimately prove both unyielding to empirical analysis and beyond the scope of human comprehension (Plomin 1994; Turkheimer 2004). In sum, according a partial causal influence of genes on trust is entirely consistent with both cross-national and temporal variability in trust.

If one accepts the broad conclusion that genes do influence social trust, we must also address the issue of the mechanism through which this comes about. We propose two broad but not mutually exclusive possibilities, the first can be considered a ‘weak’, the second a ‘stronger’ biological explanation (Turkheimer 1998). First, genes may exert only an *indirect* effect on trust via some other trait or behaviour which is itself more directly genetically determined (Fowler and Dawes 2008). Recent evidence from a Japanese twin study lends support for this type of mediational model. Hiraishi et al. (2008) show that the additive genetic components of the extraversion and agreeableness dimensions of the Big Five personality inventory are able to account for 9 and 6%, respectively, of the trust facet of the NEOPI-R. They argue that humans adaptively control their levels of trust (and other dispositions) through the interaction of personality and environment. The adaptive advantage of trust varies across individuals in different environments, so personality traits act as regulatory mechanisms to control its phenotypic manifestation. In sum, the phenotype has a direct genetic basis but environmental conditions will determine whether or not the genetic mechanism is ‘switched on’.

In addition to this kind of indirect biological influence, trust might have a more direct, yet still highly complex and contingent, genetic foundation. In this view, trust has developed as an evolutionary adaptation to over-come collective action and free-rider problems in social and economic life. Many manifestations of human cooperation and trust belie explanation by rational choice models of selfish utility-maximization (Gintis et al. 2003; Ostrom and Walker 2003). Direct genetic selection of a ‘trusting’ trait has, in consequence, been proposed as the most plausible explanation for its manifestation in human populations across time and culture (Kurzban and Houser 2005). Evidence from agent-based simulations (Boyd et al. 2003) and behavioural economics (Fischbacher et al. 2001) have lent growing support to the notion of trust as a genetically evolved dispositional trait. This, of course, takes us back to the idea discussed earlier; that social trust, as measured in surveys, might ultimately be an aspect of personality.

Twin studies represent only a first tentative step in understanding how genetic hard-wiring might link to complex human traits and behaviours (Alford et al. 2008; Turkheimer 2004). They can enable us to directly address the question of whether, and to what extent, a given trait or behaviour is genetically determined for a specific population at a particular point in time. On the question of *how* this influence is instantiated, however, they are silent. These speculations, then, suggest some potentially fruitful avenues for how research into the origins of social trust might be usefully developed in the future.

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Appendix

See Table 4.

Table 4 Trust variables (NEO-PI-R) in two Australian twin samples

Trust question (questions in italics were those used in this paper)

I tend to be cynical and sceptical of others' intentions
 I believe that most people are basically well-intentioned
 I believe that most people will take advantage of you if you let them
 I think that most of the people I dealt with are honest and trustworthy
 I'm suspicious when someone does something nice for me
 My first reaction is to trust people
 I tend to assume the best about people
 I have a good deal of faith in human nature

