Genetic and Environmental Transmission of Political Attitudes Over a Life Time

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Recently political scientists have looked anew at the source of political preferences and find support for the heuristic that political attitudes and behaviors are influenced by endogenous factors. The present research attempts to characterize how the transmission of political orientations develops over the life course. Using longitudinal data collected on twins throughout childhood and adolescence combined with cross-sectional data from adult twins, the present study finds that genetic influences on political attitudes are absent prior to young adulthood. During childhood and adolescence, individual differences in political attitudes are accounted for by a variety of environmental influences with the role of shared "family" environment, including parental socialization, accumulating markedly between the ages of 9 and 17. However, at the point of early adulthood (in the early 20s), for those who left their parental home, there is evidence of a sizeable genetic influence on political attitudes which remains stable throughout adult life. The pattern of genetic transmission shows some similarity to an "impressionable years" model of attitude crystallization showing both the important influence of family and other shared environmental influences in adolescence and then an increased role of genetic factors as familial environmental influences diminish.

Political socialization research has traditionally focused on how elements of the social environment influence and interact with individual development (Sigel 1989). Within the social environment, familial, and especially parental, influences have long been considered a primary source of political learning over the life course. This focus on the parent seemed well-founded as numerous studies have found a strong correspondence between ideological orientations of parents and their children (e.g., Alwin, Cohen, and Newcomb 1991; Jencks et al. 1972; Jennings and Niemi 1982; Miller and Glass 1989).

Questions remain about the nature of the transmission between parents and their offspring, however. One of the central issues is whether similarity between parent and child political attitudes stems directly from parental socialization (Beck and Jennings 1975; Searing, Wright, and Rabinowitz 1976) or whether it represents an indirect influence of parents through shared social class, race, religion, place of residence, and other elements of the social environment (Acock 1984; Glass, Bengtson, and Dunham 1986). There are also a number of questions about the pattern of effects across the life course (Jennings, Stoker, and Bowers 2001). For example, do parents influence their offspring's political attitudes to a fairly constant degree starting from an early age with an effect that persists over time? Or is the effect stronger during the adolescent and early adult years before the time political attitudes are believed to have crystallized and concurrent with a time of life that typically represents greater contact between parents and children?

Recently political scientists have given more serious consideration to the role of genes in the transmission of political attitudes and orientations (e.g., Fowler and Dawes 2008; Hatemi 2006; Hatemi,

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Medland, and Eaves 2009). Elaborating on previous analyses in the human genetics and interdisciplinary domains (e.g., Eaves, Eysenck, and Martin 1989; Martin et al. 1986), Alford, Funk, and Hibbing (2005) presented findings to the political science community that substantial genetic influence for liberal-conservative orientations exist. Studies in the behavioral genetics literature have long provided similar conclusions in western democracies (e.g., Eaves et al. 1999). There is a substantial genetic influence on political attitudes in the United States, the United Kingdom, and Australia (Eaves and Hatemi 2008; Martin et al. 1986), as well as vote choice in Australia (Hatemi et al. 2007a) and voter participation in the United States (Fowler, Baker, and Dawes 2008). Indeed, adult family resemblance on political attitudes appears to be only slightly lower than those for physical measures such as height and weight (e.g., Maes, Neale, and Eaves 1997).

Genetic influences represent another source of indirect transmission of political attitudes between generations. Some portion of the parent-child correspondence, previously assumed to be environmental, appears to stem from shared genetic material. However, past research showing genetic influences on political attitudes has largely focused on adults. That is, neither the genetic nor the social science literature has explored when (that is, at what age) genetic influences become realized, or the mechanism by which the developmental patterns emerge (for an exception see Eaves et al. 1997). Thus, it is important to look at the role of genetic influences on political attitudes from a life course perspective. Research on other social traits has shown that the role of genetic factors can take a variety of forms over the life course. Eaves et al. (2008) found that the genetic and environmental contributions of religious practices and church attendance (religiosity) vary with age. Shared environmental factors accounted for the vast majority of variance in children and adolescents, but decreased in importance during late adolescence and young adulthood, while genetic influences on religiosity increased over the same period. This is important as political ideology is believed to stem from the same socialization process as religion; both share the same high levels of high parent-child concordance (Niemi and Jennings 1991).

A sizeable genetic contribution for political attitudes, then, cannot be assumed to be constant over the life course. In principle, genetic differences expressed at birth may be eradicated by the cumulative effect of the post natal environment or imperceptible early on. Genetic differences may also increase over time as a result of constant environmental reinforcement (e.g., Eaves, Long, and Heath 1986). There are at least four theoretical models present in the extant political science literature for how environmental and genetic factors could influence political attitudes—lifelong persistence, lifelong openness to change, impressionable years, and life stage changes; these models mirror the more general models of political socialization laid out by Sears (1983). The influence of each factor (whether it be genes, shared environment, or unshared environment) could follow any or none of these basic patterns. Past longitudinal studies on the stability of political attitudes, mostly looking at party identification but also some attitudes, are consistent with an impressionable years model where attitudes are more susceptible to change during adolescence, but once ''crystallized'' in early adulthood remain relatively stable (Alwin and Krosnick 1991; Beck and Jennings 1991; Markus 1986; Sears and Funk 1999). However, some cross-sectional analyses by age suggest a curvilinear pattern may also be present with attitude stability dropping among older adults (Visser and Krosnick 1998).

The present study analyzes data from population based twin surveys to address both the pattern and sources of political attitudes over the life course. We use a longitudinal study of twins collected throughout childhood to reveal the developmental pattern of political attitudes. Our focus is on the transmission of liberal-conservative orientations on a multi-item index of political attitudes. We then couple these findings with an age cohort analysis from a large sample of adult twins to look in more detail at both the pattern and sources of the transmission of political attitudes over the life course. With this combination of population based data, it is possible to determine whether genetic influences are present throughout the entire life span, or if social forces suppress or enhance genetic influences during certain developmental periods.

Methods

Commonly used for accounting for variation within a population, the classical twin design was originally conceived by Francis Galton (1876) and further developed by R. A. Fisher (1918) for the analysis of genetic and environmental influence in kinships. The current approach based on biometrical genetic theory is an elaboration of statistical methods introduced by Jinks and Fulker (1970; for a review see Medland and Hatemi 2009). Studies using twins are powerful tools for examining sources of individual differences and allow researchers one method to disentangle the

influences of genes and the environment (Eaves 1977). Subject to well understood limitations, this design allows researchers to estimate the amount of variance attributed to one of three sources: additive genetic (A), common or shared environment (C), and unique or unshared environment (E). Additive genetic is the sum of all individual genetic influences; shared environmental influences include the ''nurture'' and environmental factors that family members share. Unique or unshared environmental influences refer to experiences and stimuli unique to an individual (e.g., getting a traffic ticket this morning), along with measurement error.

