

# The Relationship between Genes, Psychological Traits, and Political Participation

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*Recent research demonstrates that a wide range of political attitudes, beliefs, and behaviors can be explained in part by genetic variation. However, these studies have not yet identified the mechanisms that generate such a relationship. Some scholars have speculated that psychological traits mediate the relationship between genes and political participation, but so far there have been no empirical tests. Here we focus on the role of three psychological traits that are believed to influence political participation: cognitive ability, personal control, and extraversion. Utilizing a unique sample of more than 2,000 Swedish twin pairs, we show that a common genetic factor can explain most of the relationship between these psychological traits and acts of political participation, as well as predispositions related to participation. While our analysis is not a definitive test, our results suggest an upper bound for a proposed mediation relationship between genes, psychological traits, and political participation.*

Motivated by earlier research showing a genetic basis for political attitudes (Alford, Funk, and Hibbing 2005; Martin et al. 1986), researchers recently discovered that political behaviors, like voter turnout and other acts of political participation, are also influenced by genetic variation (Fowler, Baker, and Dawes 2008). These findings raise the question of how genes and political participation are linked. Mondak (2010) suggested that personality traits may intermediate the relationship between genes and political participation, a conjecture that is potentially supported by recent schol-

arship demonstrating a relationship between personality traits and political participation (Blais and St-Vincent 2011; Denny and Doyle 2008; Gallego and Oberski 2012; Gerber et al. 2011; Mondak 2010; Mondak and Halperin 2008; Mondak et al. 2010; Vecchione and Caprara 2009). However, an empirical link between genes, personality traits, and political participation has yet to be established. This article seeks to explore the relationship between all three using a uniquely assembled and comprehensive genetically informative data set with information on personality, cognitive ability, and a wide range of political

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attitudes, beliefs, and behaviors. We focus on three potential intermediate psychological traits identified by the literature: cognitive ability, personal control, and extraversion.

In order to investigate a relationship between genes, psychological traits, and political participation, it is necessary to move from a univariate to a bivariate framework of analysis. The primary bivariate model we employ, a Cholesky decomposition model, allows us to estimate the genetic contribution to the observed covariation between political participation and psychological traits.<sup>1</sup> However, while the Cholesky model shows that political participation and the three psychological traits we study are genetically related, it is limited in that it does not allow us to adjudicate between different types of possible relationships. Psychological traits may mediate the relationship between genes and political participation; however, alternatively, psychological traits and political participation may share the same underlying genetic mechanism but not share a causal relationship (Posthuma et al. 2003).<sup>2</sup> The latter scenario, known as pleiotropy, implies that genetic factors are a confounder.

To preview our results, we demonstrate that both acts of participation and related political predispositions share a common source of genetic variation with psychological traits. However, the three psychological traits we study account for only a modest amount of the heritable variation in political participation and predispositions. If psychological traits are in fact mediators, as has been hypothesized by other scholars (Mondak 2010; Mondak et al. 2010), a majority of the heritable variation in political participation and predispositions is likely mediated by traits other than cognitive ability, personal control, and extraversion. Finally, we attempt to test the nature of the relationship between genes, psychological traits, and political participation using a direction of causation model (Duffy and Martin 1994; Heath et al. 1993).<sup>3</sup>

Our work aims to address a fundamental question in political science, namely, why some individuals participate in politics whereas others do not. One answer to this

question is that genetic variation can ultimately explain a moderate to large share of individual differences in these behaviors. However, this begs the important question of *how* genes influence political behaviors. This article examines potential mechanisms that have been hypothesized in the literature to mediate the relationship between genetic factors and various acts of political participation and demonstrates the utility of combining methods from behavioral genetics and personality psychology to better understand heterogeneity in political participation. While our analysis is not a definitive test, our results suggest an upper bound for a proposed mediation relationship between genes, psychological traits, and political participation.

## Theoretical and Empirical Evidence

Fowler, Baker, and Dawes (2008) first established a link between genes and political participation based on their analysis of acts such as voting, volunteering in a political club or organization, contributing money to a political party or candidate, contacting a government official regarding political or community issues, running for public office, or attending a political rally or march. The authors found that 60% of the variation in overall participation could be attributed to genetic factors. Recently, a group of scholars found similar heritability estimates for measures of nonvoting participation in Denmark and a new U.S. sample (Klemmensen et al. 2012).

While the fact that individual differences in political participation can be traced to genetic variation is interesting, the influence of genes on modern behaviors such as these is likely indirect via more fundamental traits.<sup>4</sup> Distinguishing between the various mechanisms that might help explain the heritable variation in a trait is an important next step in this research agenda. Scholars studying the effect of personality on political participation and attitudes have argued that since personality traits are formed before political behaviors, and are known to be heritable (Bouchard and McGue 2003), they likely represent an intermediate link in the causal chain (Mondak 2010; Mondak et al. 2010).

The idea that personality traits in part shape political participation can be traced back to *The American Voter* (Campbell et al. 1960); however, a new generation of scholars has begun to rigorously investigate this assertion (Blais and St-Vincent 2011; Denny and Doyle 2008; Gallego and Oberski 2012; Gerber et al. 2011; Mondak

<sup>1</sup>Medland and Hatemi (2009) provide a detailed description of the Cholesky model geared toward a political science audience. The Cholesky decomposition has also been utilized in several recently published political science studies (Arceneaux, Johnson, and Maes 2012; Fazekas and Littvay 2012; Hatemi, Hibbing, et al. 2009; Klemmensen et al. 2012; Littvay, Weith, and Dawes 2011; Oskarsson et al. 2012; Weber, Johnson, and Arceneaux 2011).

<sup>2</sup>These two possible relationships are illustrated by Online Appendix Figure 1 and Figure 2 in the supporting information. It may also be the case that political participation causes psychological traits or there is reciprocal causation (Verhulst, Eaves, and Hatemi 2012).

<sup>3</sup>Verhulst, Eaves, and Hatemi (2012) was the first study in political science to utilize the direction of causation model.

<sup>4</sup>There are several recent reviews of the genetics of politics (Fowler and Schreiber 2008; Hatemi, Byrne, and McDermott 2012; Hatemi et al. 2011; Hatemi and McDermott 2012).

and Halperin 2008; Mondak et al. 2010; Vecchione and Caprara 2009).<sup>5</sup> While comprehensive theory linking personality traits to political participation is being actively developed (Mondak 2010; Mondak and Halperin 2008; Mondak et al. 2010), scholars have consistently argued that traits related to personal control and a willingness to engage in social interaction are likely to influence political participation (Blais and St-Vincent 2011; Carlson and Hyde 1980; Carmines 1978; Cohen, Vigoda, and Samorly 2001; Gerber et al. 2011; Guyton 1988; Milbrath and Goel 1977; Mondak and Halperin 2008; Mondak et al. 2010; Vecchione and Caprara 2009).

Campbell et al. (1960) originally argued that differences in one's general feeling of mastery over the self and environment probably translate into the political process as well. Competence theory, developed by Carmines (1978), postulates that personal control promotes political participation. Personal control is the belief that outcomes are the product of one's own efforts. The incentive to engage in any kind of action is predicated on whether or not it can produce a desired outcome. If the outcome is believed to be out of one's control, then there is little incentive to undertake an action, especially if it is costly to do so. Competence theory extends this thinking to political engagement. Individuals with high personal control will be motivated to become involved in the political process because their actions will be rewarded with a desired political outcome. Several studies have found empirical support for competence theory (Carlson and Hyde 1980; Carmines 1978; Guyton 1988; Milbrath and Goel 1977). Recent work has also demonstrated an empirical link between self-efficacy, a trait strongly related to personal control (Bono and Judge 2003; Judge et al. 2002), and political participation. Blais and St-Vincent (2011) reported a positive relationship between a measure of general self-efficacy and two different indicators of turnout. Self-efficacy and personal control are strongly related concepts; self-efficacy is defined as the belief in one's ability to perform across many different contexts, and personal control is the belief in one's ability to control one's environment (Bono and Judge 2003). However, self-efficacy is a broader concept tapping both control over the environment and a general belief in one's competence, so the two concepts are not equivalent.<sup>6</sup>

<sup>5</sup>The literature studying the personality and political attitudes goes back further to Adorno et al. (1950), Eysenck (1954), and McClosky (1958).

<sup>6</sup>The correlation between self-efficacy and personal control is 0.56 (Bono and Judge 2003). The two-question measure Blais and St-Vincent (2011) use asks whether respondents agree with the statements "I can do just about anything I really set my mind to" and

Mondak and Halperin (2008) theorize that since social interaction is essential for many political acts, one's general predisposition toward engaging with others should influence one's willingness to participate in politics. This is especially true for acts like attending and speaking at meetings or rallies, signing petitions, and participating in political discussions. In support of this assertion, Mondak et al. (2010) found a significant relationship between the Big Five personality trait extraversion, which is marked by sociability and an eagerness to engage with others, and contacting an elected official, attending public meetings, and attending election rallies. Vecchione and Caprara (2009) also reported extraversion to be significantly related to overall participation. Finally, Blais and St-Vincent (2011) found shyness to be inversely related to the propensity to vote.