References

- Akaike, H. (1987). Factor analysis and AIC. *Psychometrika*, *52*, 317–332.
- Alesina, A., & Ferrara, E. L. (2004). *Ethnic diversity and economic performance* (pp. 1–46). Cambridge, MA: National Bureau of Economic Research.
- Alesina, A., & Ferrara, E. L. (2000). Participation in heterogeneous communities. *The Quarterly Journal of Economics*, *115*, 847–904.
- Alesina, A., & Ferrara, E. L. (2002). Who trusts others? *Journal of Public Economics*, *85*, 207–234.
- Alford, J. R., Funk, C. L., & Hibbing, J. R. (2005). Are political orientations genetically transmitted? *American political Science Review*, *99*, 153–167.
- Alford, J., Funk, C. L., & Hibbing, J. (2008). Beyond liberals and conservatives to political genotypes and phenotypes. *Perspectives in Politics*, *6*, 321–328.
- Alford, J., & Hibbing, J. (2008). The new empirical biopolitics. *Annual Review of Political Science*, *11*, 183–203.
- Almond, G., & Verba, S. (1963). *The civic culture*. Boston: Little, Brown.
- Arvey, R., Bouchard, T. J., Segal, N., & Abraham, L. (1989). Job satisfaction: Environmental and genetic components. *Journal of Applied Psychology*, *74*, 187–192.
- Bellah, R., Madsen, R., Sullivan, W., Swidler, A., & Tipton, S. (1985). *Habits of the heart: Individualism and commitment in American life*. Berkeley, CA: University of California Press.
- Bollen, K. (1989). *Structural equations with latent variables*. New York: Wiley.
- Bouchard, T. J. (1998). Genetic and environmental influences on adult intelligence and special mental abilities. *Human Biology*, *70*, 257–279.
- Bouchard, T. J., & Loehlin, J. C. (2001). Genes, evolution and personality. *Behavior Genetics*, *31*, 243–273.
- Bouchard, T. J., Jr., & McGue, M. (2003). Genetic and environmental influences on human psychological differences. *Journal of Neurobiology*, *54*, 4–45.
- Bouchard, T. J., Segal, N. L., Tellegen, A., McGue, M., Keyes, M., & Krueger, R. (2003). Evidence for the construct validity and heritability of the Wilson-Patterson conservatism scale: A reared-apart twins study of social attitudes. *Journal of Personality and Individual Differences*, *34*, 959–969.
- Boyd, R., Gintis, H., Bowles, S., & Richerson, P. J. (2003). The evolution of altruistic punishment. *Proceedings of the National Academy of Sciences of the United States of America*, *100*, 3531–3535.
- Brehm, J., & Rahn, W. (1997). Individual-level evidence for the causes and consequences of social capital. *American Journal of Political Science*, *41*, 999–1023.
- Carpenter, J. P. (2004). Trust and reciprocity: Interdisciplinary lessons from experimental research. In E. Ostrom & J. Walker (Eds.), *Trust and reciprocity*. New York: Russell Sage Foundation.
- Cesarini, D., Dawes, C., Fowler, J., Johannesson, M., Lichtenstein, P., & Wallace, B. (2008). Heritability of cooperative behavior in the trust game. *Proceedings of the National Academy of Sciences*, *105*, 3721–3726.
- Charney, E. (2008). Genes and ideologies. *Perspectives in Politics*, *6*, 299–315.

- Claibourn, M. P., & Martin, P. S. (2000). Trusting and joining? An empirical test of the reciprocal nature of social capital. *Political Behaviour*, 22, 267–291.
- Coleman, J. S. (1990). *Foundations of social theory*. Cambridge, MA: Harvard University Press.
- Costa, P. T., Jr., & McCrae, R. R. (1992). *NEO PI-R professional manual*. Odessa, FL: Psychological Assessment Resources, Inc.
- Delhey, J., & Newton, K. (2003). Who trusts? The origins of social trust in seven societies. *European Societies*, 5, 93–137.