Using twins this partitioning of variance is possible because monozygotic twins (MZ) receive the same genes from their parents; they are genetically identical and share 100% of their genes. On the other hand, dizygotic twins (DZ), as well as all other full siblings, on average share only 50% of the same genes from their parents, as these siblings arise from two different ova fertilized by different sperm. Thus, the combination of MZ and DZ twin pairs, raised by the same parents in the same home environment, provides a natural experiment which controls for critical elements of familial background and socialization. Over the last 40 years this design has provided beneficial research for numerous traits, from breast cancer, to alcoholism, to autism, to political attitudes (for a review see Martin, Boomsma, and Machin 1997).

Assumptions, Limitations, and the ''Twin'' Debate

The twin methodology is widely used in the psychiatric, psychological, genetic, and life sciences, but only recently has been introduced to political science (e.g., Alford, Funk, and Hibbing 2005; Hatemi, Medland, and Eaves 2009; Fowler, Baker, and Dawes 2008). The method is commonly found alongside other models of biological influences, including: extended family models, adoption studies, molecular analyses, physiological measures, and neuroimaging studies. Arguments regarding the methodological validity of the twin design were exhausted in the 1980s in the psychiatric and genetics literature and important findings for a host of psychiatric, personality, and medical traits followed (see Kendler and Gardner 1998). Twin studies have been validated in a number of ways, and the model has been under intense scrutiny for decades in the genetics and psychiatric literature, which has led to continued methodological improvements (Medland and Hatemi 2009). However, despite concordant findings which span across disciplines, utilizing different methods, including adoption studies, extended kinships, and genotypic data (e.g., see Visscher et al. 2006), challenges to the utility of twin designs have resurfaced in political science (e.g., Beckwith and Morris 2008; Charney 2008).

By far most criticism of twin models is directed at the assumption that shared environmental influences equally affect MZ and DZ cotwin pairs for the trait of interest (commonly called the ''equal environments assumption). The concern is that twin studies would overestimate genetic influences if this assumption is violated. If MZ twin pairs share a more similar environment and this environment has an influence on the trait, then this might explain (some portion of) the greater concordance between MZ twin pairs. It has been well established that MZ twin pairs do have more similar environments in certain respects. For example, parents tend to dress MZ twin pairs more similarly as toddlers, give them more similar haircuts, and due to MZ twins always being the same sex, they more often share rooms. However, these childhood shared environmental similarities have been shown to have almost nothing to do with most social and psychological traits in adult life (for a review see Hatemi et al. 2009) and can be controlled for by utilizing extensions of the model (e.g., Eaves and Hatemi 2008). To date, there has been no empirical evidence that parents socialize MZ twins to a greater degree than DZ twins for political preferences or that any aspect of the social environment systematically influences MZ twin pairs in a different manner than DZ twin pairs for political traits (e.g., Beckwith and Morris 2008; Charney 2008). It's important to keep in mind that unequal environments need to be relevant to the trait of interest (in this case, political attitudes). To the extent that MZ twins have more similar shared environments imposed upon them, these differences are much more likely to occur during childhood rather than adulthood (Kendler et al. 1993). Thus, our longitudinal adolescent sample offers a powerful means to test for unequal environmental concerns. Childhood is one of the few possible avenues in which a systemic parentally imposed difference in environments can occur. It is difficult to conceive of the possibility that the effects of a special childhood MZ twin environment would be greater in adulthood than during the time it is supposed to be present. If a special-rearing MZ twin environment for political attitudes exists, it should be most apparent in the adolescent years.

Objections aside, it is necessary to consider the statistical limitations of twin models. As part of the preliminary analyses, means and variances of the trait (a liberalism–conservatism attitude index) are tested

for significant differences between the different zygosity groups and singletons (i.e., assumptions testing). If differences existed, a customized model would be needed. Variance components analyses utilize means but focus on variance. Therefore, potential mean biases in a population sample are population wide and have minimal effect on variance analyses within a population (see Neale et al. 1989). Twin samples are not drawn randomly from a population. Rather, the twin design is utilized to explore differences within an entire population. As such, the results are specific to the population sampled and generalizations cannot be based on the results from any one sample. If similar results are found across populations, cultures, and age groups, the combined evidence leads to a more general conclusion. For example, combined evidence across populations found that personality traits are influenced by genes (Eaves, Eysenck, and Martin 1989).

Importantly, biometric, epidemiological, and genetic analyses are done in stages. The heuristic entails a progressive research program which only begins with the identification of genetic variance. DNA-based analyses, including genome wide and allelic association, which attempt to identify which genes influence a given trait, are typically employed after evidence of genetic influence is found. For example, the results of twin modeling have been vindicated by the most recent findings concerning the genetics of stature (Visscher et al. 2006), where it has been shown that a large number of genes of small effect explain the genetic variation for even the most biometric of traits. Additional ''genetic'' analyses may include sex differences (e.g., Hatemi, Medland, and Eaves 2009), epigenetic effects (gene expression), neurological processes (e.g., Meyer-Linderberg and Weinberger 2006), hormonal moderators, as well as gene-environment correlation (rGE) and gene by environment interaction (GxE).

Sample

Two separate samples of twins were used in this study. A longitudinal sample of adolescents was used to assess the development of political attitudes from childhood through adolescence and a much larger cross-sectional sample of adult twins was used to assess the role of genetic and environmental factors in the political attitudes of different age cohorts from late adolescence to late adulthood. A previous study, reporting correlations for conservatism as a function of age utilized a subset of both samples reported here (see Eaves et al. 1997); we significantly expand upon that analysis by examining in much greater detail the pattern of transmission over the life course.

