# Not by Twins Alone: Using the Extended Family Design to Investigate Genetic Influence on Political Beliefs

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*Variance components estimates of political and social attitudes suggest a substantial level of genetic influence, but the results have been challenged because they rely on data from twins only. In this analysis, we include responses from parents and nontwin full siblings of twins, account for measurement error by using a panel design, and estimate genetic and environmental variance by maximum-likelihood structural equation modeling. By doing so, we address the central concerns of critics, including that the twin-only design offers no verification of either the equal environments or random mating assumptions. Moving beyond the twin-only design leads to the conclusion that for most political and social attitudes, genetic influences account for an even greater proportion of individual differences than reported by studies using more limited data and more elementary estimation techniques. These findings make it increasingly difficult to deny that—however indirectly—genetics plays a role in the formation of political and social attitudes.*

Genetic epidemiology, psychiatric genetics, and behavior genetics have long relied on the classical twin design (CTD) to estimate the genetic and environmental components of physical, psychological, behavioral, and clinical traits. The value of this design derives from the existence of two fundamentally different types of twin pairs, each with a known level of genetic similarity. Monozygotic (MZ; frequently but erroneously called identical) twins, for several hours and often days, are the same zygote. The subsequent splitting into two zygotes means that the genetic heritage of each twin is essentially the same. Dizygotic (DZ; frequently called fraternal) twins result from separate fertilization of one egg by one sperm and a second distinct egg by a second distinct sperm. In accord with normal meiotic cell division and subsequent fertilization, the resultant twin pair shares roughly 50% of the variable genetic makeup, the same as all nontwin full sibling pairs. It is this fixed ratio (two to one) of shared genetic similarity between MZ and DZ twins that provides most of the leverage of twin studies.

The use of this powerful design allows geneticists to estimate the roles of genes, common environmental

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influences (those likely to be shared by family members), and unique environmental influences (those not necessarily shared by family members) in traits as varied as breast cancer, depression, schizophrenia, attention deficit hyperactivity disorder (ADHD), alcoholism, autism, obesity, and personality. It has also been used to estimate sources of individual differences for political beliefs.

# Genetic Influences on Political Beliefs

The most extensive early studies on attitudes were Martin et al. (1986) and Eaves, Eysenck, and Martin (1989). Using large data sets drawn from twins in Australia and the United States, respectively, these scholars reported results that "undermine the naïve assumption that the resemblance of family members can be interpreted in purely social terms" (Martin et al. 1986, 4368). Even though later analyses, often with different data and in different countries (see Bouchard and McGue 2003; Eaves et al. 1999; Olson et al. 2001), produced similar results, political scientists took virtually no notice of these provocative findings, perhaps because political scientists typically assume attitudes are entirely the product of environmental forces such as parental socialization and do not take seriously the possibility that genes could be involved (for exceptions, see Merelman 1971; Peterson 1983; Segal and Spaeth 1993, 234; Zaller 1992, 23). Then in 2005, Alford, Funk, and Hibbing performed additional analyses on the same combined data set collected and employed by Eaves et al. (1999) and presented the results to the political science community. Similar to earlier results, the findings suggested a surprising degree of genetic influence for political attitudes but suggested that genetics may play less of a role in the direction of party identification.

The claim that differences in one's political beliefs are shaped by a combination of environmental *and* genetic influences rather than just the environment may be difficult for some political scientists to accept in that incorporating genetic influences necessitates a fairly dramatic rethinking of the nature of political attitudes. One critic of Alford, Funk, and Hibbing asserted that "if true, it would require nothing less than a revision of our understanding of all of human history, much, if not most of political science, sociology, anthropology, and psychology, as well as, perhaps, our understanding of what it means to be human" (Charney 2008, 300).

Regardless, since 2005 interest in the heritability of political variables has increased. Hatemi et al. (2007) found that vote choice is heritable but that the majority of the genetic influence on vote choice appears to be accounted for not directly but indirectly through the heritability of political attitudes. Fowler, Baker, and Dawes (2008) made the important discovery that actual voter turnout (not self-reported turnout) also is influenced substantially by genes. Further studies found that strength of affiliation with a party (regardless of the particular party involved) is strongly heritable (Hatemi, Alford et al. 2009). The findings that genes appear to have only a modest effect on direction of party identification, mostly an indirect effect on vote choice, and a stronger effect on strength of group affiliation could make sense given that party identification and voting for specific candidates are time-bound phenomena whereas the tendency toward group attachment (regardless of the nature of the group) may run deeper.

Many perceive political attitudes to be entirely "learned" and therefore just as time and culture bound as party identification (see Eagly and Chaiken 1993; Perloff 2003). After all, twin studies have reported heritability for attitudes toward nuclear power, property taxes, and busing, and these issues have only been present for a generation or two, far too short a time for specific genes pertinent to such concerns to evolve. But, it may be that genes, while not relating directly to ephemeral issues of the day, work on deeper principles of group life that in turn are relevant to specific issues depending upon how they are framed in a particular culture at a particular time. There is likely no direct genetic basis for whether or not to build a wall on the Mexican border, but there might be genes that indirectly shape perception of outgroups, sensitivity to external threat, and preference for ingroup cohesion (for evidence that this may be the case, see Oxley et al. 2008).

Due in part to potentially demanding assumptions and data limitations, the classic twin design (hereafter CTD) is primarily utilized as only an initial indication of the methods by which the trait of interest has been acquired. In particular, three shortcomings are of relevance here, and the first two are specific to the CTD; namely, univariate twin-only analyses provide little opportunity to detect violations of either the equal environments assumption or the random mating assumptions. The third shortcoming is the problem of estimating and correcting for measurement error, a perennial concern for all empirical investigations but a particular concern in the CTD because measurement error creates an upward bias on estimates of the impact of unshared environment (Fisher 1918)—and in models that correct for mate assortation, as we do here, this concern is compounded (Eaves and Hatemi 2008). In this article, we address these shortcomings by employing a nuclear family design, which includes

parents and nontwin siblings, as well as test-retest measures of each of the traits of interest. By applying improved methodological procedures to a valuable data set, we provide a more accurate estimate of the influence on political attitudes of genetics, shared environment, and unshared environment.

The data we utilize were also the basis for the Eaves et al. (1999), Alford, Funk, and Hibbing (2005), and Hatemi, Medland, and Eaves (2009) twin-only studies, a data set originally known as the "Virginia 30,000" or "VA30K" for short (for information on the structure of the sample and ascertainment procedures, see Lake et al. 2000; Maes, Neale, and Eaves 1997; Truett et al. 1994). The approximately 30,000 adult subjects (aged 18–84 years) were twins (N = 14,781), spouses (N = 4,391), parents (N = 2,360), relatives (N = 195), offspring (N = 4,800), and nontwin siblings of twins (N = 3,184). The inclusion of nontwin relatives is especially helpful in identifying the multiple sources of biological and cultural inheritance (Heath et al. 1985).

The social and political attitude measures were included in a 28-item contemporary attitude battery gathered as part of a larger "Health and Life Styles" inventory conducted in 1986. Item format was the same as the Wilson-Patterson Attitude Index (Wilson and Patterson 1968), where attitude measurement is simplified by presenting each item in a one- or two-word format. Respondents are instructed to answer with the first reaction that comes to mind: "agree," "uncertain," or "disagree." Data were collected by mail, with mail and telephone follow-up of nonrespondents when needed. Approximately two years later, the same attitude items were included in a follow-up questionnaire mailed to twins aged 50+ years, providing measures of attitude stability for 1,019 men and 2,912 women. In the remainder of this article, we ply the two-wave extended family portions of these data in order to better explore the nature and transmission of political attitudes.