The assertion that personality traits are causally prior to political traits has recently been challenged (Verhulst, Eaves, and Hatemi 2012; Verhulst and Estabrook 2012; Verhulst, Hatemi, and Martin 2010). Verhulst, Eaves, and Hatemi (2012), using a genetically informative sample, directly test the hypothesis that personality traits shape political attitudes. The authors argue that the personality traits do not cause political attitudes; in some cases, both are driven by common genetic influences, whereas in others, attitudes actually cause personality traits or there is reciprocal causation. While no study has conducted a similar analysis for political participation, the findings of Verhulst, Eaves, and Hatemi (2012) suggest caution is required when considering a proposed mediation relationship.

Another possible mediator is cognitive ability. There are various mechanisms through which cognitive ability may influence political participation. One plausible hypothesis is that acts of political participation require the mobilization of costly cognitive resources, whose availability varies across individuals. To undertake a political action, an individual is usually required to acquire and then process information (Luskin 1990). If information gathering and processing are cheaper for those with higher cognitive ability, they will be more likely to participate relative to those with lower cognitive ability.

Individuals with higher cognitive ability may be better at absorbing the political information to which they are exposed in the press and may also endogenously select into environments with more information available. "Preference-based" channels from cognitive ability to political behavior are also plausible. Psychologists and behavioral economists have shown that cognitive ability is

"I have little control over what happens to me"; therefore, control is an important part of what the authors are capturing.

associated with high discount rates and other behavioral anomalies (Benjamin, Brown, and Shapiro 2013; Kirby, Winston, and Santiesteban 2005). On this assessment, political participation is an act that entails paying an immediate cost to enjoy instrumental benefits at some later stage (Fowler and Kam 2006).<sup>7</sup>

Several studies have established a link between cognitive ability, using a variety of different measures, and voter turnout (Deary, Batty, and Gale 2008; Denny and Doyle 2008; Hauser 2000) as well as overall participation (Nie, Junn, and Stehlik-Barry 1996; Verba, Schlozman, and Brady 1995). As with personality traits, growing empirical evidence supports the assertion that individual differences in cognitive ability are associated with different levels and types of political participation.

Scholars studying the relationship between personality traits and political participation have also argued that this relationship is likely to be indirect, mediated by political predispositions like political interest, feelings of civic duty (Blais and St-Vincent 2011; Gallego and Oberski 2012), a desire to acquire political knowledge, and perceived political efficacy (Cohen, Vigoda, and Samorly 2001; Gallego and Oberski 2012; Guyton 1988; Mondak et al. 2010; Vecchione and Caprara 2009). In terms of the personality traits we study in this article, Cohen, Vigoda, and Samorly (2001) and Guyton (1988) showed that personal control influences political participation via political efficacy. Gallego and Oberski (2012) found that extraversion influences both turnout and engagement in acts of protest via political efficacy, and Vecchione and Caprara (2009) reported that political efficacy fully mediated the effect of extraversion on overall political participation.

There is also empirical evidence that cognitive ability exerts an indirect effect on participation. Verba, Schlozman, and Brady (1995) demonstrated that when including interest in politics, political efficacy, and political information in a regression model of political participation, verbal ability became insignificant, suggesting that these variables mediate a relationship between cognitive ability and participation.

On the genetics side, recent work has shown that political efficacy, knowledge, and interest are all heritable based on U.S. and European samples (Klemmensen et al. 2012). Further, Klemmensen et al. (2012) found that most of the covariation between efficacy and political participation could be traced to a common genetic factor. Taken together, this research suggests that psychological traits

like cognitive ability, personal control, and extraversion may possibly mediate the relationship between genes and political predispositions known to be strongly related to political participation.

In summary, there is growing empirical evidence that cognitive ability, personal control, and extraversion are associated with political participation as well as political predispositions. Further, scholars have argued that since development of these psychological traits predates coming of age politically, they are causally prior to political participation and predispositions (Mondak 2010; Mondak et al. 2010). This assertion, combined with findings from behavioral genetics that personality traits and cognitive ability are highly heritable (Bouchard and McGue 2003) and recent work that has also established the heritability of political participation and predispositions (Fowler, Baker, and Dawes 2008; Klemmensen et al. 2012), suggests a causal relationship may go from genes to psychological traits to political predispositions and political participation.<sup>8</sup> However, as has been suggested by Verhulst, Eaves, and Hatemi (2012) for political attitudes and personality traits, the underlying relationships may be more complicated.

## Sample and Measures

The Swedish Twin Registry (STR) began in the 1950s and contains nearly all twins born in Sweden between 1886 and 2000, totaling more than 170,000 twins (Lichtenstein et al. 2006). The STR routinely administers surveys to its members, and this article uses data from a recently administered survey called Screening Across the Life-span Twin study, Younger cohort (SALTY).<sup>9</sup> The SALTY study was initiated in 2007 by a group of researchers in epidemiology, medicine, economics, and political science.

Beginning in early 2009, the survey was sent out to 24,914 Swedish twins born between 1943 and 1958, and the final reminders were sent out in the spring of 2010. The survey generated a total of 11,578 responses. Of these, 11,261 (97.2%) respondents gave informed consent to have their responses stored and analyzed.

<sup>8</sup>In addition to twin studies, recent work has used molecular genetic data to estimate the heritability of cognitive ability and personality traits (Davies et al. 2011; Vinkhuyzen et al. 2012). Also, studies have identified specific variants associated with both (Deary, Johnson, and Houlihan 2009; de Moor et al. 2012); however, it is important that these associations are adequately replicated (Chabris et al. 2012).

<sup>9</sup>Twins in the Swedish Twin Registry with a date of birth between January 1, 1943, and December 13, 1958, were sent the SALTY survey, provided at least one member of each twin pair had previously participated in a major phone survey administered by the registry.

<sup>7</sup>Individuals may enjoy immediate benefits from seeing one's preferred candidate win or warm-glow utility from doing one's civic duty. However, many of the policy-related benefits are not realized until the future.

**TABLE 1 Univariate Estimates for Psychological and Political Traits**

	<b>Heritability</b>	<b>Common Environment</b>	<b>Unique Environment</b>
Vote (Parliament)	0.41 [0.03, 0.58]	0.00 [0.00, 0.29]	0.59 [0.42, 0.79]
Vote (EU)	0.17 [0.00, 0.43]	0.19 [0.00, 0.36]	0.64 [0.55, 0.73]
Contact Politician	0.52 [0.31, 0.63]	0.00 [0.00, 0.15]	0.48 [0.37, 0.61]
Contact Official	0.41 [0.15, 0.53]	0.00 [0.00, 0.20]	0.59 [0.47, 0.72]
Attend Protest	0.35 [0.00, 0.61]	0.11 [0.00, 0.44]	0.55 [0.39, 0.73]
Boycott Participation	0.29 [0.00, 0.49]	0.08 [0.00, 0.33]	0.63 [0.51, 0.76]
Financial Contributions	0.44 [0.00, 0.65]	0.04 [0.00, 0.41]	0.52 [0.35, 0.74]
Sign a Petition	0.15 [0.00, 0.39]	0.16 [0.00, 0.32]	0.69 [0.60, 0.78]
Participation Index (0–8)	0.36 [0.20, 0.46]	0.05 [0.00, 0.18]	0.59 [0.54, 0.64]
Interest in Politics	0.50 [0.35, 0.61]	0.06 [0.00, 0.19]	0.44 [0.39, 0.49]
Internal Efficacy	0.36 [0.23, 0.41]	0.00 [0.00, 0.09]	0.64 [0.59, 0.70]
External Efficacy	0.24 [0.08, 0.39]	0.10 [0.00, 0.22]	0.66 [0.61, 0.72]
Civic Duty	0.29 [0.12, 0.39]	0.05 [0.00, 0.18]	0.67 [0.61, 0.73]
Confidence in Politicians	0.37 [0.19, 0.49]	0.06 [0.00, 0.20]	0.57 [0.51, 0.63]
Personal Control	0.23 [0.09, 0.29]	0.00 [0.00, 0.11]	0.77 [0.71, 0.83]
Extraversion	0.45 [0.38, 0.49]	0.00 [0.00, 0.05]	0.55 [0.51, 0.60]
Cognitive Ability (Males)	0.67 [0.51, 0.81]	0.12 [0.00, 0.26]	0.21 [0.18, 0.25]

*Notes:* Parameter estimates and 95% confidence intervals (in brackets) are shown for a univariate ACE model that allows different thresholds for males and females.

Subject zygosity was classified 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 2,346 complete same-sex twin pairs. In Online Appendix Table 1, we report a comparison of respondents to nonrespondents on a number of background characteristics.<sup>10</sup> As is common in twin research,

there is some oversampling of women. Respondents are also better educated and earn more money than nonrespondents. These differences, however, are quantitatively quite modest, never amounting to more than 0.2 standard deviations.