Longitudinal sample of adolescent twins. The longitudinal study of adolescent twins was conducted between 1983 and 1993 as part of a larger study of cardiovascular function (MCV cardiovascular twin study). Two overlapping cohorts of twins, approximately 550 twin pairs in total, were ascertained through schools in the county of Henrico (Richmond), Virginia (Schieken et al. 1992). The original cohort was ascertained and studied at a target age of 11 years and assessed every 18 months thereafter until age 17. The second, younger cohort was ascertained for initial study at age 9.5 years and assessed every 18 months until age 14. The key measure for the present analysis stems from a series of attitude questions used to construct a Wilson-Patterson (1970) style index (for a list of specific items see the online Appendix A at http://journalofpolitics.org). At each data collection point, twins completed a paper and pencil questionnaire while waiting for other laboratory assessments. Each of the questions used a brief phrase or statement and asked respondents to indicate whether they agree, disagree, or are uncertain about the topic. The topics range widely from attitudes about sexual behavior, abortion, gay rights, school prayer, as well as property taxes, the death penalty, and the military. The attitude index for adolescents is based on a composite of these 50 items scored from liberal to conservative.[1]

Sample of adult twins. The adult sample of approximately 12,000 twins comes from what is now known as the Mid Atlantic Twin Registry (originating from the Virginia 30,000). As part of a large questionnaire on ''Health and Life Styles'' administered in the mid to late 1980s, 28 political attitudes were measured by a Wilson-Patterson type of attitude index (online Appendix B). All twins were aged 18 and older (up to 88 years) at the time of data collection. Data were collected by mail, with mail follow-up of nonrespondents and further telephone follow-up when needed. Ascertainment and composition of the sample are described in detail by Maes, Neale, and Eaves (1997). A number of other studies have analyzed the political items gathered in this study including

[1]The ''liberalism/ conservatism'' score is the sum of the scores for all the items with positive loadings (k = 34) plus the sum of the loadings recoded in the opposite direction (2,1,0) for the items with negative loadings (k = 16) yielding a total conservatism score with a range 0 to 100. Wilson-Patterson indices vary in the number of individual items depending upon the study. In these analyses, the number of individual items differs between the adolescent study (50) and the adult study (28). However, parents in the adolescent study assessed with the 50-item scale prvoided only marginal differences in the structure of the index score from the adult only cohort sample of 28 items, similar to previous comparisons of a 50-item Australian adult sample and 28-item US adult sample (Martin et al. 1986).

more advanced models which included the parents and siblings of twins (see Eaves and Hatemi 2008; Hatemi et al. 2007b).

Statistical Modeling of Genetic and Environmental Influences

The basic approach to genetic analysis uses structural equation modeling to partition the variance into additive genetic (A), a common or shared environment (C), and a unique environment (E). Model parameters were estimated by full maximum likelihood (see Lange, Westlake, and Spence 1976) applied to the individual vectors of twins' paired liberalism-conservatism scale scores across repeated measures using the Mx program (Neale et al. 2003). The program implements an efficient algorithm for constrained nonlinear optimization to obtain parameter values that minimize −2LL (minus twice the natural logarithm of the likelihood). An advantage of the full ML approach is the inclusion of data from all subjects, even those families with some missing values, on the assumption that data are missing at random (MAR) or missing completely at random (MCAR, Little and Rubin 1987). Likelihood-ratio significance tests of differences in fit between (nested) sub models may be constructed and Akaike's Information Criterion[2] used to aid selection of the model (s) that give the most informative balance of parsimony and goodness of fit.

For the longitudinal twin data, several models were fitted to the repeated measures by full maximum likelihood and compared to reveal the principal characteristics of the developmental process. The most general model for the covariance structure of the repeated measures twin data is the so-called "ACE" Cholesky decomposition (for further explanation see Loehlin 1996; Neale and Cardon 1992). This model constitutes a baseline against which the relative fit of simpler, reduced models for the latent structure may be compared (see below).

Results

We turn first to the analysis of the longitudinal sample of twins throughout childhood and adolescence and then combine this analysis with evidence from the adult sample of twins. Our analyses focus on the overall index of liberal-conservative orientation measured by the Wilson-Patterson inventory. Psychometric analyses of this scale support the treatment of items as indices of a single liberal-conservatism factor (Eaves et al. 1999). In practice, additional correlated factors can be extracted reflecting the clustering of items by content including those referring to the use of military power and defense, the economy and resources, sex, reproduction and social liberalism, Religious Right, and political orientation (Truett et al. 1992).[3]

The Development of Political Attitudes over Childhood and Adolescence

A key strength of our design comes from the repeated measures of attitudes over time. The longitudinal design allows us to observe the emergence of attitudes within subjects and between twin pairs during development, rather than to assume stable attitudes any given point. Past studies measuring political and social attitudes during childhood and adolescence, lead us to expect increasing attitude stability and constraint. Thus, we expect the variance due to the common factor to increase during adolescence but to begin to stabilize at an asymptotic value in older ages. These expectations are borne out. Table 1 shows the first eigenvalue of the matrices of inter-item covariances for the Wilson-Patterson index at each age. The results show increased attitude constraint with age, which is the degree to which responses reflect a consistent liberal or conservative direction; the amount of variance explained by the general factor also increased with age (from 16.82 to 23.85). By ages 14–15, the time most adolescents are exposed to political stimuli in high school, attitude constraint increased dramatically. At 17, the factor structure roughly approximated the factor structure and total variance explained in adult samples. Table 1 also provides a comparison with one such adult sample, the parents of twins in the study.

A similar pattern is found when we look at the level of opinionation (i.e., the average number of missing items). Table 1 shows that at the youngest age,

[2]The Akaike's Information Criterion (AIC) is a common goodness-of-fit measure used for selection among competing statistical models. The model with the lowest AIC is deemed as the best (see Bozdogan 1987).

[3]In order to ensure that the overall index was not being biased by one or more items, we examined the variation in the pattern of genetic and environmental influences for each sub factor (see online Appendices F and G for the factor structures). The pattern of genetic and environmental influences reported here for the liberalism-conservatism index was generally similar to each of the sub factors. However future longitudinal explorations of the individual items and subfactors may provide more insight and help identify if any particular items have divergent patterns of transmission.