## The Equal Environments Assumption

An important drawback with data restricted to twin-only analyses is that questions inevitably arise over the assumed similarity in the environments for MZ and for DZ twin pairs. In fact, no feature of the CTD has generated more attention and concern. If the environments of MZ twin pairs are more similar than the environments of DZ twin pairs, and if this increased similarity is in any way related to the trait of interest, variance may be attributed to genetics when it actually belongs to environmental influence. Often misunderstood is that contemporary twin

studies do not assume that the environments of MZ twins are no more similar than the environments of DZ twins. MZ twins are indeed more likely than DZ twins to share certain environmental experiences, such as sleeping in the same bedroom and having the same friends (Kendler et al. 1992; Scarr and Carter-Saltzman 1979). The key question is whether violations of the equal environments assumption (EEA) occur with regard to political attitudes. Sharing the same bedroom is one thing; expecting a shared bedroom during childhood to lead to greater similarity in political attitudes and behaviors is another. It certainly seems unlikely that the parents of DZ twins are less eager than the parents of MZ twins for their children to hold the same political beliefs. Nevertheless, the CTD by itself is incapable of empirically alleviating suspicions that violations of the EEA artificially inflate heritability estimates.

Over the last 30 years, a variety of methods in psychology, psychiatry, and genetics have been used to verify that MZ and DZ pairs are not unequally influenced by different environments for a wide array of behavioral traits (for a review, see Medland and Hatemi 2009). These methods include comparing the twin trait similarity for blood-determined zygosity and for family-perceived zygosity among those twins for whom genetic zygosity is misperceived by family members (blood-determined zygosity is consistently found to be the better predictor—see Matheny, Wilson, and Dolan 1976; Plomin, Willerman, and Loehlin 1976; Scarr and Carter-Saltzman 1979); observing twin treatment by family members and others to examine differences in behaviors toward the different twin types (Lytton 1977); measuring specific environmental indicators for each twin and modeling differences in environment for the trait of interest while controlling for actual zygosity (Kendler et al. 1987; Heath, Jardine, and Martin 1989); extending the CTD by partitioning the shared environment into the overall common environment, $C_{residual}$, which is completely correlated for all twin pairs, and that which is influenced by the perceived zygosity, $C_{specific}$, (Hettema, Neale, and Kendler 1995; Kendler et al. 1993; Xian et al. 2000); and utilizing actual genetic similarity, known as identity by descent (IBD), rather than assuming that DZ twins or full siblings share on average 50% of their segregating genes. Regarding this last method, Visscher et al. (2006) obtained exact measures of genetic sharing of sibling pairs, and excluded MZ twins, thus removing any equal environmental concerns, and found that the heritability estimate for height was very similar to that derived from traditional CTD analyses.

Perhaps of most relevance to questions about the EEA is recent work by Hatemi, Funk et al. (2009). Utilizing a longitudinal panel study of adolescent twins (aged 8–18) to assess political attitudes every two years, they found

that there was no difference in MZ/DZ twin pair similarity throughout adolescence but that twin pair differences in political attitudes emerged later, when twins had departed from the parental nest. Thus, in order for it to be believed that a violation of the EEA is responsible for the heritability estimates previously reported, it would be necessary to argue that a special MZ twin environment for political attitudes exists in adolescence but remains dormant until adulthood, when it is triggered by some unidentified mechanism that then shapes adult preferences.

In light of these findings, a substantial amount of evidence runs against the existence of a special twin environment for political beliefs. Still, since doubts continue, we adopt an alternative strategy here. Directly testing for potential differences between MZ and DZ pair environments and for the method by which these differences might influence the trait for each zygosity type requires specific common environmental measures not typically available. Such direct tests include analysis of MZ twins reared apart and adoption studies, but these approaches have their own problems (see Medland and Hatemi 2009). Our approach here is to include data on nontwin siblings, thereby allowing the model to partition variance separately for siblings generally and for twin siblings specifically. If the more similar treatment of MZ twins were indeed influencing relevant (i.e., political) trait values, then the more similar treatment of DZ twins relative to nontwin full siblings should also affect that trait. The degree of genetic similarity of DZ twins and full siblings is the same, so after correcting for fixed effects (e.g., age), differences between twins and nontwin siblings provide an indirect estimate of twin-specific environmental effects. In simple terms, while we cannot identify specific EEA violations, we can identify the total amount of variance attributable to twin-specific environmental effects.

Using a full maximum-likelihood (ML) approach, the statistical significance of the twin-only environment can be estimated in two ways. The first is to examine the confidence intervals for the twin-specific environment since if the bounds extend to zero, the effect of the twin-specific environment is not likely to reach statistical significance. A more robust measure is to drop the twin-only environmental effects and compare the fit of this reduced model with that of the full model. If the contribution of the twin-only environment does not reach statistical significance, it suggests the EEA is met for the trait being studied. Given that this is an indirect test of the equal environments assumption, it is important to consider the mathematical potential for there to be some MZ-specific environmental impact despite the overall absence of twin-specific effects. If the combination of both types of twins produces no

twin-specific environmental effect, the mean influence of the two sources of the twin-only environmental variance (MZ and DZ) is zero. What are the possible combinations of MZ and DZ effects that would produce a zero overall twin effect? In a sample with an equal or greater number of MZ twin pairs relative to that of DZ twin pairs, the DZ twin pairs would have to have a zero environmental correlation and the MZ twin pairs an environmental correlation of 1 in order for an MZ-only environment effect to exist despite the presence of a zero-combined twin impact. Since we know that DZ twin pairs share the same parents, schools, SES, and home environment, a scenario of a zero DZ cotwin common environment is not possible. Thus, we can reasonably conclude that if the twin-only environment is not significantly different from zero, there is insufficient evidence to support the contention of a statistically significant influence from differences in the common environment between DZ and MZ twins.

Another significant advantage of modeling nontwin sibling data is that it vastly increases the power to detect common environmental effects (Coventry and Keller 2005; Posthuma and Boomsma 2000; Posthuma et al. 2003). The ability to identify common environmental influences or genetic dominance is maximized when there are four times as many DZ pairs as MZ pairs and nontwin siblings effectively increase the DZ/sib to MZ ratio (for a more detailed conceptual and mathematical discussion, see Nance and Neale 1989 and Posthuma and Boomsma 2000).

In sum, checking for differences between the DZ covariance and the twin-sibling and sibling-sibling covariances provides additional information and offers researchers more confidence in the EEA for the trait in question. If the more similar treatment of MZ twins affects their trait values, the more similar treatment of DZ twins as compared to regular siblings is likely to impact their values. The data set being employed in this research contains information on 9,727 nontwin sibling pairs, making it extremely valuable for these purposes.