- Distel, M. A., Ligthart, L., Willemssen, G., Nyholt, D. R., Trull, T. J., & Boomsma, D. I. (2007). Personality, health and lifestyle in a questionnaire family study: A comparison between highly cooperative and less cooperative families. *Twin Research and Human Genetics*, 10, 348–353.
- Dohmen, T., Falk, A., Huffman, D., Sunde, U. (2006). The intergenerational transmission of risk and trust attitudes. (IZA Discussion Paper No. 2380).
- Eaves, L., & Erkanli, A. (2003). Markov chain Monte Carlo approaches to analysis of genetic and environmental components of human developmental change and G X E interaction. *Behavior Genetics*, 33, 279–299.
- Eaves, L. J., Eysenck, H. J., & Martin, N. G. (1989). *Genes, culture, and personality: An empirical approach*. San Diego: Academic.
- Eaves, L. J., & Hatemi, P. K. (2008). Transmission of attitudes toward abortion and gay rights: Parental socialization or parental mate selection? *Behavior Genetics*, 38, 247–256.
- Elster, J. (1993a). *The cement of society: A survey of social order*. Cambridge: Cambridge University Press.
- Elster, J. (1993b). Some unresolved problems in the theory of rational behaviour. *Acta Sociologica*, 36, 179.
- Ermisch, J., Laurie, H., Uhrig, N., Siedler, T., & Gambetta, D. (2009). Measuring people's trust. *Journal of the Royal Statistical Society*, 172, 749–769.
- Evans, D. M., & Martin, N. G. (2000). The validity of twin studies. *GeneScreen*, 1, 77–79.
- Falconer, D. S., & Mackay, T. F. C. (1996). *Introduction to quantitative genetics* (4th ed.). Harlow, Essex: Longmans Green.
- Fehr, E., & Fischbacher, U. (2004). Third-party punishment and social norms. *Evolution and Human Behavior*, 25, 63–87.
- Fehr, E., & Gintis, H. (2007). Human motivation and social cooperation: Experimental and analytical foundations. *Annual Review of Sociology*, 33, 43–64.
- Fischbacher, U., Gächter, S., & Fehr, E. (2001). Are people conditionally cooperative? Evidence from a public goods experiment. *Economic Letters*, 71, 397–404.
- Fowler, J., Baker, L., & Dawes, C. (2008). Genetic variation in political participation. *American Political Science Review*, 102, 233–248.
- Fowler, J., & Dawes, C. (2008). Two genes predict voter turnout. *Journal of Politics*, 70, 579–594.
- Fukuyama, F. (1995). *Trust*. New York: Free Press.
- Fukuyama, F. (1995a). Social capital and the global economy. *Foreign Affairs*, 74, 89–98.
- Fukuyama, F. (1995b). *Trust: The social virtues and the creation of prosperity*. London: Penguin.
- Gächter, S., Hermann, B., & Thoni, C. (2004). Trust, voluntary cooperation, and socio-economic background: Survey and experimental evidence. *Journal of Economic Behavior and Organization*, 55, 505–531.
- Gintis, H., Bowles, S., Boyd, R., & Fehr, E. (2003). Explaining altruistic behavior in humans. *Evolution and Human Behavior*, 24, 153–172.
- Glaeser, E. L., Laibson, D., Scheinkman, J. A., & Soutter, C. L. (2000). Measuring trust. *The Quarterly Journal of Economics*, 115, 811–846.
- Goldberg, L. R. (1993). The structure of phenotypic personality traits. *American Psychologist*, 48, 26–34.
- Halpern, D. (2001). Moral values, social trust and inequality: Can values explain crime. *British Journal of Criminology*, 41, 236–252.
- Harden, K. P., Turkheimer, E., & Loehlin, J. C. (2007). Genotype by environment interaction in adolescents' cognitive aptitude. *Behavior Genetics*, 37, 273–283.
- Hardin, R. (2001). Conceptions and explanations of trust. In K. Cook (Ed.), *Trust and society* (pp. 3–39). New York: Russell Sage Foundation.
- Hardin, R. (2006). *Trust*. Cambridge: Polity.
- Harris, J. R. (1998). *The nurture assumption: Why children turn out the way they do*. New York: Simon and Schuster.