TABLE 1 Attitude Constraint over Childhood and Adolescence: Inter-item Covariance by Age Cohorts

	Age at time of data collection						
Eigenvalues	**9.5**	**11.0**	**12.5**	**14.0**	**15.5**	**17.0**	**Parents**
1	1.70	2.25	2.42	2.30	2.65	2.45	3.61
2	1.01	1.24	1.46	1.71	1.95	1.96	1.98
3	0.91	1.12	1.33	1.44	1.53	1.62	1.46
4	0.84	0.90	0.99	1.15	1.17	1.21	1.38
5	0.74	0.79	0.87	0.84	0.85	1.03	0.78
Total percent of variance explained	16.82	20.06	21.77	23.28	23.59	23.85	25.01
Percent missing	34	29	18	15	13	8	13
Total N	477	795	774	524	453	349	1513

Note: Entries are the first five eigenvalues of principal component inter-item covariance matrices at each age. Percent missing shows the percentage out of 50 items where no answer was given.
Source: MCV cardiovascular twin study (longitudinal study of adolescent twins)

34% of the items (about 17 out of 50) were not answered. However, the level of opinionation increases markedly with age. By about ages 14 or 15, the percentage answering all items approximates that of an adult sample. At age 17, just 8% (about 4 out of the 50 items) were missing. The evidence points to the concept that attitudes gradually emerge. The first few eigenvalues of the inter-item covariance matrix increase throughout the age range pointing clearly to a developing organization of attitudes during adolescence. This is also supported by the number of individual attitudes answered with a ''yes'' or ''no'' by the participants. The proportion of ''undecided'' values goes down with age, consistent with the emergence of ''meaning'' (for more detail on item sophistication and the emergence of meaning see online Appendix C).

We turn next to whether or not there is a genetic basis for political preferences in childhood. We begin with the simplest gauge: comparisons of the polychoric correlations on the index for MZ twins as compared with DZ twins (online Appendix D). If the within-pair differences in MZ and DZ pairs are roughly equal, then it is assumed environmental factors alone are sufficient to explain the variance in attitudes; if there are substantially greater within-pair differences in DZ versus MZ pairs, there is support to explore the potential for genetic influences. We also consider the possibility that genetic effects may operate differently in males and females (e.g., Hatemi, Medland, and Eaves 2009).[4] Thus, we examine the polychoric correlations separately for twin pairs of males, females, and unlike sex pairs. This preliminary analysis shows little evidence for genetic influence among this sample and no evidence that the effects differ among sexes (online Appendix E).

For a more careful consideration of the sources of variance on attitudes, we fit an autoregressive structural equation model to the data which accounts for repeated measures of attitudes taken every 18 months for the liberalism-conservatism index. The structure of the repeated measures is represented initially by the most agnostic model; one that estimates the additive genetic, shared environmental, and unique environmental covariance matrices subject only to the constraints that each should be nonnegative definite. Alternative reduced models are compared by log-likelihood ratio chi-square tests and Akaike's information criterion (AIC) to determine the best-fitting model to the data.

Table 2 shows that for adolescents a model *without* genetic influences fit just as well as a baseline model that includes genetic influences ($\chi^2_{(19)} = 9.09$, AIC = 28.90). Consequently, further analysis of the developmental process in adolescents is justified without reference to genetic influences. The ''CE'' model containing only shared and unique environmental influences is the most parsimonious and best-fitting model. Figure 1 shows the estimates of the variance components due to the shared environment and unique environment across age. Under this ''nongenetic'' model, the variance of the political liberalism-conservatism index stemming from unique environmental factors (E) is relatively stable during this period, with a modest decline at the oldest age of 17. By contrast, the variance explained by shared environment (C) increases at each age. The effects of ''C'' are smaller than those of ''E'' at the youngest age of 9.5 years but

[4]Preliminary comparison of the structure for male and female like-sex pairs in the adolescents suggested that there was no significant heterogeneity of the means or the covariance structure of data with respect to sex (χ^2 (60) = 53.13, $0.5 < P < 0.75$). Subsequent model-fitting assumed that the same genetic and environmental influences had identical effects on the covariance structure of males and females and included both like-sex and unlike sex pairs.

TABLE 2 Model Comparisons of Longitudinal Data Estimating Genetic, Shared Environment and Unique Environment on Liberalism-Conservatism during Childhood and Adolescence

Model		Statistic				
#	Description	−2ln(l)	K	χ^2	d.f.	AIC
1	Genes + Environment (''ACE'')	21127.779	57	—	—	
2	Environment only (''CE'')	21136.873	38	9.09	19	−28.906
3	No shared environment (''AE'')	21360.879	38	233.10	19	195.100
4	Autoregressive: constant parameters	21199.244	4	71.47	50	−28.535
5	Autoregressive: All parameters free	21147.299	22	19.52	32	−44.480
6	Autoregressive: cross-temporal paths constant	21160.430	14	32.65	40	−47.349
7	Autoregressive: Model 5+error term	21154.049	15	26.27	39	−51.730
8	Autoregressive: C free	21186.336	10	58.56	44	−29.443
9	Autoregressive: E free	21171.451	10	43.67	44	−44.328

Source: Longitudinal study of adolescent twins

Notes: 1. Models are fitted to all five groups of twins assuming no differences in mean or structure between the sexes (assumption is justified by homogeneity of ACE parameters within like-sex pairs).

2. Correlation estimates are missing for two cross-time points because follow-up of 9.5 yr olds stopped at age 14.

3. Autoregressive models assume first order regression (i.e. C and E factors are diagonal) and separate cross-temporal regressions for C and E.

4. In model 4, it is assumed that the autoregressive paths and the innovations are constant across time.

5. In model 5 the ''innovations'' and cross-temporal regressions are allowed to differ across ages.

6. Model 6 is model 5 with the added constraint that the cross-temporal regressions are constant. Note this is the best model judged by AIC and has quite powerful implications.

7. Model 7 is model 5 with the added error term.

8. Model 8 is model 7 with the added constraint that the unique environmental innovations (E) are constant.

9. Model 9 is model 7 with the added constraint that the shared environmental innovations (C) are constant.

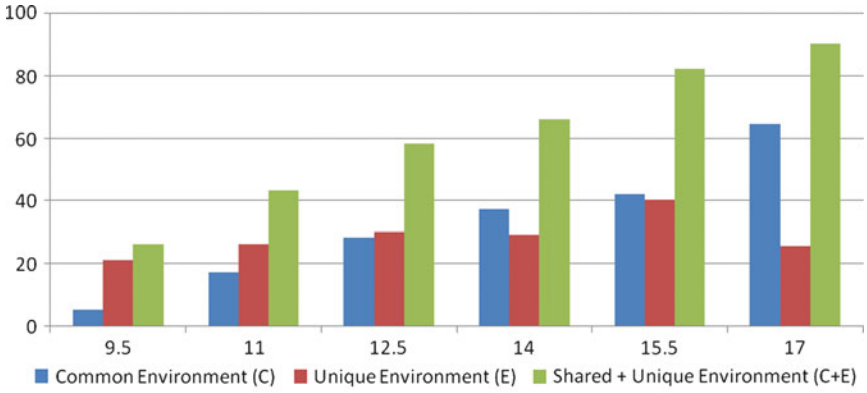
increase more than tenfold by the time the twins reach 17. That is, the impact of the shared ''family'' environment on social attitudes increases substantially throughout adolescence.