The addition of parents and nontwin siblings to the analysis also allows for a more extended exploration of the extent to which some part of the genetic variation is nonadditive. Nonadditive genetic influences arise from interactions either within a gene (known as *dominance*) or between genes (known as *epistasis*; Neale et al. 2003). Typically, twin models focus on the additive estimate because the combined effect of all genes can be estimated with more confidence than models which partition out nonadditive influences. This limitation is important when diagnostics suggest nonadditive effects are present. Diagnostics for detection of nonadditive influences are most

**TABLE 1    Wilson-Patterson Inventory Polychoric Correlations for Relatives**

| Item | Nontwin Siblings | | | Dizygotic Twins | | | Monozygotic Twins | | | Parent-Offspring | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MM | FF | MF | DZM | DZF | DZMF | MZM | MZF | M-D | M-S | F-D | F-S |
| Death Penalty | .28 | .31 | .27 | .41 | .37 | .33 | .52 | .54 | .35 | .19 | .26 | .18 |
| Astrology | .25 | .25 | .16 | .23 | .31 | .23 | .48 | .47 | .17 | .23 | .15 | .14 |
| X-rated movies | .34 | .31 | .26 | .35 | .40 | .31 | .58 | .59 | .22 | .15 | .20 | .25 |
| Modern art | .22 | .26 | .20 | .27 | .32 | .23 | .43 | .43 | .22 | .14 | .14 | .09 |
| Women's liberation | .25 | .32 | .23 | .20 | .35 | .16 | .31 | .52 | .29 | .19 | .25 | .25 |
| Foreign aid | .20 | .23 | .20 | .28 | .21 | .23 | .41 | .46 | .20 | .22 | .21 | .15 |
| Federal housing | .18 | .15 | .16 | .25 | .25 | .16 | .28 | .40 | .21 | .21 | .13 | .18 |
| Democrats | .17 | .27 | .24 | .29 | .37 | .27 | .43 | .48 | .38 | .26 | .29 | .30 |
| Military drill | .18 | .17 | .17 | .19 | .24 | .10 | .40 | .36 | .20 | .14 | .17 | .15 |
| The draft | .28 | .21 | .21 | .29 | .17 | .25 | .49 | .36 | .16 | .11 | .19 | .18 |
| Abortion | .42 | .46 | .41 | .42 | .56 | .43 | .55 | .68 | .48 | .34 | .43 | .37 |
| Property tax | .23 | .26 | .25 | .22 | .29 | .27 | .50 | .45 | .21 | .24 | .18 | .12 |
| Gay rights | .31 | .45 | .35 | .37 | .49 | .39 | .57 | .60 | .48 | .33 | .30 | .32 |
| Liberals | .24 | .31 | .26 | .32 | .37 | .24 | .36 | .47 | .29 | .21 | .16 | .25 |
| Immigration | .26 | .24 | .23 | .30 | .28 | .20 | .45 | .46 | .22 | .21 | .20 | .20 |
| Capitalism | .34 | .24 | .24 | .36 | .31 | .23 | .62 | .47 | .28 | .21 | .26 | .27 |
| Segregation | .21 | .20 | .23 | .21 | .26 | .14 | .38 | .38 | .19 | .19 | .21 | .11 |
| Moral Majority | .20 | .24 | .17 | .19 | .24 | .17 | .41 | .43 | .23 | .23 | .18 | .23 |
| Pacifism | .10 | .14 | .15 | .14 | .14 | .18 | .36 | .31 | .08 | .07* | .05* | .04† |
| Censorship | .29 | .17 | .15 | .15 | .27 | .15 | .43 | .37 | .17 | .09 | .12 | .03† |
| Nuclear power | .26 | .12 | .14 | .20 | .26 | .18 | .45 | .33 | .22 | .18 | .13 | .20 |
| Living together | .39 | .52 | .44 | .51 | .50 | .36 | .56 | .70 | .45 | .29 | .36 | .32 |
| Republicans | .26 | .22 | .21 | .24 | .33 | .28 | .47 | .48 | .33 | .31 | .29 | .27 |
| Divorce | .21 | .27 | .24 | .32 | .35 | .19 | .42 | .49 | .25 | .25 | .22 | .24 |
| School prayer | .50 | .44 | .42 | .45 | .46 | .44 | .67 | .66 | .47 | .52 | .48 | .45 |
| Unions | .20 | .18 | .12 | .25 | .25 | .14 | .46 | .42 | .26 | .23 | .20 | .25 |
| Socialism | .13 | .16 | .19 | .22 | .26 | .26 | .38 | .45 | .16 | .12 | .15 | .05* |
| Busing | .20 | .23 | .18 | .36 | .27 | .26 | .45 | .42 | .21 | .14 | .19 | .14 |
| N (pairs) | 4462 | 1564 | 3701 | 610 | 1273 | 1397 | 814 | 1982 | 4802 | 3233 | 3166 | 2315 |
| $S^2$ | 17.73 | 7.67 | 13.75 | 20.13 | 15.50 | 28.48 | 7.56 | 2.39 | .40 | .34 | .68 | 1.35 |

*Notes*: All correlations are significant (p = .01 or better), unless otherwise marked; * = .05, † = not significant.

Key:
MM = male siblings; FF = female siblings; MF = male and female siblings; DZM = male dizygotic twins; DZF = female dizygotic twins; DZMF = mixed sex dizygotic twins; MZM = male monozygotic twins; MZF = female monozygotic twins; M-D = mother-daughter; M-S = mother-son; F-D = father-daughter; and F-S = father-son.

often performed by comparing the MZ and DZ twin correlations. If the MZ pair correlation is significantly more than twice as large as the DZ correlations, nonadditive influences are likely to be important (Neale et al. 2003). The correlations presented in Table 1 show that for only three of the 28 items (for females) and seven of the 28 items (for males)—a total of only 10 out of a possible 56—is there any suggestion of nonadditive effects. For these 10, the DZ correlations are only slightly below half of the MZ correlations; thus preliminary analyses give little cause to suspect significant nonadditive effects.

A more developed assessment of the presence of nonadditive effects is made possible by the inclusion in our data set of nontwin family members. Additive genetic effects typically produce trait correlations that are at similar levels for DZ twins, nontwin siblings, and parent-offspring pairs, and that, for all three of these relationship categories, average at least half the size of the MZ twin pair correlations. When nonadditive genetic effects dominate, the MZ twin correlations will remain robust, but all three of the other family pairs will exhibit much reduced similarity. This distinction gives rise to the readily

apparent family history of traits that exhibit "narrow sense" heritability (i.e., heritability that "runs in the family" and that characterizes simple additive genetic effects) in contrast to traits that exhibit only "broad sense" heritability (i.e., traits that show little clear clustering in families despite the fact that they may have equally strong, if more complex, genetic underpinnings).

As it turns out, extended twin-family studies of personality provide clear evidence of nonadditive genetic effects (Keller et al. 2005), but our Table 1 provides no evidence of this pattern for political temperaments. At least for the Wilson-Patterson items examined here, trait correlations are very similar across same-sex DZ twins, nontwin siblings, and parent-offspring pairs, and for all three of these relationship categories, average correlations are approximately half the size of the MZ twin pair correlations. Political temperament as measured here appears to exhibit narrow sense heritability, in clear contrast to the broad sense heritability that characterizes personality traits.

## Assortative Mating

A second major assumption of the CTD is that mating is random regarding the trait of interest. If it is not, variance components estimates will again be biased. Interestingly, however, the direction of this bias is opposite to that of the EEA. The danger here is that genetic variance will be underestimated, not overestimated. As detailed above, the assumption that DZ twins, like any other pair of biological siblings, share on average 50% of the variable genetic code, is crucial to the estimation of heritability since the 50%-for-DZ/100%-for-MZ contrast provides the leverage for separating genetics from the shared environment. The assumption that purely genetic traits in DZ twins will on average correlate at .50 is itself built on the assumption that their biological parents will on average correlate at .00 for the same traits, and that these traits are not genetically influenced. In short, the CTD is built on the assumption that, with regard to the phenotypic trait under observation, the parents do not share the same genes.

This assumption, however, is violated if mate choice itself is based on the trait of interest. If, in the extreme example, parents have identical genetic codes for a trait of interest, then the shuffling of that genetic code produced by sexual reproduction will not result in any variation among DZ twins (or any other siblings) with regard to their genotype for that trait. For this particular phenotype, DZ twins of these parents will be as genetically alike as MZ twins (Eaves 1979; Heath et al. 1985). In such a case, the additive genetic path that sets DZ = .5/MZ = 1 no longer would be accurate. Across a study population, the higher the proportion of spouses who share genes for a trait, the closer the DZ correlation will be to the MZ correlation and the more the genetic variance of this trait will be underestimated (regardless of the genetic similarity of parents, MZ twins share 100% of the variable genetic code). Thus, if people tend to choose mates with similar positions on political issues, the CTD understates the heritability of political attitudes and inflates estimates of the importance of shared environment.