The SALT survey collected detailed answers to questions about political attitudes, predispositions, and behaviors from a genetically informative sample. In this article, we focus on political predispositions and acts of participation. The acts are whether respondents

<sup>10</sup>These data are for respondents and nonrespondents from same-sex twin pairs.

reported voting in the 2006 Swedish parliamentary election, whether they reported voting in the 2009 European Union (EU) election, and whether they have performed any of the following in the previous 5 years in order to express their political opinions: contacted a politician, contacted a public sector official, participated in a protest or demonstration, boycotted a certain good, made a financial contribution, and/or signed a petition. The eight acts of participation are summed to create a participation index ranging from 0 to 8.<sup>11</sup>

In terms of political predispositions, we asked subjects how interested they were in politics, with questions gauging internal and external efficacy, how confident they were in Swedish politicians, and whether they viewed the act of voting as a civic duty. The questions about contacting officials, protesting, boycotting, making financial contributions, signing a petition, civic duty, internal efficacy, and external efficacy are taken from the Swedish Citizenship Survey (Petersson, Westholm, and Blomberg 1989). The questions about voting in the Swedish and EU parliamentary elections, interest in politics, and confidence in politicians are taken from the Swedish Election Study.<sup>12</sup>

As part of SALTY, we also administered batteries designed to measure personal control and extraversion. In order to measure personal control, we used the Locus of Control Scale (LOC) battery (Rotter 1966).<sup>13</sup> The LOC classifies individuals along a single dimension capturing the degree to which they feel like they control the outcome of events. Individuals with an *internal* locus of control feel they control their own destiny and believe outcomes they realize are the product of their own effort and skills. Those with an *external* locus of control believe that outcomes are outside of their control. A low score on the scale is associated with an internal locus of control and a high score with an external locus of control. External control is also strongly related to neuroticism and internal control with self-efficacy (Judge et al. 2002). We reverse-coded the LOC so that higher scores are associated with higher internal locus of control. To measure extraversion, the survey included the 16-item Adult Measure of Behavioral Inhibition (AMBI) battery

(Gladstone and Parker 2005). The AMBI is a subjective measure of general long-standing inhibition designed to capture how an individual responds to social novelty and risk stimuli (Gladstone and Parker 2005). Higher scores on the AMBI reflect a proneness for social avoidance and introversion.<sup>14</sup> We reverse-coded the AMBI so that higher scores are associated with extraversion.

Finally, we used social security numbers to match the men in the SALTY sample to conscription data provided by the Military Archives of Sweden. All men in our sample were required by law to participate in military conscription around the age of 18. They enlisted at a point in time when exemptions from military duty were rare and typically only granted to men who could document a serious handicap that would make it impossible to complete training. Indeed, in our sample, we were able to successfully match 95% of male twins to the information in the Military Archives. For the men born after 1950, approximately half of our sample, the military data have been digitalized. For the remaining twins, we manually retrieved the information from the Military Archives. The first test of cognitive ability used by the Swedish military was implemented in 1944, and it has subsequently been revised and improved on a few occasions. Carlstedt (2000) discusses the history of psychometric testing in the Swedish military and provides evidence that the measure of cognitive ability is a good measure of general intelligence (Spearman 1904).

During the study period considered in this article, the cognitive ability test consisted of four subtests: logical, verbal, spatial, and technical. The first subtest about logical ability was called "Instructions" and measured the ability to understand complicated instructions (the test had a raw score of 0–40). The second subtest about verbal ability was called "Selection," and in these questions, the subjects had to pick out one of five words that differed from the four other words (the test had a raw score of 0–40). The third test was a test of spatial ability called "Composition," where the subjects had to see which pieces fit with a specific figure (the test had a raw score of 0–25). The final test was called "Technical Comprehension," and here the subjects answered questions about technical problems with the guidance of graphs (the test had a raw score of 0–52). To construct our measure of cognitive ability, we summed the raw test scores for the four subtests. We then transformed the subjects, summed test scores to the percentile rank in that birth year (using a standardization sample of all twins for whom cognitive ability data from

<sup>11</sup>A Cronbach test of internal consistency is 0.59, similar to those reported by Fowler, Baker, and Dawes (2008) and Verba, Schlozman, and Brady (1995) ( $\alpha = 0.61$  and  $\alpha = 0.62$ , respectively).

<sup>12</sup>Exact question wording is reported in the supporting information.

<sup>13</sup>The Rotter (1966) battery is made up of 13 questions, one of which that asked about student testing was not included on the survey due to the age of the sample. Two other questions were explicitly political in nature, so we excluded them from our analysis. Therefore, our LOC score is based on 10 questions and thus ranges from 0 to 10.

<sup>14</sup>The correlation between AMBI and the Extraversion-Introversion scale from the Eysenck Personality Questionnaire-Revised (EPQ-R; Eysenck, Eysenck, and Barrett 1985) is 0.75 (Gladstone and Parker 2005).

the Military Archives were available, not just the SALTY respondents). This transformation ensures that there is no trend in cognitive ability over time in the data.

Since our measures of political predispositions and participation are all ordinal, we have transformed cognitive ability, personal control, and extraversion into deciles. Online Appendix Table 2 in the supporting information includes summary statistics for each of these variables broken out by zygosity. We expect cognitive ability, personal control, and extraversion to be positively related to both political predispositions and participation.

## Biometric Modeling

The process we follow for analyzing the SALTY data is in two steps. In the first step, we estimate how much of the variation in acts of participation and predispositions can be attributed to genetic and environmental factors. In the second step, we estimate the amount of genetic and environmental variation political behaviors and predispositions share with psychological traits. This is achieved by using a bivariate twin model.

### Univariate ACE Model

The power of the classic twin design is that it leverages the fact that monozygotic (MZ) twins share 100% of their genes, whereas dizygotic (DZ) twins share on average 50% of their genes. If we are willing to assume that differences in MZ and DZ twins for a particular trait are not due to similarity in the exogenous environmental conditions facing MZ twins, known as the equal environments assumption (EEA), we can then compare the similarity for that trait among MZ twin pairs to that of DZ twin pairs in order to get an estimate of the degree to which genes influence that trait. However, a violation of the EEA leads to an upward bias in heritability and a downward bias in common environment estimates. This bias may result in underestimating the common environmental correlation and overestimating the genetic correlation between two traits in the bivariate analysis (described below). Several recent studies attempting to test for upward bias in the heritability of political attitudes have failed to find evidence of an EEA violation (Hatemi, Funk, et al. 2009; Hatemi et al. 2010; Littvay 2012; Smith et al. 2012). However, scholars continue to criticize the use of the classic twin design to study political traits (Shultziner 2013).<sup>15</sup>

<sup>15</sup>A more detailed discussion of the EEA is contained in the online supporting information.

More formally, the classical twin model assumes that the variance in observed behavior can be partitioned into additive genetic factors (A), environmental factors that are shared or common to co-twins (C), and unique environmental factors (E). This is the so-called ACE model.<sup>16</sup> Common environment includes the family environment in which both twins were raised and any other factor to which both twins were equally exposed. In contrast, the unique environment includes influences that are experienced individually. The roles of genes and environment are not measured directly, but their influence is inferred via their effects on the covariances of twin siblings (Neale and Cardon 1992).<sup>17</sup>

Since the variables we focus on in this study are ordinal, we estimate a threshold model that assumes a continuous latent distribution underlying a given trait for which we observe thresholds demarcating categories. The thresholds are typically constrained to be the same for both members of the twin pair as well as for MZ and DZ twins, both of which we do here. However, we estimate different thresholds for males and females in all of the models.<sup>18</sup> The variance components as well as the thresholds are estimated via maximum likelihood.

### Bivariate ACE Model

In order to estimate how much of the *covariation* between political behaviors and psychological traits can be attributed to the same genetic source, we must move from a univariate to a bivariate model. We use a Cholesky decomposition model (Martin and Eaves 1977) that assumes the latent factors underlying a first trait also influence a second trait, but the latent factors underlying the second trait do not affect the first trait.<sup>19</sup> The Cholesky model, as developed here, assumes a recursive ordering where genes influence a psychological trait and then the psychological trait influences the political variable, subject to a disturbance that has the familiar ACE structure. This recursive structure is, of course, incorrect if personality

<sup>16</sup>For a primer of biometric modeling geared for political scientists, see Medland and Hatemi (2009).

<sup>17</sup>A more detailed description of the univariate model is presented in the *Online supporting information*.

<sup>18</sup>We ran sex limitation models that assume sex-specific variance components. In each case, we could not statistically reject a pooled model in favor of a sex limitation model. Model fit statistics for the pooled and sex limitation models are resorted in Online Appendix Table 3. Estimates from both models are presented in Online Appendix Table 4. Based on the univariate results, we only estimate pooled bivariate models.