However, the cross-sectional data in Figure 1 does not address the underlying process that leads to the increase of the shared environment (C) and the relative stability of unique environmental influences (E). In order to clarify how these influences unfold during development (i.e., accounting for the repeated measures over time) the cross-age correlations over time are portrayed for unique environmental effects in Figure 2 and for shared environmental effects in Figure 3. These cross-temporal correlations are derived from the estimates of their respective covariance matrices under the minimally constrained environmental model. The heat maps indicate the degree to which unique or shared environmental influences persist with age. The magnitude of the correlation between age points is shown by the intensity of the color (red), while the ''width'' of the red band indicates the duration of the effect, with wider bands indicating more enduring effects (attitudes from previous ages correlate with those in future ages).

Both figures show the decrease in correlation with increasing difference in age of assessment characteristic of a first-order autoregressive developmental process in which acquired information persists, with greater or lesser fidelity, from one time to the next. The decrease in correlation between the unique environmental effects is marked, although correlations tend to be higher between adjacent measures in older twins. Thus, the cross-temporal transmission (''remembering'') of influences of the unique environment is modest (Figure 2). In contrast, the decay in correlation between the effects of the shared environment is much slower implying that these effects persist much more faithfully over time (Figure 3). Indeed, the cross-temporal correlations are very large (>0.9) for shared environmental influences in older twins. The pattern of results for the shared environment implies that the effects accumulate and persist markedly during adolescence.

Further structural models were fitted to account for this first-order autoregressive development process more parsimoniously. The model that represents the best balance of parsimony and fit is model 7 ($\chi^2_{(39)} = 26.27$, AIC = −51.73) which included both unique (E) and shared environmental (C) innovations that affect the adolescent child at each time point. Maximum-likelihood estimates of the parameters of the covariance structure between twins and across ages are shown in Figure 4. Simpler models, such as those that eliminate the time-specific error

FIGURE 1 **The Relative Influence of Shared and Unique Environmental Influence on Liberalism-Conservatism during Childhood and Adolescence**



Source: Longitudinal study of adolescent twins

term, or constrain the age-specific effects of C or E to be constant over time lead to a poorer fit and an increase in the AIC (comparison statistics for all models are presented in Table 2). Allowing the autoregression coefficients to change over time does not improve the model fit and leads to reduced parsimony.

In this best-fitting model, the sources of environmental variance are age-specific but once they occur, they persist over time to a greater or lesser degree. Although there are significant fluctuations in their magnitude, they are of the same order at each age. The autoregression coefficient estimate (assumed to be constant across time) is small for the effects of the unique environment, giving quantitative confirmation of the qualitative character of the cross-age correlations shown in Figures 2 and 3. The autoregression coefficient for the shared environment is very close to unity, suggesting that virtually all effects of the shared environment persist and accumulate with age. In a nutshell, as far as the effects of the shared environment are concerned "This year is last year plus whatever is new." In addition there are constant, age-specific, errors of measurement that do not persist over time.

Political Attitudes from Childhood to Older Adulthood

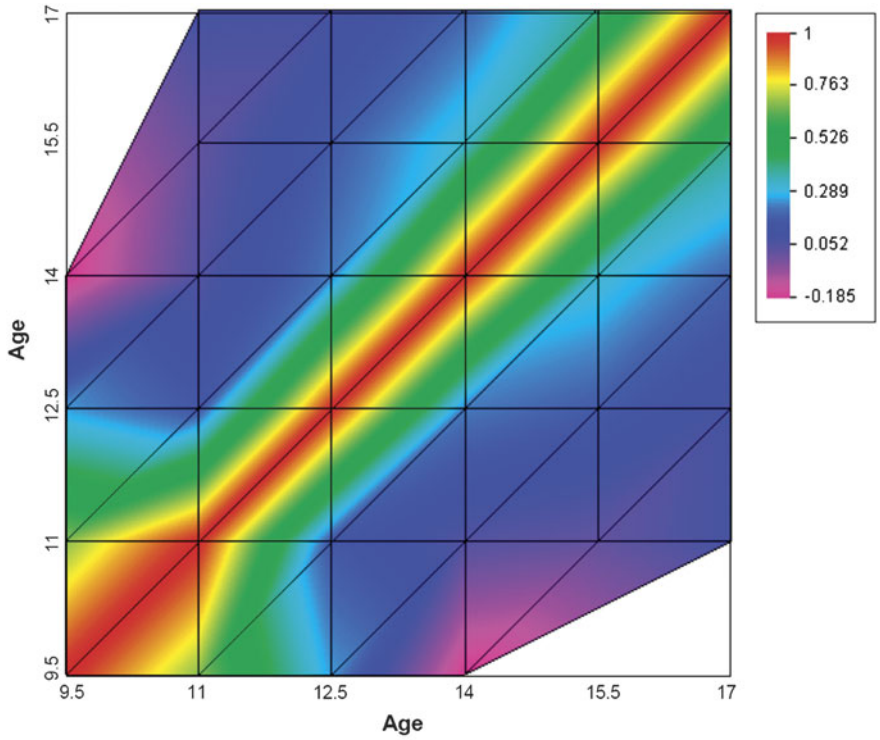
We turn, next, to the sources of variance in attitudes over the life course. To do so, we conduct an age cohort analysis on the combined data from the longitudinal study and the Virginia 30K study of adults. We focus on the question of whether and at what point in the life course genetic influences, in part, explain individual differences in political attitudes. For ease of presentation, we show the polychoric correlations of the MZ and DZ twin pairs by age cohort, thereby providing a simple gauge of whether or not genetic influences are present.

Figure 5 shows that the correlations of MZ and DZ twin pairs for both samples; they are remarkably similar up to the age of 20. Further, the correlations of the 18–20 year olds are nearly identical to the adolescent sample at age 17. This is particularly convincing since the two age groups come from different samples and used somewhat different indices of liberalism-conservatism.[5] In sum, there is no evidence of genetic influence in childhood or late adolescence in either sample.