The preliminary empirical issue thus is the extent to which assortative mating takes place with regard to political issue positions (see also McCourt et al. 1999). An answer can be found by looking at the interspouse correlations for the mate pairs in the VA30K study. This survey was completed by the spouses of 4,387 twins as well as by 773 mate pairs with twins as offspring—a total of 5,160 spousal pairs, making it ideal for inspecting interspousal correlations. Table 2 consists primarily of the 28 Wilson-Patterson Inventory items and also, at the top, an overall additive index of "liberal/conservative" responses to these 28 items, but for purposes of comparison we also include results from four nonpolitical variables contained in the data set: extraversion and neuroticism (as measured by items in the Eysenck Personality Quotient), plus height and weight.

Correlations for political attitudes far outstrip those for physical and personality traits. Extraverts are as likely to marry introverts as other extraverts, and the interspousal correlation for neuroticism is not much larger. The correlations for height and weight of spouses are positive and statistically significant but small, suggesting that taller and heavier individuals do indeed have spouses who tend to be tall and heavy but that this pattern is often violated. In direct contrast, attitudes on political and social items are quite likely to be shared by mate pairs. The correlation for the overall index of attitudes is extremely high (.647) and inspection of the individual items indicates why. Though the correlations for some of the less salient items, such as military drill, modern art, federal housing, and censorship, are modest, most others are substantial and, as was the case in Table 1, the correlations for hot-button issues such as school prayer, abortion, gay rights, and living together are very high.

Spousal pairs tend to share the same political and social attitudes. Of course, some of this interspouse similarity could be the result of assimilation over the course of a relationship or to social homogamy (the tendency of people to mate with those around them). However, Martin et al. (1986) find that the correlation between mates is due primarily to assortation and not to convergence.

TABLE 2    Spousal Concordance on the 28
Individual Wilson-Patterson Items,
Ranked, and Selected Nonpolitical
Traits

|  | Pearson's Corr. | Statistical Significance | N |
|---|---|---|---|
| *Nonpolitical Items* | | | |
| EPQ neuroticism | .082 | .000 | 4991 |
| EPQ extraversion | .005 | .750 | 4739 |
| Height | .227 | .000 | 4964 |
| Weight | .164 | .000 | 4985 |
| Liberal-Conservative Index | .647 | .000 | 3984 |
| *Individual W-P Items* | | | |
| School prayer | .647 | .000 | 5002 |
| Abortion | .631 | .000 | 4968 |
| Gay rights | .581 | .000 | 4953 |
| Living together | .573 | .000 | 4977 |
| Democrats | .527 | .000 | 4906 |
| Republicans | .498 | .000 | 4902 |
| X-rated movies | .472 | .000 | 5005 |
| Unions | .462 | .000 | 4953 |
| Liberals | .451 | .000 | 4912 |
| Capitalism | .443 | .000 | 4895 |
| Death penalty | .437 | .000 | 4999 |
| Moral Majority | .412 | .000 | 4882 |
| Divorce | .410 | .000 | 4955 |
| Women's liberation | .408 | .000 | 4980 |
| The draft | .400 | .000 | 4938 |
| Nuclear power | .392 | .000 | 4952 |
| Property tax | .381 | .000 | 4923 |
| Busing | .352 | .000 | 4978 |
| Socialism | .348 | .000 | 4888 |
| Foreign aid | .343 | .000 | 4986 |
| Astrology | .336 | .000 | 4889 |
| Federal housing | .317 | .000 | 4978 |
| Immigration | .316 | .000 | 4961 |
| Pacifism | .304 | .000 | 4809 |
| Segregation | .303 | .000 | 4933 |
| Modern art | .300 | .000 | 4977 |
| Military drill | .281 | .000 | 4897 |
| Censorship | .253 | .000 | 4909 |

*Source*: VA30K survey data.

With regard to most attitudes, spouses do not become more similar with the passage of the years. The social homogamy explanation for high spousal correlations also seems to fail as these correlations persist even among specific demographic categories, including religious denomination, frequency of church attendance, family income level, and education. All in all, it seems that spouses have similar political and social attitudes not only because they move (and find mates) in environments filled with people like them and not only because they grow to accommodate each other's views with the passage of the years, but also and perhaps primarily because—knowingly or unknowingly—they select mates in part on these views in the first place. Because it appears political assortative mating does occur, more accurate estimates of the effects of heritability and the environment will be obtained if parents are included in the model.

## Measurement Error and the Unique Environment

Measurement error is always a concern but especially with survey items for which respondents frequently provide answers that do not reflect their true feelings (see Converse 1964; Zaller 1992). When respondents change their answers to the same item, suspicion grows that researchers are picking up noise or error. Error of this sort may create a particular problem for variance components modeling because standard methodological procedures push the error term into estimates for the unshared (unique) environment, thus inflating the apparent importance of idiosyncratic environmental events at the expense of estimates of the importance of both the shared environment and additive genetic influences.

Repeated measures offer the difference between "reliable variance" and a measure at "one point in time." To take one example, if spousal concordance exists for a "political" phenotype (see previous section), it might be expected that concordance is due to long-term political similarity, rather than any error-prone single assessment. Repeated measures offer one approach to estimating and, thus, controlling for such short-term fluctuations, thereby making it possible to correct estimates (Eaves 1973). Not accounting for this error may affect conclusions concerning the relative importance of the primary shapers of attitudes, thereby leading to erroneous interpretations.

The VA30K data set provides a solution to this problem as well. In addition to including thousands of non-twin respondents, portions of the instrument were administered again, approximately two years later (note the contrast with typical procedures that repeat items just weeks, days, or even minutes apart), to nearly 4,000 of the initial respondents. These two separate soundings make it possible to correct for response instability, thereby affording more accurate estimates of the relative influence of additive genetic, as well as shared and unshared environmental influences.

Rather than present a separate table with these test-retest results, they are built into our primary tabular result, Table 3. In the last two columns of this table, the test-retest coefficients are presented, first for males and then for females. As can be seen, these numbers are quite low on salient items such as school prayer, abortion, the death penalty, and gay rights, but the "measurement error" is much higher precisely for those less salient responses for which sentiments could reasonably be expected to vary from one time to the next: property taxes, federal housing, military drill, pacifism, and censorship. Measuring and accounting for these differential levels of test-retest correlation greatly improves the accuracy of the estimates produced by the extended twin family analysis we are about to undertake.

# The Model

Genetic models, including extended nuclear family models, can be estimated using a wide variety of approaches including mixed effects models and Bayesian techniques (for a review, see Rabe-Hesketh, Skrondal, and Gjessing 2008). Such approaches have the advantage of being more familiar to political scientists and also allowing the use of standard social science statistical software, including SPSS, Stata, SAS, or S-PLUS. Our use of SEM modeling, as implemented in the Mx software package, is the standard approach in behavior genetics (Martin et al. 1986; Neale and Cardon 1992; Truett et al. 1994) and provides advantages in the visual display of relationships in path diagrams, estimation of sibling interaction models, homogamy models, and more complex models of parent-child resemblance.