<sup>19</sup>A more detailed description of the bivariate model is presented in the online supporting information.

is not causally antecedent to political behavior. An alternative approach is to allow each variance component of the first trait to be correlated with the corresponding variance component in the second trait. Loehlin (1996) shows how the parameter estimates from such a model are readily transformed into the parameters from our recursive model, since both models span the same model parameter space.<sup>20</sup> In addition, this model assumes that the latent genetic and environmental factors underlying the two traits are uncorrelated with one another across and within individuals. These assumptions are necessary in order for the model to be identified and leaves us with nine parameters to be estimated. Since both variables in our bivariate models are ordinal, estimation of the thresholds and variance components is achieved following the same approach described in the univariate case.

The parameter estimates generated by this bivariate model can be used to construct quantities of interest. The genetic correlation quantifies the degree to which the genetic endowments of two traits covary.<sup>21</sup> A correlation of 0 means that the two traits are influenced by completely different genes, and a correlation of 1 means the same genes influence both traits. Another meaningful quantity is the percentage of the *covariation* between two traits that can be explained by additive genetic factors.<sup>22</sup>

## Univariate Results

The estimates of heritability, common environment, and unique environment for self-reported vote in the 2006 Swedish parliamentary election and 2009 European Union election are presented in Table 1.<sup>23</sup> We also show estimates for other acts of participation, including contacting a politician, contacting a public sector official, participating in a protest or demonstration, boycotting a certain good, making a financial contribution, and signing a petition.

The heritability estimates for three of the acts are significantly different from zero. In particular, the heritability for voting in the Swedish parliamentary election

is close to the estimates reported by Fowler, Baker, and Dawes (2008); however, it should be noted that there is very little variation in our measure since 96% of the sample reported voting. Therefore, we urge caution in interpreting the univariate and bivariate results for voting in the parliamentary election.<sup>24</sup> The heritability estimate for the sum of self-reported activities is a bit lower than the participation index reported by Fowler, Baker, and Dawes (2008), but it is very close to the estimates reported by Klemmensen et al. (2012) based on U.S. and Danish samples. While not statistically different from zero in the ACE model, heritability estimates for protesting, participating in a boycott, and making financial contributions to candidates or parties are similar in magnitude. Like voting in the EU election, signing a petition yields a heritability estimate that is small and about the same size as the estimate for common environment. The point estimates for common environment are at or near zero for contacting a politician, contacting an elected official, voting in the Swedish parliamentary election, and the overall index and are insignificant for every act of participation, suggesting the common environment plays at best a small role in these outcomes.

The univariate results for political interest, internal and external political efficacy, confidence in politicians, and civic duty are also presented in Table 1. The heritability estimates are significantly different from zero, and the percentage of the variation accounted for by common environment is insignificant for all five variables. The heritability estimates for most of the variables are moderate in magnitude; however, genetic factors account for approximately half of the variation in interest in politics.

Our estimate for political efficacy is similar to those reported by Klemmensen et al. (2012), and our estimate for civic duty is similar to Loewen and Dawes (2012).<sup>25</sup> Confidence in politicians has never been studied in a behavioral genetic context. These results suggest that genetic variation influences a wide variety of political behaviors and predispositions that are thought to influence political participation.

## Bivariate Results

The purpose of the second step of our analysis is to quantify the amount of the covariation between acts of participation and psychological traits that can be attributed to a common genetic source. As a starting point, Table 2

<sup>20</sup>The proof of this is straightforward and consists of merely writing the variance-covariance matrices of the two models in terms of the underlying structural parameters and equating the elements from Matrix 1 with the corresponding elements from Matrix 2.

<sup>21</sup>We denote the genetic correlation as  $r_g$ , the common environment correlation as  $r_c$ , and the unique environment correlation as  $r_e$ .

<sup>22</sup>The genetic correlation, without incorporating the extent to which the two traits are heritable, only tells part of the story. For example, the same genes may be influencing two traits, but these genes may not account for very much of the variation in each of the traits.

<sup>23</sup>All results reported are based on complete twin pairs.

<sup>24</sup>Overall turnout in Sweden was 90% in the age group we study.

<sup>25</sup>Klemmensen et al. (2012) did not find significant heritable variation in civic duty based on a Danish sample.

**TABLE 2 Relationship between Political Traits and Psychological Traits**

	<b>Personal Control</b>	<b>Extraversion</b>	<b>Cognitive Ability (Males)</b>
Vote (Parliament)	0.13 (0.04)	0.18 (0.03)	0.19 (0.05)
Contact Politician	0.09 (0.03)	0.22 (0.03)	0.26 (0.04)
Contact Official	0.10 (0.03)	0.22 (0.03)	0.19 (0.04)
Participation Index (0–8)	0.09 (0.02)	0.19 (0.02)	0.25 (0.02)
Interest in Politics	0.16 (0.02)	0.22 (0.02)	0.20 (0.03)
Internal Efficacy	0.20 (0.01)	0.26 (0.01)	0.27 (0.02)
External Efficacy	0.20 (0.01)	0.21 (0.01)	0.30 (0.02)
Voting Is a Civic Duty	0.10 (0.01)	0.13 (0.01)	0.10 (0.02)
Confidence in Politicians	0.21 (0.02)	0.17 (0.02)	0.25 (0.03)

*Notes:* Correlation coefficients and standard errors (in parentheses) are shown.

presents the polychoric correlations between each trait we found to be heritable and personal control, extraversion, and cognitive ability. The correlations are relatively moderate (ranging from 0.09 to 0.30 in absolute value) but significant, suggesting that each of these psychological characteristics plays a role in explaining several different acts of political engagement.

Based on the results from the univariate model, we restrict the bivariate analysis of personal control and extraversion to acts for which we found a heritability estimate statistically distinguishable from zero (i.e., voting in the Swedish parliamentary election, contacting a politician, contacting a public sector official, and the overall index). For cognitive ability, we restrict the analysis to acts for which heritability estimates are statistically distinguishable from zero for men (i.e., contacting a politician and contacting a public sector official) since we only have a measure of cognitive ability for males in the sample. Additionally, since the common environment point estimates for these acts of participation and psychological traits are at or close to zero and insignificant in the univariate model, we estimate a model assuming that the common environment correlation is zero. However, while dropping insignificant parameters from the model is common practice in behavioral genetics, it is not without its critics (Goldberger 2002) because the reported *p*-values do not reflect the model selection procedure.

Therefore, we also present the results for the unrestricted models in the online supporting information.<sup>26</sup>

The genetic and environmental correlations for the three acts of political participation as well as the overall index and the the percentage of the total correlation due to genetic and environmental factors are presented in Table 3.<sup>27</sup> The only insignificant genetic correlation is between turnout and personal control. Of the acts for which the genetic correlations were significant, genetic factors make up between 67% and 98% of the total correlation. These results suggest that for contacting politicians and public sector officials, common genes account for nearly all of the correlations with the three psychological traits. There is also evidence of genetic overlap for the index of overall participation and both personal control and extraversion. The results for turnout are not as strong likely due to the limited variation in the measure.

The genetic and environmental correlations for all of the political predispositions and the percentage of the total correlation due to genetic and environmental factors

<sup>26</sup>Fit statistics comparing the restricted and unrestricted models are presented in Online Appendix Table 5, and estimates from the unrestricted model are presented in Online Appendix Table 6 and Online Appendix Table 7. In all cases, the common environment correlation is insignificant in the full model.

<sup>27</sup>The percentages are graphically illustrated in Online Appendix Figure 3.