- Hatemi, P. K., Funk, C. L., Medland, S. E., Maes, H., Silberg, J., Martin, N. G., et al. (2009c). Genetic and environmental transmission of political attitudes across the life-course. *Journal of Politics*, *71*(3), 1141–1156.
- Hatemi, P. K., Hibbing, J. R., Alford, J. R., Martin, N. G., & Eaves, L. J. (2009a). Is there a party in your genes? *Political Research Quarterly*, *62*, 584–600.
- Hatemi, P. K., Medland, S. E., & Eaves, L. J. (2009b). Genetic sources of the gender gap? *Journal of Politics*, *71*, 262–276.
- Hatemi, P. K., Medland, S. E., Morley, K. I., Heath, A. C., & Martin, N. G. (2007). The genetics of voting: An Australian twin study. *Behavior Genetics*, *37*, 435–448.
- Hayduk, L. A. (1987). *Structural equation modeling with LISREL: Essentials and advances*. Baltimore, MD: Johns Hopkins University Press.
- Heath, A. F., Jowell, Roger., & Curtice, John. (1985). *How Britain votes*. Oxford: Pergamon.
- Hiraishi, K., Yamagata, S., Shikishima, C., & Ando, J. (2008). Maintenance of genetic variation in personality through control of mental mechanisms: A test of trust, extraversion, and agreeableness. *Evolution and Human Behavior*, *29*, 79–85.
- Inglehart, R. (1997). *Modernisation and postmodernisation*. Princeton: Princeton University Press.
- Inglehart, R. (1999a). Postmodernization erodes respect for authority but increases support for democracy. In P. Norris (Ed.), *Critical citizens* (pp. 236–256). Oxford: Oxford University Press.
- Inglehart, R. (1999b). Trust, well-being and democracy. In M. E. Warren (Ed.), *Democracy and trust* (pp. 88–120). Cambridge: Cambridge University Press.
- Jang, K. L., Livesley, W. J., Angleitner, A., Riemann, R., & Vernon, P. A. (2002). Genetic and environmental influences on the covariance of facets defining the domains of the five-factor model of personality. *Personality and Individual Differences*, *33*, 83–101.
- Jang, K. L., McCrae, R. R., Angleitner, A., Riemann, R., & Livesley, W. J. (1998). Heritability of facet-level traits in a cross-cultural twin sample: Support for a hierarchical model of personality. *Journal of Personality and Social Psychology*, *74*, 1556–1565.
- Kawachi, I. (1997). Long live community: Social capital as public health. *American Prospect*, *35*, 56–59.
- Kawachi, I., Kennedy, B., & Glass, R. (1999). Social capital and self-rated health: A contextual analysis. *American Journal of Public Health*, *8*, 1187–1193.
- Kendler, K. S., Martin, N. G., Heath, A. C., & Eaves, L. J. (1995). Self-report psychiatric symptoms in twins and their nontwin relatives: Are twins different? *American Journal of Medical Genetics (Neuropsychiatric Genetics)*, *60*, 588–591.
- Knack, S. (2002). Social capital and the quality of government: Evidence from the United States. *American Journal of Political Science*, *46*, 772–785.
- Knack, S., & Keefer, P. (1997). Does social capital have an economic payoff? A cross-country investigation. *The Quarterly Journal of Economics*, *112*, 1251–1288.
- Kosfeld, M., Heinrichs, M., Zak, P., Fischbacher, U., & Fehr, E. (2005). Oxytocin increases trust in humans. *Nature*, *435*, 673–676.
- Kurzban, R., & Houser, D. (2005). Experiments investigating cooperative types in humans: A complement to evolutionary theory and simulations. *Proceedings of the National Academy of Sciences of the United States of America*, *102*, 1803–1807.
- La Porta, R., Lopez-de-Silanes, F., Shleifer, A., & Vishny, R. (1999). The quality of government. *Journal of Law, Economics and Organization*, *15*, 222–279.
- Li, Y., Pickles, A., & Savage, M. (2005). Social capital and social trust in Britain. *European Sociological Review*, *21*, 109–123.
- Mansbridge, J. (1999). Altruistic trust. In M. E. Warren (Ed.), *Democracy and trust* (pp. 290–309). Cambridge: Cambridge University Press.
- Martin, N. G., Eaves, L. J., Heath, A. C., Jardine, R., Feingold, L. M., & Eysenck, H. J. (1986). Transmission of social attitudes. *Proceedings of the National Academy of Sciences of the United States of America*, *83*, 4364–4368.
- Medland, S. E., & Hatemi, P. K. (2009). Political science, biometric theory, and twin studies: A methodological introduction. *Political Analysis*, *17*, 191–214.
- Mischel, W. (1986). *Introduction to personality* (4th ed.). New York: Holt, Rinehart & Winston.
- Nannestad, P. (2008). What have we learned about generalized trust, if anything? *Annual Review of Political Science*, *11*, 413–436.
- Neale, M. C. (1997). *Mx: Statistical modeling (Box980126)* (3rd ed.). Richmond, VA: MCV.
- Neale, M. C., & Cardon, L. R. (1992). *Methodology for genetic studies of twins and families*. Dordrecht: Kluwer Academic Publishers.