SEM allows for the inclusion of mean effects for covariates, provides a way to test model parameters, permits comparison of alternative models, and makes possible more complicated models including a wider range of relations (e.g., parents, nontwin siblings, and half-sibs). SEM requires explicit delineation of hypotheses in terms of covariance/variance matrices. ML is then used to maximize the goodness-of-fit between observed and predicted covariance/variance matrices, yielding estimates of how well the model fits the data. The optimization converges at the solution when it locates the parameters that produce the largest log-likelihood. The resulting parameters are estimates of the magnitude of the latent sources of genetic and environmental variance (ACE: A for additive genetic; C for common environment; E for unique environment). The reliability of these estimates is typically expressed as 95% confidence intervals, which are the de-

viations from the estimates that result in a change in the fit of the model (minus twice log likelihood, –2LL) of 3.64 (equivalent to $\chi^2_1$, p = .05).

The relationship between twins can be modeled according to the conventions of path analysis as illustrated in Figure 1. Squares denote observed variables, circles denote latent variables, upper-case letters denote variables, lower-case letters denote covariances or path coefficients, single-headed arrows represent hypothesized causal relationships, and double-headed arrows represent covariances between variables. The expected covariance is computed by multiplying together all the coefficients in a chain and then summing over all possible chains (trace backwards, change direction at a double-headed arrow, and then trace forwards). Thus, the variance for an MZ twin is calculated as: $(a * 1 * a) + (c * 1 * c) + (e * 1 * e) = a^2 + c^2 + e^2$.

Extending the CTD, the "nuclear family" model was initially formulated by Truett et al. (1994) and Eaves et al. (1999), and first applied to political traits by Eaves and Hatemi (2008). The maximum-likelihood model used here to identify the influences of genes and environment on the reliable components of family resemblance for the social attitude items is presented in Figure 2. For explanatory purposes, the nuclear family model shown is specifically for use with opposite-sex DZ twins and their parents and is adjusted for use with each type of sibling in subsequent analyses. The same method of tracing rules is applied and each path calculated accordingly (for a detailed explanation of the model and path calculations, see Truett et al. 1994). The model presented in Figure 2 allows for (1) additive genetic influences for males and females ($h_m$ and $h_f$) on the latent constructs that represent opinions on each of the individual attitudes (Johannsen 1911); (2) environmental effects not shared by twins or siblings, (unique environment) $e_m$ and $e_f$; (3) environmental effects shared by male and female siblings and DZ twins but not transmitted from parents (common environment) $c_m$ and $c_f$; (4) additional environmental similarity between twins (MZ and DZ) because twin environments often correlate more highly than siblings, $t_m$ and $t_f$; (5) direct social transmission ("vertical cultural inheritance"; Cavalli-Sforza and Feldman 1981) from mothers and fathers to their sons and daughters ($u_m$, $u_f$, $v_m$, and $v_f$); and (6) phenotypic assortment between spouses $m$ (correlation between mates—"assortative mating").

In addition, the nuclear family model contains two parameters corresponding to the correlations between the genotypes and phenotypes of both parents individually ($r_{gm}$ and $r_{gf}$). Under the assumption that the model parameters are stable over generations, these can be expressed as functions of the other parameters of

## TABLE 3 Maximum-Likelihood Estimates of the Nuclear Family Model

| Political Phenotypes | Additive Genetic | | Unique Environment | | Shared Sibling Environment | | Extra-Shared Twin Environment | | Vertical Cultural Inheritance | | Genotype-Environment Covariance | | Measurement Error | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $V_{AM}$ | $V_{AF}$ | $V_{EM}$ | $V_{EF}$ | $V_{CM}$ | $V_{CF}$ | $V_{TSM}$ | $V_{TSF}$ | $V_{CIM}$ | $V_{CIF}$ | $C_{GEM}$ | $C_{GEF}$ | $V_{ERM}$ | $V_{ERF}$ |
| Death penalty | .380 | .472 | .285 | .246 | .093 | .010 | .105 | .090 | .020 | .007 | −.105 | −.020 | .222 | .195 |
| Astrology | .476 | .387 | .198 | .259 | .007 | .065 | .020 | .061 | .036 | .008 | −.099 | −.056 | .362 | .278 |
| X-rated movies | .687 | .619 | .193 | .102 | .000 | .000 | .000 | .031 | .069 | .035 | −.262 | −.180 | .313 | .393 |
| Women's liberation | .343 | .439 | .279 | .179 | .000 | .045 | .000 | .036 | .013 | .000 | −.037 | −.014 | .402 | .314 |
| Foreign aid | .392 | .617 | .226 | .170 | .004 | .005 | .076 | .004 | .030 | .056 | −.126 | −.246 | .398 | .393 |
| Federal housing | .167 | .385 | .293 | .154 | .042 | .000 | .017 | .086 | .002 | .031 | .016 | −.091 | .463 | .434 |
| Democrats | .383 | .338 | .284 | .281 | .000 | .000 | .038 | .114 | .015 | .018 | −.050 | .023 | .329 | .226 |
| Military drill | .315 | .408 | .246 | .143 | .000 | .000 | .016 | .000 | .004 | .001 | −.030 | −.015 | .449 | .464 |
| The draft | .302 | .381 | .245 | .162 | .000 | .000 | .105 | .022 | .023 | .010 | −.056 | −.056 | .381 | .482 |
| Abortion | .430 | .385 | .229 | .194 | .109 | .080 | .023 | .048 | .002 | .032 | .008 | .126 | .199 | .135 |
| Property tax | .475 | .537 | .090 | .195 | .000 | .000 | .000 | .000 | .092 | .026 | −.182 | −.142 | .525 | .384 |
| Gay rights | .506 | .442 | .219 | .181 | .021 | .000 | .080 | .049 | .004 | .060 | −.052 | .072 | .222 | .195 |
| Liberals | .312 | .394 | .269 | .154 | .054 | .033 | .000 | .087 | .008 | .050 | −.032 | −.079 | .390 | .362 |
| Immigration | .456 | .633 | .149 | .134 | .024 | .024 | .062 | .000 | .026 | .050 | −.146 | −.231 | .428 | .390 |
| Capitalism | .658 | .330 | .124 | .223 | .011 | .000 | .010 | .127 | .043 | .002 | −.188 | .025 | .342 | .293 |
| Segregation | .497 | .369 | .143 | .191 | .019 | .012 | .000 | .069 | .079 | .014 | −.237 | −.087 | .499 | .431 |
| Pacifism | .304 | .337 | .292 | .179 | .000 | .000 | .059 | .057 | .057 | .059 | −.141 | −.154 | .428 | .521 |
| Censorship | .506 | .250 | .123 | .168 | .023 | .056 | .000 | .091 | .104 | .004 | −.250 | −.022 | .494 | .452 |
| Nuclear power | .475 | .133 | .155 | .251 | .000 | .000 | .009 | .143 | .109 | .041 | −.109 | .017 | .451 | .415 |
| Living together | .399 | .837 | .085 | .132 | .000 | .000 | .163 | .000 | .028 | .032 | −.081 | −.231 | .406 | .231 |
| Republicans | .422 | .307 | .188 | .249 | .000 | .000 | .018 | .098 | .003 | .011 | −.021 | .062 | .390 | .272 |
| Divorce | .196 | .446 | .256 | .241 | .003 | .109 | .155 | .000 | .003 | .009 | .031 | −.075 | .357 | .271 |
| School prayer | .695 | .643 | .202 | .203 | .029 | .000 | .000 | .047 | .017 | .002 | −.084 | −.037 | .141 | .141 |
| Socialism | .318 | .483 | .314 | .148 | .000 | .000 | .057 | .054 | .054 | .039 | −.145 | −.166 | .402 | .442 |
| Busing | .166 | .336 | .165 | .200 | .095 | .048 | .141 | .030 | .000 | .000 | −.002 | −.004 | .436 | .390 |
| Modern art | .459 | .286 | .266 | .267 | .000 | .009 | .010 | .068 | .045 | .006 | −.139 | .003 | .360 | .360 |
| Liberalism-Conservatism | .577 | .343 | .014 | .013 | .000 | .000 | .012 | .054 | .008 | .089 | .012 | .160 | .378 | .341 |
| Party ID | .130 | .099 | .379 | .357 | .138 | .057 | .081 | .160 | .161 | .223 | .112 | .103 | NA | NA |

*Note*: Estimates in grayscale are not significant (p = .05 or better).