**TABLE 3 Bivariate Cholesky Estimates for Psychological and Political Traits**

	<i>Personal Control</i>		<i>Extraversion</i>		<i>Cognitive Ability (Males)</i>	
	$r_g$	$r_e$	$r_g$	$r_e$	$r_g$	$r_e$
Vote (Parl)	0.08 [-0.25, 1.00]	0.15 [-0.01, 0.31]	0.29 [0.09, 1.00]	0.11 [-0.04, 0.25]		
Contact Pol	0.24 [0.03, 0.56]	0.00 [-0.13, 0.13]	0.41 [0.27, 0.58]	0.05 [-0.08, 0.17]	0.39 [0.24, 0.56]	0.02 [-0.18, 0.23]
Contact Off	0.31 [0.06, 0.74]	0.01 [-0.10, 0.13]	0.42 [0.26, 1.00]	0.09 [-0.03, 0.19]	0.27 [0.10, 0.52]	0.07 [-0.13, 0.27]
Index	0.28 [0.11, 0.59]	0.02 [-0.05, 0.08]	0.40 [0.28, 0.57]	0.07 [0.01, 0.13]		
Interest	0.32 [0.18, 0.55]	0.07 [0.00, 0.14]	0.27 [0.18, 0.37]	0.19 [0.12, 0.26]	0.30 [0.20, 0.41]	0.00 [-0.12, 0.12]
Int Efficacy	0.44 [0.29, 0.72]	0.10 [0.04, 0.16]	0.44 [0.34, 0.56]	0.16 [0.11, 0.22]	0.59 [0.46, 0.77]	-0.02 [-0.12, 0.09]
Ext Efficacy	0.66 [0.40, 1.00]	0.08 [0.02, 0.14]	0.42 [0.30, 0.64]	0.11 [0.05, 0.17]	0.65 [0.52, 0.90]	-0.05 [-0.16, 0.05]
Duty	0.21 [0.04, 0.48]	0.08 [0.01, 0.14]	0.32 [0.19, 0.54]	0.05 [-0.01, 0.11]	0.19 [0.05, 1.00]	0.04 [-0.06, 0.14]
Confidence	0.44 [0.26, 0.77]	0.13 [0.06, 0.20]	0.33 [0.22, 0.51]	0.06 [-0.01, 0.12]	0.43 [0.31, 0.74]	0.01 [-0.10, 0.13]
	$\%_g$	$\%_e$	$\%_g$	$\%_e$	$\%_g$	$\%_e$
Vote (Parl)	0.19 [-0.88, 1.06]	0.81 [-0.06, 1.88]	0.67 [0.23, 1.14]	0.33 [-0.14, 0.77]		
Contact Pol	0.98 [0.14, 2.90]	0.02 [-1.91, 0.86]	0.89 [0.61, 1.20]	0.11 [-0.20, 0.39]	0.97 [0.73, 1.24]	0.03 [-0.24, 0.27]
Contact Off	0.91 [0.20, 2.24]	0.09 [-1.24, 0.80]	0.76 [0.49, 1.05]	0.24 [-0.05, 0.51]	0.87 [0.45, 1.29]	0.13 [-0.29, 0.55]
Index	0.87 [0.39, 1.47]	0.13 [-0.47, 0.61]	0.79 [0.62, 0.97]	0.21 [0.03, 0.38]		
Interest	0.71 [0.44, 1.00]	0.29 [0.00, 0.56]	0.58 [0.42, 0.73]	0.42 [0.27, 0.58]	1.01 [0.82, 1.20]	-0.01 [-0.20, 0.18]
Int Efficacy	0.64 [0.43, 0.85]	0.36 [0.15, 0.57]	0.64 [0.51, 0.77]	0.36 [0.23, 0.49]	1.03 [0.88, 1.18]	-0.03 [-0.18, 0.12]
Ext Efficacy	0.72 [0.50, 0.94]	0.28 [0.06, 0.50]	0.71 [0.55, 0.86]	0.29 [0.14, 0.45]	1.06 [0.94, 1.19]	-0.06 [-0.19, 0.06]
Duty	0.50 [0.09, 0.90]	0.50 [0.10, 0.91]	0.80 [0.55, 1.06]	0.20 [-0.06, 0.45]	0.85 [0.36, 1.30]	0.15 [-0.30, 0.64]
Confidence	0.59 [0.38, 0.79]	0.41 [0.21, 0.62]	0.81 [0.59, 1.04]	0.19 [-0.04, 0.41]	0.98 [0.82, 1.15]	0.02 [-0.15, 0.18]

Notes: Top panel shows genetic and environmental correlation and 95% confidence intervals from a bivariate Cholesky ACE model of personal control, extraversion, and cognitive ability with political traits. Bottom panel shows percentage of total correlation due to genetic and unique environmental factors and 95% confidence intervals.

are also presented in Table 3.<sup>28</sup> All of the genetic correlations between political predispositions and the psycho-

logical traits are significant, and genetic factors account for between 50% and 100% of the total correlation.<sup>29</sup>

<sup>28</sup>The percentages are graphically illustrated in Online Appendix Figure 4.

<sup>29</sup>The genetic correlations for cognitive ability and several of the predispositions are over 100% because the unique environmental

Our results add a new dimension to the behavior literature. Verba, Schlozman, and Brady (1995) classify contacting officials as a *skill-based* act because it requires individuals to be organized and write and speak effectively, skills that are correlated with cognitive ability. Competence theory holds that individuals who believe that they will achieve a desired policy goal by contacting an official will be more likely to do so. Mondak et al. (2010) report a strong positive relationship between extraversion and contacting a member of the U.S. Congress. Also, previous research has demonstrated that personal control is linked with political efficacy (Cohen, Vigoda, and Samorly 2001; Guyton 1988) and civic duty (Blais and St-Vincent 2011); extraversion to political efficacy (Blais and St-Vincent 2011; Mondak and Halperin 2008; Vecchione and Caprara 2009), interest in politics (Blais and St-Vincent 2011), and civic duty (Blais and St-Vincent 2011); and cognitive ability to interest in politics (Verba, Schlozman, and Brady 1995) and political efficacy (Verba, Schlozman, and Brady 1995). We demonstrate that most of these relationships can be explained by variation in the same set of genes.

The question is how to interpret these results. Most scholars studying the relationship between psychological and political traits have at least implicitly assumed that political traits are causally influenced by personality and cognitive ability. This implies genes would exert an indirect influence on political participation via psychological traits. Alternatively, if the same set of genes influences psychological traits and political participation separately, then the observed relationship between the two may be at least in part confounded by genetic factors.

## Direction of Causation

The Cholesky bivariate model does not provide information about the causal relationship between genes, psychological traits, and political participation (Posthuma et al. 2003). However, behavioral genetics scholars have developed the Direction of causation (DoC) model, which attempts to test empirically the potential causal pathways (Duffy and Martin 1994; Heath et al. 1993). The DoC model has recently been employed by Verhulst, Eaves, and Hatemi (2012) to study the relationship between personality and political attitudes.

The DoC model takes advantage of genetic relationships among family members to study, based on cross-sectional data, hypothesized causal relationships between two traits. The model tests three scenarios: a unidirectional

causal influence of Trait A on Trait B, a unidirectional influence of Trait B on Trait A, and reciprocal causation. The DoC model evaluates expected cross-twin cross-trait covariances given possible causal relationships. If Trait A and Trait B have different modes of inheritance—for instance, Trait A is best explained by common environmental and unique environmental factors, whereas Trait B is best explained by additive genetic and unique environmental factors—then the cross-twin cross-trait covariance expected given A causes B would be different than if B causes A. More specifically, in the case of the former, the cross-twin cross-trait covariance would be proportional to the common environmental component of Trait A, and in the case of the latter, the cross-twin cross-trait covariance would be proportional to the genetic component of Trait B. In the case of reciprocal causation, the cross-twin cross-trait covariance would be a combination of the common environment component of Trait A and the genetic component of Trait B.<sup>30</sup> Since all three cases of the DoC model are nested within the Cholesky model (Heath et al. 1993), they can be compared to the Cholesky using a likelihood ratio test to suggest the most appropriate causal relationship based on the data.

We estimate the three DoC models (two unidirectional and one reciprocal causation) for each of the three psychological traits and the political activity index as well as the measures of political dispositions.<sup>31</sup> The model fit information is presented in Online Appendix Table 8. The DoC analysis cannot reject the Cholesky as the best fitting model for all of the political predispositions and both extraversion and personal control. The best-fitting model for the political activity index and extraversion is reciprocal causation, and for the political activity index and personal control, is reverse causality. The best-fitting model suggests a causal relationship running from cognitive ability to the overall measure of political activity, interest in politics, civic duty, and confidence in politicians. A reciprocal causation model fits best for the relationship between cognitive ability and internal efficacy, and external efficacy. However, reverse causality is unlikely since cognitive ability was measured in adolescence, whereas political efficacy was measured much later in life.

In summary, similar to what Verhulst, Eaves, and Hatemi (2012) report for political attitudes, our DoC

<sup>30</sup>This example is expanded upon in the online supporting information. See Verhulst and Estabrook (2012) for a detailed discussion of the DoC model intended for a political science audience.

<sup>31</sup>DoC models are sensitive to measurement errors (Duffy and Martin 1994; Gillespie et al. 2003; Heath et al. 1993). Therefore, we use test-retest correlations for each of the traits, based on 496 twins in the SALTY sample, to correct for measurement error in the DoC and Cholesky models. In general, our estimation process is modeled after Luciano et al. (2005). All measures are treated as continuous in our DoC analysis.

correlations are negative. However, all of these environmental correlations are not significantly different from zero.

results suggest a pleiotropic relationship between personality traits and political predispositions. We also found support for a mediation relationship between cognitive ability and political predispositions and participation. However, it is important to point out a major limitation of the DoC analysis. The power to detect the direction of causality is greatest when both traits have very different modes of inheritance (Duffy and Martin 1994; Gillespie et al. 2003; Heath et al. 1993). It is clear from the univariate results presented in Table 1 that all of the political and psychological traits we study are best explained by an additive genetic and unique environmental component. As a result, the cross-twin cross-trait covariances will be very similar under the two unidirectional hypotheses, and therefore large samples are required to achieve adequate power necessary to distinguish between the two directional hypotheses (Gillespie et al. 2003).

## Discussion

The SALT sample is unique in a number of ways. It is one of the first studies to ask a very large sample of twins an extensive battery of questions about engagement in well-studied political activities as well as predispositions toward politics. Our sample also contains measures of psychological traits, allowing us to explore the conjecture that genes influence political participation indirectly through these traits. And since cognitive ability was measured in adolescence whereas political variables were measured later in life, it suggests that the causal arrow flows from cognitive ability to politics and not the other way around.