- Newton, K., & Delhey, J. (2005). Predicting cross-national levels of social trust: Global pattern or Nordic exceptionalism? *European Sociological Review*, 21, 311–327.
- Nie, N., Junn, J., & Stehlik-Barry, K. (1996). *Education and democratic citizenship in America*. Chicago: University of Chicago Press.
- Norris, P. (2001). Making democracies work: Social capital and civic engagement in 47 countries. In: *European science foundation EURESCO conference on social capital: Interdisciplinary perspectives*. Exeter: University of Exeter.
- Ostrom, E., & Walker, J. (Eds.). (2003). *Trust and reciprocity: Interdisciplinary lessons from experimental research*. New York: Russell Sage Foundation.
- Ostrom, E., & Walker, J. (2004). Trust and reciprocity: Interdisciplinary lessons from experimental research. *Contemporary Sociology*, 33, 493–494.
- Patterson, O. (1999). Liberty against the democratic state: On the historical and contemporary sources of American distrust. In M. E. Warren (Ed.), *Democracy and trust* (pp. 151–207). Cambridge: Cambridge University Press.
- Paxton, P. (1999). Is social capital declining in the United States? A multiple indicator assessment. *The American Journal of Sociology*, 105, 88–127.
- Paxton, P. (2007). Not all association memberships increase trust: A model of generalized trust in thirty-one countries. *Social Forces*, 86, 47–76.
- Pilia, G., Chen, W. -M., Scuteri, A., Orrù, M., Albai, G., Dei, M., et al. (2006). Heritability of cardiovascular and personality traits in 6, 148 sardinians. *PLoS Genetics*, 2, e132.
- Plomin, R. (1994). *Genetics and experience: The interplay between nature and nurture*. Thousand Oaks CA: Sage.
- Putnam, R. D. (1993). *Making democracy work: Civic traditions in modern Italy*. Princeton: Princeton University Press.
- Putnam, R. (1996). The strange disappearance of civic America. *The American Prospect*, 24, 34–48.
- Putnam, R. (2000). *Bowling alone: The collapse and revival of American community*. New York: Simon and Schuster.
- Putnam, R. (2002). Bowling together. *The American Prospect*, 13, 20–22.
- Putnam, R. D. (2007). E Pluribus Unum: Diversity and community in the twenty-first century the 2006 Johan Skytte prize lecture. *Scandinavian Political Studies*, 30, 137–174.
- Rosenberg, M. (1956). Misanthropy and political ideology. *American Sociological Review*, 21, 690–695.
- Rothstein, B. (2004). Social trust and honesty in government: A causal mechanisms approach. In J. Kornai, B. Rothstein, & S. Rose-Ackerman (Eds.), *Creating social trust in post-socialist transitions*. New York: Palgrave Macmillan.
- Rothstein, B., & Uslaner, E. M. (2006). All for all: Equality and social trust. *World Politics*, 58, 652–654.
- Rotter, J. (1980). Interpersonal trust, trustworthiness, and gullibility. *American Psychologist*, 35, 1–7.
- Rowe, D. (1994). *The limits of family influence: Genes, experience, and behavior*. New York: The Guildford Press.
- Sampson, R. J., Raudenbush, S., & Earls, F. (1997). Neighborhoods and violent crime: A multilevel study of collective efficacy. *Science*, 277, 918–924.
- Scarr, S., & Carter-Saltzman, L. (1979). Twin method: Defense of a critical assumption. *Behavior Genetics*, 9, 527–542.
- Shikishima, C., Hiraishi, K., & Ando, J. (2006). Genetic and environmental influences on general trust: A test of a theory of trust with behavioral genetic and evolutionary psychological approaches. *Japanese Journal of Social Psychology*, 22, 48–57.
- Stolle, D. (2003). The sources of social capital. In D. Stolle & M. Hooghe (Eds.), *Generating social capital: Civil society, institutions in comparative perspective*. New York: Palgrave Macmillan.
- Stolle, D., & Hooghe, M. (2004). The roots of social capital: Attitudinal and network mechanisms in the relation between youth and adult indicators of social capital. *Acta Politica*, 39, 422–441.
- Sturgis, P., Patulny, R., Allum, N. (2007, February 22–25). *What makes trusters trust?* Paper presented at the reciprocity: Theories and facts conference, Verbania, Italy.
- Sturgis, P., & Smith, P. (in press). Assessing the validity of generalized trust questions: What kind of trust are we measuring? *International Journal of Public Opinion Research*.
- Turkheimer, E. (1998). Heritability and biological explanation. *Psychological Review*, 105, 782–791.
- Turkheimer, E. (2004). Spinach and ice cream: Why social science is so difficult. In L. DiLalla (Ed.), *Behavior genetics principles: Perspectives in development, personality, psychopathology* (pp. 161–189). Washington, DC: American Psychological Association.
- Uslaner, E. M. (2000). Producing and consuming trust. *Political Science Quarterly*, 115, 569–590.

- Uslaner, E. (2002). *The moral foundations of trust*. Cambridge: Cambridge University Press.
- Uslaner, E. (2008). Where you stand depends upon where your grandparents sat. *Public Opinion Quarterly*, 72, 725–740.
- Uslaner, Eric M., & Mitchell Brown. (2005). “Inequality, Trust and Civic Engagement: a review of the literature for the Russell Sage Foundation.” *American Politics Research*, 33(6), 868–894.
- Visscher, P. M. (2004). Power of the classical twin design revisited. *Twin Research*, 7, 505–512.
- Whiteley, P. (1999). The origins of social capital. In J. van Deth, M. Maraffi, K. Newton, & P. Whiteley (Eds.), *Social capital and European democracy*. London: Routledge.
- Wright, M. J., & Martin, N. G. (2004). The brisbane adolescent twin study: Outline of study methods and research projects. *Australian Journal of Psychology*, 56(2004), 65–78.
- Zak, P. J., Kurzban, R., & Matzner, W. (2005). Oxytocin is associated with human trustworthiness. *Hormones and Behavior*, 48, 522–527.
- Zmerli, S., & Newton, K. (2008). Social trust and attitudes toward democracy. *Public Opinion Quarterly*, 72, 706–724.