## FIGURE 1 Classical Twin Design—ACE Path Diagram with Labeled Paths
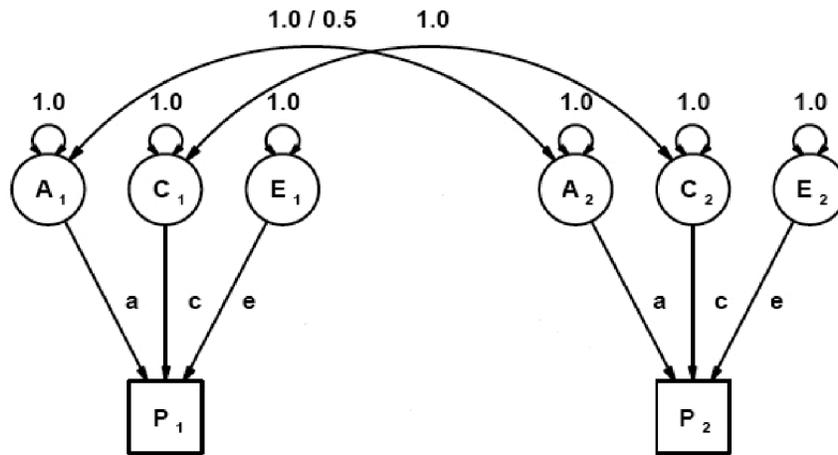


*Notes*: A = additive genetic, C = common or shared environment, E = unique environment and measurement error, $P_1$ = trait value for Twin 1 and $P_2$ = trait value for Twin 2. Diagram originally presented in Medland and Hatemi (2009).

## FIGURE 2 Path Model for Biological and Cultural Inheritance in Kinships
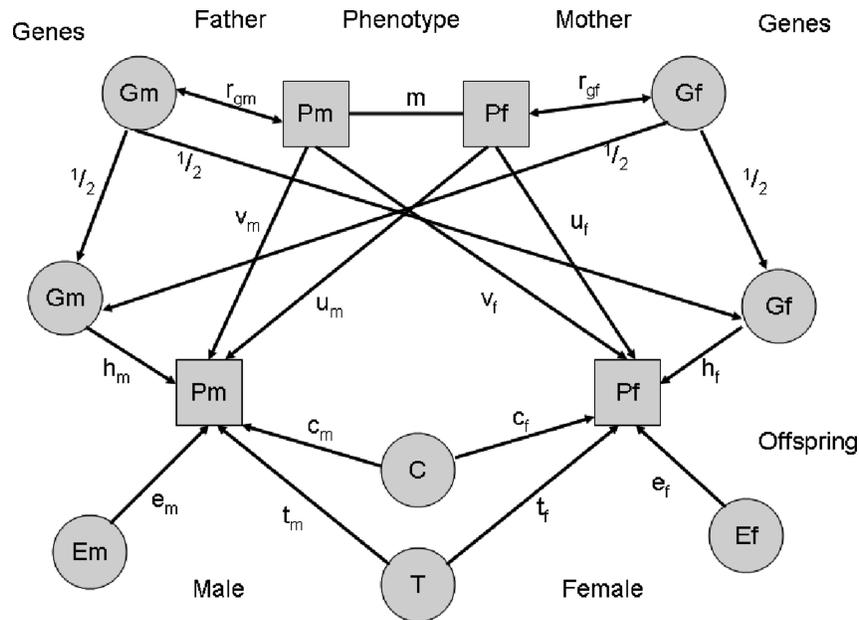


*Notes*: Paths are labeled as follows: hm = Additive genetic effects to male phenotype; hf = Additive genetic effects to female phenotype; cm = Non-transmitted shared environment to male siblings; cf = Non-transmitted shared environment to female siblings; em = path from environment to phenotype (males); ef = from environment to phenotype (females); tm = Additional twin shared environment (males); tf = Additional twin shared environment (females); um = Mother–son cultural inheritance; vm = Father–son cultural inheritance; uf = Mother–daughter cultural inheritance; vf = Mother–son cultural inheritance; m = Phenotypic correlation between spouses; rgm = the correlation between genotype and environment (male); rgf = the correlation between genotype and environment (female). Diagram originally presented in Eaves and Hatemi (2008).

intergenerational transmission. Assuming that genetic effects are additive, the paths from parental to offspring genetic influence are fixed at 0.5 (Jencks et al. 1972; Morton 1974). The path for nontwin siblings is obtained by allowing the effects contributing to the twin-specific environment ($T$) to be uncorrelated in siblings. A recent study by Hatemi, Medland, and Eaves (2009) found significant quantitative (and in some cases qualitative) sex difference in the variance components analyses for political attitudes. Thus, in the model used here males and females are not equated, but rather are estimated independently within the same model. Due to the already complex nature of the model, we do not correct for genetic and environmental influences that may vary with age. To the extent there is interaction between genetic effects and age, parent-offspring similarity may be reduced and additive genetic effects could be confounded with nonadditive genetic effects. We leave this area for future study, but it is important to stress that there are many ways to model genetic and environmental influences and many ways to correct for error, attitude stability, and the influence of mate similarity. We only offer an initial means to improve upon previous, more limited models and to correct for known concerns.

The expected correlations between family members were derived from the path model (Cloninger, Rice, and Reich 1979; Duncan 1966; Truett et al. 1994; Wright 1921). Variance component estimates were obtained by applying strict maximum-likelihood procedures to the raw data. In theory, reduced models are typically fit in order to evaluate the implications of omitting principal sources of individual differences, but due to the large number of phenotypes examined and the numerous models possible, only the full models and models dropping the twin environments are reported here.

# The Results

The results generated by estimating this model with the VA30K data are presented in Table 3. Standard notation procedures in behavioral genetics dictate that "A" refers to additive genetic effects, "E" to unshared or unique environmental effects, and "C" to common or shared environmental effects. Thus in the table, $V_{AM}$ refers to the additive genetic variance for males and $V_{AF}$ to the additive genetic variance for females just as $V_{EM}$ and $V_{EF}$ refer to the unique environmental effects for males and females, respectively, and $V_{CM}$ and $V_{CF}$ refer to the shared (or common) environmental effects for males and females, respectively. The extended family feature of the model (specifically, the inclusion of nontwin full siblings) makes it possible to estimate the effects specifically attributable to the "twin" environment's being more similar than a nontwin sibling environment, and in the table these terms are labeled as $V_{TSM}$ and $V_{TSF}$. Total shared environment is simply the sum of the two distinct components of shared environmental effects, again for males and females, respectively. $V_{CTM}$ (vertical cultural transmission) is the share of variation attributable to the direct, nongenetic social transmission from parents to their male offspring and $V_{CTF}$ is the same for female offspring. $C_{GEM}$ and $C_{GEF}$ tap passive genotype-environment covariance resulting from the fact that, for example, advantageous genetic forces will often provide advantageous environments. Finally and importantly, because many respondents completed the survey two times separated by a two-year interval, it is possible to use this test-retest coefficient as an adjustment for measurement error. Most attempts at identifying the relative effects of genetic and environmental forces merely push this error into the unshared environment term, but this data set makes it possible to separate unique environmental effects from the error term. This error is labeled $V_{ERM}$ for males and $V_{ERF}$ for females.