Based on our univariate modeling, we find that the total number of self-reported participatory acts is heritable, as are specific acts like contacting a politician or a public sector employee. These heritabilities range from 0.36 to 0.52, similar to what has been found for other political behaviors (Fowler, Baker, and Dawes 2008; Klemmensen et al. 2012). We find mixed results for turnout; however, the confidence intervals for voting in the Swedish and EU elections overlap, suggesting the two estimates cannot be distinguished from one another statistically. On the other hand, we fail to find significant heritability for participating in a protest, boycotting, making a financial contribution, or signing a petition. The fact that the total number of acts is heritable, combined with similar magnitudes for the heritability estimates for protesting, boycotting, and making contributions, suggests that genetic variation explains individual differences in overall political participation.

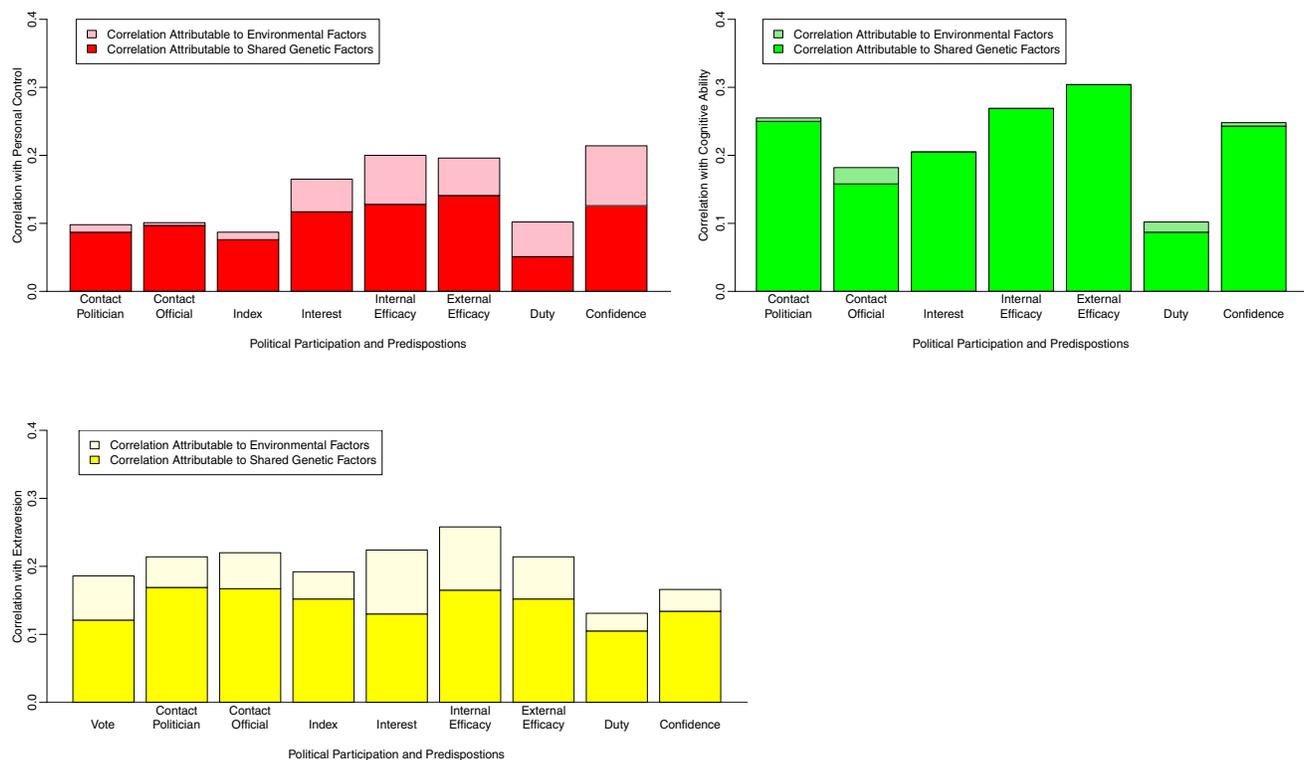
For political predispositions, heritability estimates were significant for political interest, internal and external political efficacy, confidence in politicians, and

the view that voting is a civic duty. These estimates range from 0.24 to 0.50, in line with other recent studies (Klemmensen et al. 2012). The magnitudes for these estimates are also quite similar to what we found for acts of participation. Our result that 50% of the variation in political interest can be attributable to genetic factors potentially has implications for the finding by Prior (2010) that people tend to be either interested or uninterested in politics and that this predisposition is exceptionally stable over the life cycle. The determinants of political interest are not currently well known; however, the observed relationship may be due in part to genetic variation in the population.

These results are very similar to those based on samples in the United States as well as Sweden's neighbor Denmark, suggesting that our findings may be informative about the heritability of political participation and predispositions in other modern Western democracies. However, it is important to point out that our heritability estimates, like any other descriptive statistic, are specific to the time and population on which they are based.<sup>32</sup> Therefore, we urge caution when extrapolating to other societies and eras. The relative importance of genes crucially depends on the prevailing cultural and institutional setting.

Our bivariate results for political participation show that genetic factors account for 67% to 79% of the correlation between extraversion and the three acts of participation we examined, as well as the overall number of reported acts. In addition, personal control significantly overlaps with contacting a politician and contacting a public sector official, with genetic factors accounting for 91% and 98% of the total correlation. For political predispositions, all of the genetic correlations are significant and account for between 50% and 100% of the total correlation. These results thus present evidence that most of the relationship between psychological traits and political participation can be explained by *the same set of genes*. In this light, we view the work presented here as an important step in a research agenda aimed at better understanding the role that variation in genetic endowments for personality, skills, traits, and preferences plays in generating heritable variation in political behavior. The theoretical argument made by Mondak (2010) suggests that a significant genetic correlation should be interpreted as evidence of mediation; however, since the Cholesky model cannot establish mediation, our estimates should be thought of only as an upper bound on the proportion of the heritable variation in political traits that *may* be mediated by the psychological traits we study.

<sup>32</sup>For a more detailed discussion of the concept of heritability, see Hatemi, Hibbing, et al. (2009) and Hatemi, Byrne, and McDermott (2012).

**FIGURE 1 Correlations between Psychological and Political Traits**

*Note:* The overall height of the bar is the total correlation, the dark portion is the genetic component, and the light portion is the environmental component.

Overall, genes account for the lion's share of the overlap between the psychological traits and political behaviors we focus on, but the size of this overlap is relatively modest. Figure 1 illustrates this by putting the percentages in terms of the correlations between psychological and political traits (all presented in Table 3). For example, nearly all of the correlation between cognitive ability and contacting a politician can be attributed to genetic factors. However, since the total correlation is 0.26, it implies that the influence of extraversion can only account for 7% of the variation in contacting a politician. If our results are viewed as evidence of mediation, the remaining 45% of the variation in contacting a politician explained by genetic factors is not mediated by cognitive ability. Therefore, our findings suggest that future work must consider other potential mediators.

## Limitations

There are several limitations to our study. Though we have applied standard methodology, it is well known that the assumptions needed to identify an ACE model are

quite strong, especially the equal environments assumption. As we stated earlier, a violation of the EEA leads to an upward bias in heritability and a downward bias in common environment estimates. We suggest that future work use samples incorporating other sibling types and pedigrees to evaluate some of the moment restrictions assumptions in the ACE model. New analytical tools have also recently been developed that rely on direct measures of genetic relatedness, and thus do not rely on the EEA, to estimate heritability (Visscher, Yang, and Goddard 2010; Yang et al. 2010, 2011).

Another limitation is that we have only studied bivariate relationships, but in future work we will examine more complicated pathways linking genes, psychological traits, political predispositions, and political participation. In addition, several of the relationships between political and psychological traits are small in magnitude, making it difficult to decompose their covariance without a very large sample. Therefore, our results for trait pairs with correlations smaller than 0.2 can only be considered suggestive at this point.

Finally, based on recent work discussed earlier, we argue that our results raise the possibility that psychological traits mediate the relationship between

genes and political participation. We attempted to test this assertion by estimating a direction of causation, but unfortunately power limitations due to the similar inheritance pattern exhibited by all of the traits we study likely limit our ability to distinguish between possible relationships (Duffy and Martin 1994; Heath et al. 1993). However, more adequately powered studies should revisit this question in the future.