The pattern changes significantly for age cohorts 21 and older. Starting at age 21 there is a marked drop in the DZ cotwin correlations while MZ correlations remain at least the same and in some cases slightly stronger. The respondents are grouped into five-year age cohorts in order to increase statistical power. However, additional analyses pulled apart each year and showed that starting at age 21, the MZ and DZ correlations statistically differ. Thus, the cut point of age 21–25 is not selected for convenience; it is the age at which the pattern changes markedly. The differences in correlations between MZ and DZ cotwin correlations is sizeable and persists across age cohorts over 21 during the adult years. Thus, genetic influences on political attitudes are exhibited starting at about age 21 and persist through the adult years.

[5]The 28-item version of the liberalism-conservatism index is a subset of the 50-item index. All 28-items overlap with the larger index. In a validation exercise, there were no substantive differences in the findings using the shorter index for the longitudinal sample.

FIGURE 2 Cross-age Correlations Showing Modest Change in Unique Environment Effects during Childhood and Adolescence

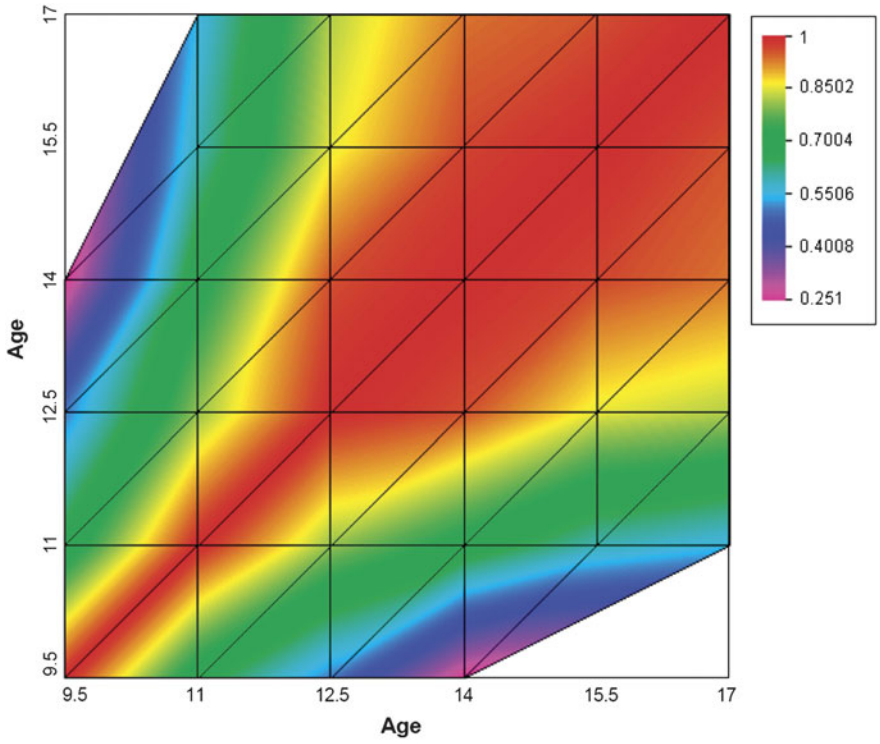


Note: Figure portrays cross-age correlations over time in unique environmental effects on the liberalism-conservatism index
Source: Longitudinal study of adolescent twins

These findings correspond to a predominant life change; the early twenties is a period when many young adults "leave the family nest" and set up independent homes. Fortunately, the adult survey instrument also included a measure on whether the respondents still lived at home (with their parents) or not. We compared the MZ and DZ correlations between twin pairs ages 21–25 which were concordant for either living at home (n = 184) or not living at home (n = 307). Comparing only same sex twin pairs, who were 21–25 and living at home, the cotwin correlations of MZ (n = 137) and DZ (n = 98) pairs were almost the same (MZ = .575; DZ = .571), a pattern that matches the 17 and 18–20 year old groups. However for twins not living at home in this age group the cotwin correlations were .577 for MZ pairs (N = 41), .229 for DZ pairs (N = 20) and .129 for unlike sex pairs (N = 34). Thus the significant change in MZ and DZ correlations (i.e., the drop in DZ cotwin correlation) between those under 21 and the 21–25 age group stems almost wholly from twins that are no longer living in their parent's home. The sample sizes are small and necessitate replication; however the evidence suggests that genetic influences on political preferences are not a simple function of age. Rather, genetic influences are only expressed in early adulthood *and* only when powerful social pressures such as the parental environment are removed.

A cohort analysis showing the best-fitting ACE models for the adult sample confirms the pattern of genetic influence seen in the MZ and DZ correlations. Figure 6 presents the results of the saturated model for each age cohort, in which all three variance components (genes, shared and unique environment) are estimated. Results from the best fitting and most parsimonious models are provided in online Appendix H). In both models, the influence of the shared or common environment significantly drops after age 20, and genetic influences remain fairly stable throughout each age cohort after that point. The one exception is the oldest age cohort, ages 75 and over, where genetic influence drops. Why genetic influences dissipate after age 75 may be due to a specific age cohort effect (e.g., growing up in the great depression), an aging effect (e.g., senility), or some other effect specific to this age group, such as decreased attitude stability

FIGURE 3 **Cross-age Correlations Showing Shared Environment Effects Persist and Accumulate during Childhood and Adolescence**



Note: Figure portrays cross-age correlations over time in shared environmental effects on the liberalism-conservatism index
Source: Longitudinal study of adolescent twins