With the notation established, we turn to the results themselves. The central finding of the table is that heritability estimates for political and social attitudes persist even when extended family data rather than twin-only data are used, when maximum-likelihood estimates rather than simple polychoric correlation transformations are employed, when mate assortation is acknowledged, and when repeated soundings are included for reliability. A quick scan down the two columns reporting additive genetic influences (one for males and one for females) indicates heritability consistently in the .3 to .7 range. The individual attitudes showing the largest additive genetic influences appear to be those directed toward school prayer and X-rated movies, with heritability being responsible for roughly two-thirds of the variation in these particular attitudes (for males and for females). "Living together" is also strongly heritable but illustrates the fact that sometimes additive genetic forces are quite different for males and females. The additive genetic term is .40 for males but .84 for females. Attitudes toward gay rights and immigration are also among the items showing the highest degrees of heritability, so it would appear the issues widely perceived to be hot-button social issues are the very issues that tend to be strongly heritable, just as Tesser (1993) predicted.

Our estimates of "unique" environmental effects are somewhat reduced from those generated without test-retest data since they are not artificially inflated by measurement error. These effects range from .10 to .28,

typically smaller than additive genetic effects but larger than the shared environmental effects (usually less than .10). Of the two components of total shared environment, the extra-shared environment attributable to siblings' being twins appears to be the more important, but overall shared environmental effects are minimal.

In addition, the design employed here is able to provide distinct estimates of vertical cultural inheritance. As can be seen, for both males and females, cultural "inheritance" is minimal, never over .11 and usually under .05. Consistent with earlier findings, party identification appears to be an exception. Here we find that vertical transmission influences are similar to those of the shared environment, but still less than the unique environment and cultural effects that come from siblings, especially cotwins.

Genotype by environment correlation ($r_{GE}$) refers to the hypothesis that an individual's genes may influence his or her exposure to certain nonrandom environmental stimuli (see McCourt et al. 1999; Scarr and McCartney 1983). This correlation can be classified as active, in which the individual's own genes influence his or her exposures to certain environments, or passive, in which the environment of an individual is influenced by the genes of a relative. For example, positive passive interaction occurs when parents with liberal genetic predispositions, simply by following their own listening inclinations, increase the liberalism of their daughter by providing a childhood environment rich in public radio exposure. In contrast, an example of positive active interaction occurs when the daughter decides on her own to buttress her genetic liberal predispositions by choosing to attend Berkeley. If the same teenager opted to self-medicate her taste for liberalism by enrolling at Oral Roberts University, that would be an example of negative active gene-environment correlation. Finally, liberal parents tempering the unwelcome evidence of genetic predispositions toward conservatism in their daughter by shipping her to a Montessori school would be an example of a negative evocative gene-environment correlation. Unmodeled active $r_{GE}$ may either inflate or deflate the estimates of genetic effects. In the nuclear family analyses presented here, we estimate the global genotype by environment correlation that is an estimate of all genotype by environment variance.

The coefficients for genotype-environment covariance are slightly larger than those for vertical transmission but almost always negative, meaning that, with regard to most political attitudes, the effects of social (environmental) forces tend to oppose the effects of genetic transmission. Interestingly, it would appear that genetic predispositions are often pushing in the opposite direction as that of important environmental forces whether those forces

are unique or shared with siblings and cotwins—but we should stress that these negative coefficients for genotype-environment covariance are generally quite small and most have confidence intervals that approach zero.

As discussed previously, the last two columns of Table 3 provide separate estimates of "measurement error." Once this error is pulled out of the estimates for unshared (or unique) environment, we see that the effects of the unique environment are still larger than those of the shared environment, but the gap is now quite small (in standard twin-only designs, unique environmental forces tend to dwarf shared environmental forces). Moreover, in relative terms, additive genetic effects are much more powerful when measurement error is taken into consideration (for examples of estimates that did not correct for assortative mating and measurement error, see Alford, Funk, and Hibbing 2005; Hatemi, Medland, and Eaves 2009). When compared to previous estimates of the effects of genes and the environment on variations in political attitudes, the important improvements made here in data, methodology, and measurement indicate a larger role of genetics.

Table 3 also includes estimates for a composite attitude index labeled Liberalism-Conservatism (made up of all the items in the Wilson-Patterson Inventory) as well as for party identification. For the overall index of Liberalism-Conservatism, genetics accounts for approximately .34 of the variance in females and over half (.58) of the variance in males, while twin-specific environment and vertical cultural transmission (parental influence) account for less—.16 in females and just .03 in males. The shared environment is inconsequential. Turning to party identification, in previous analyses, party identification exhibited only modest or insignificant genetic influence and notable common environmental effects (Hatemi, Alford et al. 2009). With parents and non-twin siblings in the analysis, however, it appears that the variance previously attributed to the common environment can be partitioned into equal amounts of vertical cultural transmission and common environment. Furthermore, unique environmental influence provides a greater role than previously indicated. However, it is important to note that party identification was the one measure where retest data were not available and therefore, as mentioned above, for this variable we may be underestimating familial resemblance and inflating unique environmental estimates. Equally important is that the gene-environment correlation is positive and over .1, making party identification the only trait measured for which such a claim can be made. In essence, party identification for adults is influenced by personal experiences, but initially influenced by home environment and

cultural upbringing. Furthermore, there is some evidence that those raised with a certain party disposition tend to choose environments that continue to support their initial position.

Table 4 provides the model fits for the twin-specific environment of the 56 independent tests (28 items for males and females independently). For males only, two traits (living together and busing) are significantly different from zero. For females, just four items (Democrats, nuclear power, capitalism, and party identification) have twin-specific effects that are statistically significant. Furthermore, with the exception of living together, divorce, and busing in males, the twin-specific environment can be dropped from the models without harming model fit (and, in fact, improving parsimony), and for females the twin-specific environment can be dropped from the model without affecting model fit for all variables except nuclear power and party identification. Thus, while, as noted above, the inclusion of nontwin siblings does not directly test specific MZ and DZ twin environments, only six of the 56 tests show twin-specific environmental effects that reach statistical significance. The charge raised by critics of earlier estimations—i.e., that EEA violations could in fact be responsible for most if not all of the impact that was attributed to genetic inheritance—is disconfirmed by the results reported here.

All told, previous claims that additive genetic influences account for at least 40% of the variance in political and social attitudes hold up even when more sophisticated modeling techniques are employed on data from family members other than just twin pairs. Modeling twin-specific environments (by including nontwin siblings) may diminish heritability estimates a bit, but correcting for assortative mating (by including parents) increases heritability estimates. Moreover, eliminating the variation attributable to measurement error (by including test-retest assessments of political phenotypes) ensures a more accurate measure of attitudes. Furthermore, we continue to see relatively weak contributions from nongenetic parental effects (socialization), with unique environmental effects being somewhere between genes and shared environment in importance.

## Discussion and Conclusion

As Eaves et al. noted in reflecting on the growing set of results documenting that genetic influences work with environmental forces to shape attitudes, "one of the truly remarkable findings to emerge from behavior genetics over the past 20 years is the replication and consistency of findings about the transmission of. . .social attitudes" (1999, 78). Given the way in which attitude formation is generally conceived, evidence of a strong heritable component for social and political beliefs is a surprise to many political scientists and has led them to question the methodologies involved.