## References

- Adorno, Theodor W., Else Frenkel-Brunswik, Daniel J. Levinson, and R. Nevitt Sanford. 1950. *The Authoritarian Personality*. New York: Harper and Row.
- Alford, John R., Carolyn L. Funk, and John R. Hibbing. 2005. "Are Political Orientations Genetically Transmitted?" *American Political Science Review* 99(2): 153–67.
- Arceneaux, Kevin, Martin Johnson, and Hermine H. Maes. 2012. "The Genetic Basis of Political Sophistication." *Twin Research and Human Genetics* 15(1): 34–41.
- Benjamin, Daniel J., Sebastian A. Brown, and Jesse M. Shapiro. 2013. "Who Is 'Behavioral'? Cognitive Ability and Anomalous Preferences." *Journal of the European Economic Association* 11(6): 1231–55.
- Blais, Andrffe, and Simon Labbffe St-Vincent. 2011. "Personality Traits, Political Attitudes and the Propensity to Vote." *European Journal of Political Research* 50(3): 395–417.
- Bono, Joyce E., and Timothy A. Judge. 2003. "Core Self-Evaluations: A Review of the Trait and Its Role in Job Satisfaction and Job Performance." *European Journal of Personality* 17(S1): S5–S18.
- Bouchard, Thomas J., and Matt McGue. 2003. "Genetic and Environmental Influences on Human Psychological Differences." *Journal of Neurobiology* 54(1): 4–45.
- Campbell, Angus, Phillip E. Converse, Warren E. Miller, and Donald E. Stokes. 1960. *The American Voter*. Chicago: University of Chicago Press.
- Carlson, James M., and Mark S. Hyde. 1980. "Personality and Political Recruitment: Actualization or Compensation?" *Journal of Psychology* 106(1): 117–20.
- Carlstedt, Berit. 2000. "Cognitive Abilities: Aspects of Structure, Process and Measurement." PhD dissertation, University of Gothenburg.
- Carmines, Edward G., 1978. "A Competence Theory versus Need Theory of Political Involvement." *Journal of Political and Military Sociology* 6(1): 17–28.
- Chabris, Christopher F., Benjamin M. Hebert, Daniel J. Benjamin, Jonathan Beauchamp, David Cesarini, Matthijs van der Loos, Magnus Johannesson, Patrik K. E. Magnusson, Paul Lichtenstein, Craig S. Atwood, et al. 2012. "Most Reported Genetic Associations with General Intelligence Are Probably False Positives." *Psychological Science* 23(11): 1314–23.
- Cohen, Aaron, Eran Vigoda, and Aliza Samorly. 2001. "Analysis of the Mediating Effect of Personal-Psychological Variables on the Relationship between Socioeconomic Status and Political Participation: A Structural Equations Framework." *Political Psychology* 22(4): 727–57.
- Davies, Gail, Albert Tenesa, Antony Payton, Jian Yang, Sarah E. Harris, David Liewald, Xiayi Ke, Stephanie Le Hellard, Andrea Christoforou, Michelle Luciano, et al. 2011. "Genomewide Association Studies Establish That Human Intelligence Is Highly Heritable and Polygenic." *Molecular Psychiatry* 16(10): 996–1005.
- Deary, Ian J., G. David Batty, and Catharine R. Gale. 2008. "Childhood Intelligence Predicts Voter Turnout, Voting Preferences, and Political Involvement in Adulthood: The 1970 British Cohort Study." *Intelligence* 36(6): 548–55.
- Deary, Ian J., Wendy Johnson, and Lorna M. Houlihan. 2009. "Genetic Foundations of Human Intelligence." *Human Genetics* 126(1): 215–32.
- de Moor, Marleen H. M., Paul T. Costa, Antonio Terracciano, Robert F. Krueger, Eco J. C. De Geus, Tanaka Toshiko, Brenda W. Penninx, Tanu Esko, Paul A. Madden, Jaime Derringer, et al. 2012. "Meta-Analysis of Genome-Wide Association Studies for Personality." *Molecular Psychiatry* 17(3): 337–49.
- Denny, Kevin, and Orla Doyle. 2008. "Political Interest, Cognitive Ability and Personality: Determinants of Voter Turnout in Britain." *British Journal of Political Science* 38(2): 291–310.
- Duffy, David L., and Nicholas G. Martin. 1994. "Inferring the Direction of Causation in Cross-Sectional Twin Data: Theoretical and Empirical Considerations." *Genetic Epidemiology* 11(6): 483–502.
- Eysenck, Jans Jurgen. 1954. *The Psychology of Politics*. Piscataway, NJ: Transaction.
- Eysenck, Sybil B. G., Hans J. Eysenck, and Paul Barrett. 1985. "A Revised Version of the Psychoticism Scale." *Personality and Individual Differences* 6(1): 21–29.
- Fazekas, Zoltffan, and Levente Littvay. 2012. "Choosing Sides: The Genetics of Why We Go with the Loudest." *Journal of Theoretical Politics* 24(3): 389–408.
- Fowler, James H., Laura A. Baker, and Christopher T. Dawes. 2008. "Genetic Variation in Political Behavior." *American Political Science Review* 102(2): 233–48.
- Fowler, James H., and Cindy Kam. 2006. "Patience as a Political Virtue: Delayed Gratification and Turnout." *Political Behavior* 28:113–28.
- Fowler, James H., and Darren Schreiber. 2008. "Biology, Politics, and the Emerging Science of Human Nature." *Science* 322(5903): 912–14.
- Gallego, Aina, and Daniel Oberski. 2012. "Personality and Political Participation: The Mediation Hypothesis." *Political Behavior* 34(3): 425–51.
- Gerber, Alan S., Gregory A. Huber, David Doherty, Conor M. Dowling, Connor Raso, and Shang E. Ha. 2011. "Personality Traits and Participation in Political Processes." *Journal of Politics* 73(3): 692–706.
- Gillespie, Nathan A., Gu Zhu, Michael C. Neale, Andrew C. Heath, and Nicolas G. Martin. 2003. "Direction of Causation Modeling between Cross-Sectional Measures of Parenting and Psychological Distress in Female Twins." *Behavior Genetics* 33(4): 383–96.
- Gladstone, Gemma, and Gordon Parker. 2005. "Measuring a Behaviorally Inhibited Temperament Style: Development and