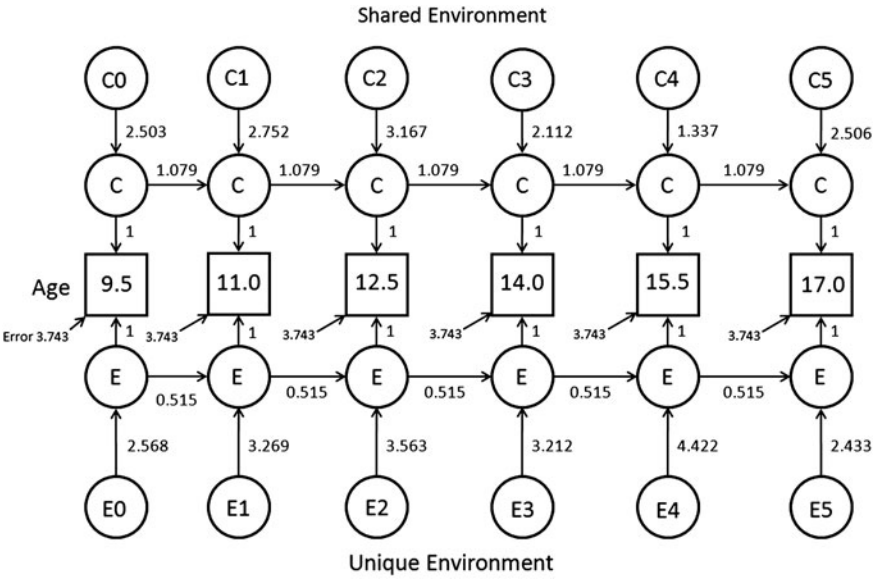
(e.g., Visser and Krosnick 1998). However, in comparison to other adult age cohorts, the sample sizes for those over 80 was much smaller, and the results may simply be stochastic.

Discussion

The political socialization literature has provided valuable insight on the basic nature of political attitudes, including attitudinal changes, civic education, and democratic participation. If parents socialize their offspring's political preferences, but these preferences only marginally change over the life course, then it is expected that the potential impact of short-term influences, such as campaigns, are relatively limited on long-term influence. Rather, it appears possible that it is equally important to target citizens in their role as parents of the future electorate rather than as the electorate per se for long term attitudinal prediction.

The findings here, however, suggest a far more complex role for parents. The role of the shared environment in the development of liberal and conservative attitude orientations increases strongly during the teenage years; the contribution of the shared environment to political attitudes increases more than tenfold over the developmental period, and this increase is carried forward during each period of development. In contrast, unique (or unshared) environmental influences show, at best, modest change during childhood and adolescence. Importantly, there is no evidence of genetic influences during this period. While the influence of unique environment experiences are relatively constant through most of life, the increasing importance of the shared environment in adolescence points toward the overall environment becoming strongly determinative of late adolescent political attitudes. To the extent that parents have an influence on the environment of their children, they are framing their children's political attitudes. Viewed in combination with increased attitude constraint and the emergence of meaning, it appears children are learning from their parents which political attitudes go with which other political attitudes (i.e., the "what goes with what" identified by Converse (1964) as being at the core of ideology). The strong increase

FIGURE 4 First-order Autoregressive Model for the Effects of the Shared and Unique Environment on the Liberalism-Conservatism Index during Childhood and Adolescence



Notes: Squares represent the measured trait for each age listed; E is the unique environment, C is the shared or common environment. Entries are maximum likelihood estimates of the parameters of the covariance structure.
Source: Longitudinal study of adolescent twins

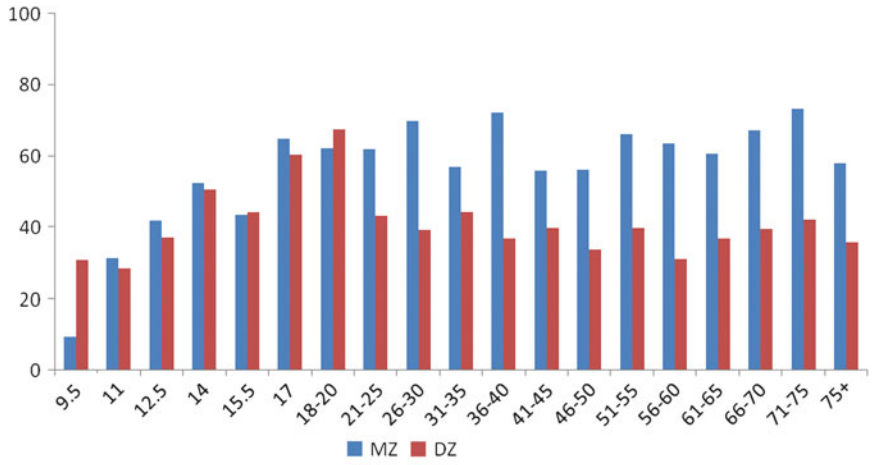
in attitudinal constraint in late adolescence also appears to run counter to certain aspects of the extant literature (e.g., Stoker and Jennings 2008). Regarding previous findings on partisanship, late adolescence and young adulthood is often viewed as a time of fluidity, not increased constraint. However, our findings are consistent with those from a large sample of adolescents to young adult's attitude stability. Hooghe and Wilkenfeld (2008) examined political trust, attitudes toward immigrants' rights, and voting behavior in 14, 18, and 18–30 year olds from eight European countries. Political trust and attitudes toward immigrant rights were fairly established by the age of 14, similar to that reported here, but stability of voter behavior was unstable in the young adult samples similar to Stoker and Jennings (2008). Our findings offer further evidence that there are differing patters of transmission and development for voter behavior, partisan affiliation, and political attitudes.

The portrait of socialization changes markedly however, as we look from the late adolescent years through older adulthood. Starting at about age 21, a substantial genetic influence on liberalism-conservatism is evident. Genetic influences remain at about the same level of magnitude throughout subsequent age cohorts. Shared environmental influences almost immediately dissipate in young adulthood and remain relatively weak. Unique environmental influences are evident throughout childhood and adulthood and the magnitude of influence from unique environment changes only modestly throughout the adult years.

The onset of genetic influences at young adulthood, however, challenges conclusions drawn from the existing literature. Our analyses suggest that the onset of genetic influence occurring at about ages 21–25 are rooted in life cycle changes from leaving the parental home. There was no evidence of genetic influences on the attitudes of twins still living with their parents at ages 21–25; only twins who no longer shared the parental home showed strong evidence of genetic influences on this index of liberal-conservative attitudes. Parental influence through social transmission on attitude orientations are strong during childhood and adolescence, but as young adults move away from the direct influences of the parental environment, the influence of parents appears to be indirect through genetic inheritance.