No research methodology, whether it be survey research, laboratory experiments, analysis of aggregate data, semistructured interviews, or familial modeling, is perfect. Fortunately, suspected flaws generally can be addressed with additional data and techniques, and that is what we offer here. We do not pretend to address all potential methodological limitations regarding twin and family studies. Indeed, numerous criticisms may arise, from generalizability to twin chorionicity. However, in response to recent concerns directed at twin studies, we have added data on the parents and siblings of twins at two different points of time. We find that utilizing proven statistical techniques, a wider range of kinships, and more parameters in the model only serves to strengthen the findings of heritability reported previously. Attempts to dismiss these consistently appearing results by attributing them to violations of the equal environments assumption (Beckwith and Morris 2008; Charney 2008; Horwitz et al. 2003) are increasingly unpersuasive.

Genetics is connected to political attitudes, though the nature of this connection is likely to be circuitous. In this study, we have attempted to contribute to efforts made by a growing band of empirical political scientists seeking to specify the precursors of politics, whether by analyzing neurotransmitters and hormones (Johnson et al. 2006; Madsen 1986; McDermott et al. 2008), simulations of evolutionary pressures (Axelrod and Hammond 2006; Orbell et al. 2004), social and economic experiments (Ostrom 1998; Sell et al. 2004; Wilson and Herrnstein 1995), involuntary physiological reactions (Lodge and Taber 2005; Mutz and Reeves 2005; Oxley et al. 2008), neuroscience (Marcus 2002; McDermott 2004; Schreiber 2005), or genetics (Alford, Funk, and Hibbing 2005; Fowler, Baker, and Dawes 2008; Fowler and Dawes 2008; Hatemi et al. 2007). As important as environmental forces undoubtedly are, it is unscientific to assume without empirical tests that they are the only forces operating. Instead, we propose it is more fruitful for political scientists to work with our life-sciences colleagues in efforts to specify the biological pathways that are politically relevant. Given the subtleties of evolutionary pressures, the complexity of the genome, the intricacies of neuroanatomy, and the nuances of environmental forces, the task is daunting, but such interdisciplinary collaborations offer the best hope of obtaining a more complete understanding of attitude formation and the source of preferences.

**TABLE 4  Confidence Intervals and Model Fit for the Twin-Specific Environment**

| Political Phenotypes | Extra-Shared Twin Environment $V_{TSM}$ | $V_{TSF}$ | $-2LL$ | $-2LL$ M | $-2LL$ F | $\Delta X^2_M$ | $\Delta X^2_F$ | $\Delta df_M$ | $\Delta df_F$ | p-Value (Comparison Model) | p-Value (Comparison Model) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Death penalty | 0.10 | 0.09 | 25418.30 | 25420.52 | 25422.52 | 2.221 | 4.221 | 1 | 2 | 0.136 | 0.121 |
| Astrology | 0.02 | 0.06 | 33478.71 | 33479.99 | 33481.09 | 1.282 | 2.38 | 1 | 2 | 0.258 | 0.304 |
| X-rated movies | 0.00 | 0.03 | 25495.11 | 25495.11 | 25495.36 | 0.002 | 0.255 | 1 | 2 | 0.964 | 0.880 |
| Women's liberation | 0.00 | 0.04 | 33494.01 | 33494.91 | 33494.65 | 0.9 | 0.633 | 1 | 2 | 0.343 | 0.729 |
| Foreign aid | 0.07 | 0.00 | 35069.72 | 35071.54 | 35071.54 | 1.821 | 1.818 | 1 | 2 | 0.177 | 0.403 |
| Federal housing | 0.02 | 0.09 | 31513.26 | 31513.47 | 31517.00 | 0.217 | 3.746 | 1 | 2 | 0.641 | 0.154 |
| Democrats | 0.04 | **0.11** | 34150.43 | 34152.22 | 34154.82 | 1.792 | 4.392 | 1 | 2 | 0.181 | 0.111 |
| Military drill | 0.02 | 0.00 | 30192.70 | 30192.87 | 30194.41 | 0.17 | 1.708 | 1 | 2 | 0.680 | 0.426 |
| The draft | 0.10 | 0.02 | 30513.18 | 30515.48 | 30515.41 | 2.294 | 2.224 | 1 | 2 | 0.130 | 0.329 |
| Abortion | 0.02 | 0.05 | 31888.90 | 31889.21 | 31888.92 | 0.312 | 0.022 | 1 | 2 | 0.576 | 0.989 |
| Property tax | 0.00 | 0.00 | 29079.09 | 29079.09 | 29079.99 | 0.001 | 0.901 | 1 | 2 | 0.975 | 0.637 |
| Gay rights | 0.08 | 0.05 | 30502.48 | 30503.31 | 30504.12 | 0.832 | 1.642 | 1 | 2 | 0.362 | 0.440 |
| Liberals | 0.00 | 0.09 | 34012.18 | 34012.18 | 34015.11 | 0.01 | 2.933 | 1 | 2 | 0.975 | 0.231 |
| Immigration | 0.06 | 0.00 | 34392.63 | 34392.84 | 34393.64 | 0.207 | 1.012 | 1 | 2 | 0.649 | 0.603 |
| Capitalism | 0.01 | **0.13** | 31910.94 | 31911.84 | 31918.62 | 0.897 | 7.679 | 1 | 2 | 0.344 | 0.022 |
| Segregation | 0.00 | 0.07 | 28403.03 | 28403.03 | 28404.89 | 0 | 1.859 | 1 | 2 | 1.000 | 0.395 |
| Pacifism | 0.06 | 0.06 | 30702.64 | 30704.35 | 30705.52 | 1.705 | 2.874 | 1 | 2 | 0.192 | 0.238 |
| Censorship | 0.00 | 0.09 | 33942.01 | 33942.02 | 33939.80 | 0.01 | 2.21 | 1 | 2 | 0.920 | 0.331 |
| Nuclear power | 0.01 | **0.14** | 34097.90 | 34098.95 | 34107.69 | 1.051 | 9.79 | 1 | 2 | 0.305 | **0.007** |
| Living together | **0.16** | 0.00 | 29593.04 | 29599.17 | 29594.83 | 6.13 | 1.79 | 1 | 2 | **0.013** | 0.409 |
| Republicans | 0.02 | 0.09 | 31732.94 | 31734.28 | 31735.13 | 1.344 | 2.195 | 1 | 2 | 0.246 | 0.334 |
| Divorce | **0.15** | 0.00 | 33598.12 | 33602.85 | 33603.51 | 5.395 | 5.395 | 1 | 2 | **0.020** | 0.067 |
| School prayer | 0.00 | 0.05 | 23592.62 | 23592.38 | 23593.41 | 0.247 | 0.788 | 1 | 2 | 0.619 | 0.674 |
| Socialism | 0.06 | 0.05 | 29373.69 | 29376.20 | 29376.63 | 2.51 | 2.941 | 1 | 2 | 0.113 | 0.230 |
| Busing | **0.14** | 0.03 | 30918.14 | 30924.67 | 30919.74 | 6.532 | 1.606 | 1 | 2 | **0.011** | 0.448 |
| Modern art | 0.01 | 0.07 | 34593.53 | 34593.51 | 34595.79 | 0.015 | 2.261 | 1 | 2 | 0.903 | 0.323 |
| Conservatism factor | 0.01 | 0.05 | 38304.21 | 38304.49 | 38310.17 | 0.283 | 5.961 | 1 | 2 | 0.595 | 0.051 |
| Party ID | 0.08 | **0.16** | 13666.36 | 13667.01 | 13678.45 | 0.655 | 12.095 | 1 | 2 | 0.418 | **0.001** |

*Note*: Estimates in bold font are significant (p = .05 or better).

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