- Initial Validation of New Self-Report Measures." *Psychiatry Research* 135(2): 133–43.
- Goldberger, Arthur S. 2002. "Structural Equation Models in Human Behavior Genetics." Working Papers 22, University of Wisconsin Madison.
- Guyton, Edith M. 1988. "Critical Thinking and Political Participation: Development and Assessment of a Causal Model." *Theory and Research in Social Education* 16(1): 23–49.
- Hatemi, Peter K., Enda Byrne, and Rose McDermott. 2012. "Introduction: What is a "Gene" and Why Does It Matter for Political Science?" *Journal of Theoretical Politics* 24(3): 305–27.
- Hatemi, Peter K., Christopher T. Dawes, Amanda Frost-Keller, Jaime E. Settle, and Brad Verhulst. 2011. "Integrating Social Science and Genetics: News from the Political Front." *Biodemography and Social Biology* 57(1): 67–87.
- Hatemi, Peter K., Carolyn L. Funk, Sarah E. Medland, Hermine M. Maes, Judy L. Silberg, Nicholas G. Martin, and Lindon J. Eaves. 2009. "Genetic and Environmental Transmission of Political Attitudes over a Life Time." *Journal of Politics* 71(3): 1141–56.
- Hatemi, Peter K., John R. Hibbing, John R. Alford, Nicholas G. Martin, and Lindon J. Eaves. 2009. "Is There a Party in Your Genes." *Political Research Quarterly* 62(3): 584–600.
- Hatemi, Peter K., John R. Hibbing, Sarah E. Medland, Matthew C. Keller, John R. Alford, Kevin B. Smith, Nicholas G. Martin, and Lindon J. Eaves. 2010. "Not by Twins Alone: Using the Extended Family Design to Investigate Genetic Influence on Political Beliefs." *American Journal of Political Science* 54(3): 798–814.
- Hatemi, Peter K., and Rose McDermott. 2012. "The Genetics of Politics: Discovery, Challenges, and Progress." *Trends in Genetics* 28(10): 525–33.
- Hauser, Seth M. 2000. "Education, Ability, and Civic Engagement in the Contemporary United States." *Social Science Research* 29(4): 556–82.
- Heath, Andrew C., Ronald C. Kessler, Michael C. Neale, John K. Hewitt, Lindon J. Eaves, and Kenneth S. Kendler. 1993. "Testing Hypotheses about Direction of Causation Using Cross-Sectional Family Data." *Behavior Genetics* 23(1): 29–50.
- Judge, Timothy A., Amir Erez, Joyce E. Bono, and Carl J. Thoresen. 2002. "Are Measures of Self-Esteem, Neuroticism, Locus of Control, and Generalized Self-Efficacy Indicators of a Common Core Construct?" *Journal of Personality and Social Psychology* 83(3): 693–710.
- Kirby, Kris N., Gordon C. Winston, and Mariana Santiesteban. 2005. "Impatience and Grades: Delay Discount Rates Correlate Negatively with College GPA." *Learning and Individual Differences* 15(3): 213–22.
- Klemmensen, Robert, Peter K. Hatemi, Sara Binzer Hobolt, Inge Petersen, Axel Skytthe, and Asbjørn S. Nffrgaard. 2012. "The Genetics of Political Participation, Civic Duty, and Political Efficacy across Cultures: Denmark and the United States." *Journal of Theoretical Politics* 24(3): 409–27.
- Lichtenstein, Paul, Patrick F. Sullivan, Sven Cnattingius, Margaret Gatz, Sofie Johansson, Eva Carlstrom, Camilla Bjork, Magnus Svartengren, Alicja Wolk, Lars Klareskog, et al. 2006. "The Swedish Twin Registry in the Third Millennium: An Update." *Twin Research and Human Genetics* 9(6): 875–82.
- Littvay, Levente. 2012. "Do Heritability Estimates of Political Phenotypes Suffer from an Equal Environment Assumption Violation? Evidence from an Empirical Study." *Twin Research and Human Genetics* 15(1): 6–14.
- Littvay, Levente, Paul T. Weith, and Christopher T. Dawes. 2011. "Sense of Control and Voting: A Genetically-Driven Relationship." *Social Science Quarterly* 92(5): 1236–52.
- Loehlin, John C. 1996. "The Cholesky Approach: A Cautionary Note." *Behavior Genetics* 26(1): 65–69.
- Loewen, Peter John, and Christopher T. Dawes. 2012. "The Heritability of Duty and Voter Turnout." *Political Psychology* 33(3): 363–73.
- Luciano, Michelle, Danielle Posthuma, Margaret J. Wright, Eco J.C. de Geus, Glen A. Smith, Gina M. Geffen, Dorret I. Boomsma, and Nicholas G. Martin. 2005. "Perceptual Speed Does Not Cause Intelligence, and Intelligence Does Not Cause Perceptual Speed." *Biological Psychology* 70(1): 1–8.
- Luskin, Robert C. 1990. "Explaining Political Sophistication." *Political Behavior* 12(4): 331–61.
- Martin, Nicholas G., and Lindon J. Eaves. 1977. "The Genetic Analysis of Covariance Structure." *Heredity* 38(1): 79–95.
- Martin, Nicholas G., Lindon J. Eaves, Andrew C. Heath, Rosemary Jardine, Lynn M. Feingold, and Hans J. Eysenck. 1986. "Transmission of Social Attitudes." *Proceedings of the National Academy of Sciences* 83(12): 4364–68.
- McClosky, Herbert. 1958. "Conservatism and Personality." *American Political Science Review* 52(1): 27–45.
- Medland, Sarah E., and Peter K. Hatemi. 2009. "Political Science, Biometric Theory, and Twin Studies: A Methodological Introduction." *Political Analysis* 17(2): 191–214.
- Milbrath, Lester W., and M. Goel. 1977. *Political Participation: How and Why Do People Get Involved in Politics?* Chicago: Rand McNally.
- Mondak, Jeffery J. 2010. *Personality and the Foundations of Political Behavior*. Cambridge: Cambridge University Press.
- Mondak, Jeffery J., and Karen D. Halperin. 2008. "A Framework for the Study of Personality and Political Behaviour." *British Journal of Political Science* 38(2): 335–62.
- Mondak, Jeffery J., Matthew V. Hibbing, Damarys Canache, Mitchell A. Seligson, and Mary R. Anderson. 2010. "Personality and Civic Engagement: An Integrative Framework for the Study of Trait Effects on Political Behavior." *American Political Science Review* 104(1): 85–110.
- Neale, Michael C., and Lon Cardon. 1992. *Methodology for Genetic Studies of Twins and Families*. Dordrecht, The Netherlands: Kluwer.
- Nie, Norman, Jane Junn, and Kenneth Stehlik-Barry. 1996. *Education and Democratic Citizenship in America*. Chicago: University of Chicago Press.
- Oskarsson, Sven, Christopher T. Dawes, Magnus Johannesson, and Patrik K. E. Magnusson. 2012. "The Genetic Origins of the Relationship between Psychological Traits and Social Trust." *Twin Research and Human Genetics* 15(1): 21–33.
- Petersson, Olof, Anders Westholm, and Göran Blomberg. 1989. *Medborgarnas Makt*. Stockholm: Carlsson.

- Posthuma, Daniëlle, A. Leo Beem, Eco J. C. De Geus, G. Caroline, M. van Baal, Jacob B. von Hjelmborg, Ivan Iachine, and Dorret I. Boomsma. 2003. "Theory and Practice in Quantitative Genetics." *Twin Research* 6(5): 361–76.
- Prior, Markus. 2010. "You've Either Got It or You Don't? The Stability of Political Interest over the Life Cycle." *Journal of Politics* 72(3): 747–66.
- Rotter, Julian B. 1966. "Generalized Expectancies for Internal versus External Control of Reinforcement." *Psychological Monographs: General and Applied* 80(1): 1–28.
- Shultziner, Doron. 2013. "Genes and Politics: A New Explanation and Evaluation of Twin Study Results and Association Studies in Political Science." *Political Analysis* 21(3): 350–67.
- Smith, Kevin, John R. Alford, Peter K. Hatemi, Lindon J. Eaves, Carolyn L. Funk, and John R. Hibbing. 2012. "Biology, Ideology, and Epistemology: How Do We Know Political Attitudes Are Inherited and Why Should We Care?" *American Journal of Political Science* 56(1): 17–33.
- Spearman, Charles. 1904. "'General Intelligence,' Objectively Determined and Measured." *American Journal of Psychology* 15(2): 201–92.
- Vecchione, Michele, and Gian Vittorio Caprara. 2009. "Personality Determinants of Political Participation: The Contribution of Traits and Self-Efficacy Beliefs." *Personality and Individual Differences* 46(4): 487–92.
- Verba, Sidney, Kay Lehman Schlozman, and Henry E. Brady. 1995. *Voice and Equality: Civic Volunteerism in American Politics*. Cambridge, MA: Harvard University Press.
- Verhulst, Brad, Lindon J. Eaves, and Peter K. Hatemi. 2012. "Correlation Not Causation: The Relationship between Personality Traits and Political Ideologies." *American Journal of Political Science* 56(1): 34–51.
- Verhulst, Brad, and Ryne Estabrook. 2012. "Using Genetic Information to Test Causal Relationships in Cross-Sectional Data." *Journal of Theoretical Politics* 24(3): 328–44.
- Verhulst, Brad, Peter K. Hatemi, and Nicholas G. Martin. 2010. "The Nature of the Relationship between Personality Traits and Political Attitudes." *Personality and Individual Differences* 49(4): 306–16.
- Vinkhuyzen, Anna A., Nancy L. Pedersen, Jian Yang, Sang Hong Lee, Patrik K. E. Magnusson, William G. Iacono, Matt McGue, Paul A. Madden, Andrew C. Heath, Michelle Luciano, et al. 2012. "Common SNPs Explain Some of the Variation in the Personality Dimensions of Neuroticism and Extraversion." *Translational Psychiatry* 2(4): e102.
- Visscher, Peter M., Jian Yang, and Michael E. Goddard. 2010. "A Commentary on 'Common SNPs Explain a Large Proportion of the Heritability for Human Height' by Yang et al. (2010)." *Twin Research and Human Genetics* 13(6): 517–24.
- Weber, Christopher, Martin Johnson, and Kevin Arceneaux. 2011. "Genetics, Personality, and Group Identity." *Social Science Quarterly* 92(5): 1314–37.
- Yang, Jian, Beben Benyamin, Brian McEvoy, Scott Gordon, Anjali Henders, Dale Nyholt, Pamela Madden, Andrew C. Heath, Nicholas G. Martin, Grant W. Montgomery, Michael E. Goddard, and Peter M. Visscher. 2010. "Common SNPs Explain a Large Proportion of the Heritability for Human Height." *Nature Genetics* 42(7): 565–69.
- Yang, Jian, Sang Hong Lee, Michael E. Goddard, and Peter M. Visscher. 2011. "GCTA: A Tool for Genome-wide Complex Trait Analysis." *American Journal of Human Genetics* 88(1): 76–82.

## Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

**Table S1:** Sample Background Statistics.

**Table S2:** Summary Statistics for Psychological and Political Traits in Monozygotic (MZ) and Dizygotic (DZ) Twins.

**Table S3:** Model Fit for the Univariate Sex-limitation and Pooled Models.

**Table S4:** Male and Female Univariate Estimates for Psychological and Political Traits.

**Table S5:** Model Fit for the Bivariate Cholesky Models.

**Table S6:** Bivariate Cholesky Genetic and Environmental Correlations.

**Table S7:** Bivariate Cholesky Percentage of Total Correlation due to Genetic and Unique Environmental Factors.

**Table S8:** Model Fit for the Bivariate Cholesky and Direction of Causation Models.

**Table S9:** Bootstrapped within-pair Correlations for Psychological and Political Traits in Monozygotic (MZ) and Dizygotic (DZ) Twins.

**Figure S1:** Mediation relationship between latent genetic factors, psychological traits, and political traits.

**Figure S2:** Pleiotropic relationship between latent genetic factors, psychological traits, and political traits.

**Figure S3:** Percentage of the total correlation attributable to genetic factors are presented along with 95% confidence intervals.

**Figure S4:** Percentage of the total correlation attributable to genetic factors are presented along with 95% confidence intervals.

**Figure S5:** Bivariate Cholesky decomposition model. The circles represent latent traits and squares represent measured traits.

**Figure S6:** Direction of Causation model. The circles represent latent traits and squares represent measured traits.