Late adolescence is seen as the formative phase for establishing social orientations (Inglehart 1977). Our data imply a much more nuanced process where social *orientations* are not established in this period, but social *learning processes* are, which is a likely starting

FIGURE 5 Correlations on the Liberalism-Conservatism Index for MZ and DZ Twin Pairs by Age Cohort

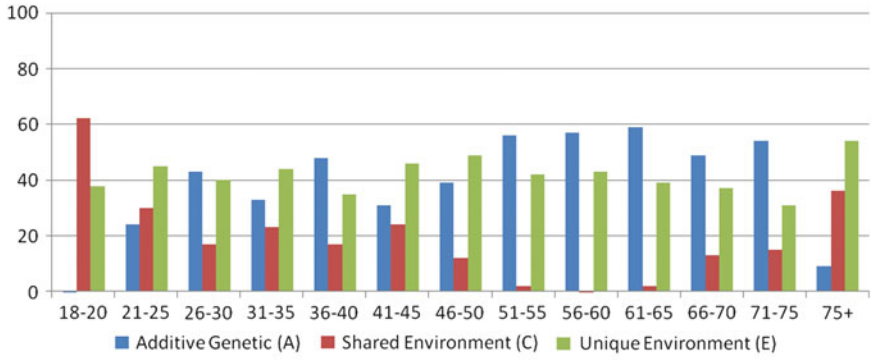


Note: MZ pairs and DZ pairs are pooled across sex
Source: Longitudinal study of adolescent twins (ages 9.5-17) combined with sample of adult twins (ages 18-88).

place for social *orientations*. Only when children leave home do their own longer-term orientations manifest themselves. What children may be gaining from their parents is a default heuristic; a process of heuristic acquisition in adolescence which then changes to heuristic application in adulthood, thereby explaining the significant correlation between parents and children but also allowing for idiosyncratic deviations. Thus, offspring begin with the attitudes learned from their parents, but as they leave home, their own experiences and individual genetic disposition interact to modify those attitudes. The degree of new information, experience, socialization, genetic influence or interactions necessary to alter attitudes once children leave home remains unclear.

The evidence for genetic influence starting at about age 21–25 stems mostly from a substantial drop in the attitude concordance between DZ twins while the correlation between MZ pairs remains stable. Why does DZ cotwin similarity remain fairly similar to that of MZ cotwins up until 20 years of age and then drop off sharply? This pattern goes against a key challenge to twin studies based on the equal environments assumption. The critique is that MZ twin pairs are treated more alike than DZ twin pairs during childhood, and this provides an alternative explanation for the greater

FIGURE 6 ACE Variance Components Estimates (Full Model) for Liberalism-Conservatism by Age Cohort



Note: MZ pairs and DZ pairs are pooled across sex
Source: Adult twins, Virginia 30K.

concordance between MZ cotwins versus that between DZ cotwins. Scholarship widely agrees that by far the greatest differences between MZ and DZ treatment occur during youth (Kendler et al. 1987, 1993). However, as the results show here, this potential difference in treatment has no effect on political preferences during childhood and adolescence. In fact, DZ cotwin similarity is almost exactly the same (if not higher) until age 20. It is only during young adulthood, after adolescents leave their shared home environments for one of increased independence from family that DZ cotwin correlations drop sharply. If there were systematic unequal environmental influence provided by social influences in adolescence, DZ correlations should be much lower in adolescence and might even grow in adulthood, but this is not at all the case. One explanation for this pattern is that those pairs who are most discordant in attitudes are the first to leave the nest, and genetic differences are a large contributor for leaving home and each other (e.g., see Posner et al. 1996). An alternative explanation may be that DZ twin pairs are choosing less similar environments than MZ twin pairs for reasons which are not influenced by genes, thus influencing MZ twin pairs to be more like each other or become less dissimilar as compared with DZ twin pairs. However, this would run counter to previous analyses of social attitudes. In a longitudinal study Posner et al. (1996) found that attitude similarity was the basis for the amount of contact between twins and not vice versa in an Australian population.[6] Based on these findings, critics of the twin design, in particular those who claim a special MZ twin environment exists for political attitudes, would have to argue that a special socialized twin environment exists in adolescence, but the influence of that environment lays dormant until adulthood, when it is then triggered by a yet to be identified mechanism which then influences adult preferences. Such a position would run counter to any known process of social influence. Rather, any special MZ socialization model for political preferences is precluded by the data here.

In evaluating our findings several issues must be considered. First, much of the past work on political socialization has examined the transmission of partisan identification or a combination of partisan and ideological orientation. This study is based on a multi-item attitude index of liberalism-conservatism. There are no data, to our knowledge, that would allow a longitudinal test of genetic influences on ideology.[7]

Second, these results argue for neither a model based on biological determinism nor a model based on environmental determinism. Political orientations are not a simple product of the environment (or in particular the familial environment), and certainly cannot be a simple product of genetic factors. Rather, these results begin to highlight the complex interaction between genotypes and social environment in a developing organism. While genes are relatively stable, gene expression may alter at differing points in the life cycle. The environment is not stable, and thus any conclusion must take into account the dynamic nature of human life and development. For example, we find genetic influence is manifest only after moving away from the parental home. Only a handful of studies have tested for the role of contextual mediators in the relationship between genes and attitudes (e.g., Boomsma et al. 1999). However, a number of other studies have demonstrated the importance of environmental context for explaining individual differences in the direction and stability of political attitudes over time. Geographic context and mobility (Brown 1981; Valentino and Sears 2005), intense exposure to events such as political campaigns (Sears and Valentino 1997), more politicized family interactions (Jennings, Stoker, and Bowers 2001), and marital transitions (Stoker and Jennings 1995) are a few of the contextual differences shown to influence political attitudes and behavior. Future research needs to address in some depth how these contextual factors interact with genetic factors to influence political attitudes and behavior in a developmental framework.

The expression of genetic influences on political attitudes occurs at the time of early adulthood and persists throughout the adult years. The onset of genetic influences at young adulthood raises new questions about the mechanism of genotype-environment interplay and the mechanism underlying the ''impressionable years'' model of political socialization. Our results suggest the parent-child correspondence in attitudes over the long-term is more likely to be due to some combination of personal experiences and shared genetic inheritance, rather than a lasting direct social influence of parents on the attitudes of their adult offspring. And the stability of political attitudes, starting from the period of young adulthood

[6]The direction of causation of attitude discordance and leaving home could not be assessed in this sample. In order to provide the same test as Posner, a follow-up of the adolescent twins is required.

[7]Previous analyses of party identification with the Virginia 30K sample of adults finds little genetic influence on party identification (Hatemi et al. 2009). So, it is likely that the transmission of party identification over the life course is quite different from one's liberal-conservative orientation.

and continuing through the adult years, is in turn also likely due in part to genetic influences.

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