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ARTICLE AVAILABLE ONLINE
Twin Research and Human Genetics
Volume 15 ▌Number 1 ▌pp. 6–14

Do Heritability Estimates of Political Phenotypes Suffer From an Equal Environment Assumption Violation? Evidence From an Empirical Study

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Using data from the Minnesota Twins Political Survey, this paper tests for the presence of unequal environments (EEA) by zygosity in political attitudes. Equal environment measures used include shared bedroom, friends, classes, and dressing alike. Results show an EEA violation at $p < .05$ in 5% of the models tested. The violations' impact on heritability estimates and their confidence levels appear random in magnitude and direction. No reasonable post hoc explanation emerged for understanding the presence of the violation in some items but not others. This article establishes reasonable priors for the absence of EEA violations in political phenotypes based on the tested environmental components. The findings place the burden on critics to present theoretical work on the specific mechanisms of EEA violations based on which additional empirical assessments could (and should) be conducted.

■ **Keywords:** equal environment assumption, ideology, Wilson-Patterson, Minnesota Twins Political Survey

The classical twin design makes the assumption that, on average, the environment that monozygotic (MZ) cotwins share is equally similar to the environment that dizygotic (DZ) twins share. This is known as the equal environment assumption (or EEA). The EEA received an exorbitant amount of attention by scholars uncomfortable with physiological predictors that have been infiltrating the social science literature. Such criticisms emerged in sociology (Horwitz, Videon, Schmitz, & Davis, 2003), education psychology (Richardson & Norgate, 2005), and also in political science (Beckwith & Morris, 2008; Charney, 2008).

The impact of this assumption on the estimates produced by the classical twin design is a legitimate concern. If the EEA is violated, and monozygotic twins share more of their environment, on average, than dizygotic twins, the classical twin design will overestimate heritability and underestimate the impact of the common environment. The leverage on estimating heritability stems from having information about how much of their genome, on average, the twins share and having information on how much environment, on average, they share. But if we lose the leverage on the environmental similarity in a way that monozygotic twins, on average, share more of their environment than dizygotic twins, we completely lose our ability to accurately estimate heritability.

The EEA has been the focal point of criticisms (Beckwith & Morris, 2008; Charney, 2008) directed toward twin designs applied to political traits (Alford, Funk & Hibbing, 2005; Martin et al., 1986). What was not mentioned in the criticisms is that the behavior genetics community accumulated a large body of relevant literature in the past 30 years on the topic of the EEA (for a review, see Hannagan & Hatemi, 2008; Hatemi, Alford, Hibbing, Martin, & Eaves, 2009; also see Derks, Dolan, & Boomsma, 2006; Kendler & Gardner, 1998; Kendler, Karkowski, Neale, & Prescott, 2000; Rose, Koskenvuo, Kaprio, Sarna, & Langinvainio, 1988; Rose, Kaprio, Williams, Viken, & Obremski, 1990; Xian et al., 2000). Unfortunately, the response articles to these critiques

RECEIVED 17 October 2011; ACCEPTED 01 December, 2011.

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Littvay, L. (2012). Do heritability estimates of political phenotypes suffer from an equal environment assumption violation? Evidence from an empirical study. *Twin Research and Human Genetics*, *15*, 1, 6–14. DOI 10.1375/twin.15.1.6

(including the response to Horwitz and colleagues) also failed to sufficiently highlight this literature (Alford, Funk & Hibbing, 2008a; Alford, Funk & Hibbing, 2008b; Hannagan & Hatemi, 2008; Freese & Powell, 2003). They also failed to highlight that the theoretical discussion actually revolved around an empirically testable question. An extensive review of the literature on the empirical EEA tests failed to produce a single instance in which EEA violations substantively influenced heritability estimates, with the single exception of bulimia (Hettema, Neale, & Kendler, 1995).

From this perspective, Horwitz et al. (2003) was most on track with their criticism of the EEA. Their article included an actual test that highlighted that MZ twins tend to share friends more often than DZ twins, and a specific mechanism on how this could influence their alcohol consumption heritability estimates. But this test employed regression methods that provided little information as to the actual impact of the EEA violation on the estimates derived with the classical twin design. Rather, the empirical evidence was presented as proof that the classical twin design is completely useless for any and all behavioral research, a common conclusion of social science articles critical of twin studies.

Previous work within political science also explored the potential effect of EEA violations on attitudes. Using longitudinal models, Hatemi, Funk, et al. (2009) found that MZ and DZ cotwin pairs were equally similar on attitudes from ages 9–18 years, but differed only when they left home. This means that, if any unequal environments existed, they had no discernable difference on twins by zygosity. Additional evidence using extended kinship models also found no influence of a twin-specific family environment (Hatemi et al., 2010).

Because these studies have not yet swayed critics, here I provide a complementary approach, and directly address critics by exploring if specific measured environments influence cotwins' similarity by zygosity. The model presented here not only tests the average differences in the socialized environments between MZ and DZ twins, but also incorporates controls that ensure the EEA does not bias our estimates when using a twin design. Modeling strategies exist that allow for such a comprehensive approach. The recently released Minnesota Twins Political Survey contains items similar to the ones used by the much-criticized paper by Alford et al. (2005). Using this data, I demonstrate the unified approach that simultaneously tests for the existence of an EEA violation (using all available equality of environment measures) and corrects the heritability and environmental proportion estimates when an EEA violation is present.

Model

To conduct the test, I drew on an empirical model first presented by Kendler, Neale, Kessler, Heath, & Eaves (1993). This model was developed to assess the impacts of the actual zygosity and the zygosity perceived by the twins' parents. The EEA model achieved this by adding a fourth latent component to the classical ACE model (Medland & Hatemi, 2009). It separated the C component into *specified common or familial environment*, or C_S, and *residual common environment*, or C_R (Kendler et al., 1993). For this reason, from this point on, I will refer to this model as the ACCE. The model is a classical ACE twin model with the added C_S component and the classic C component

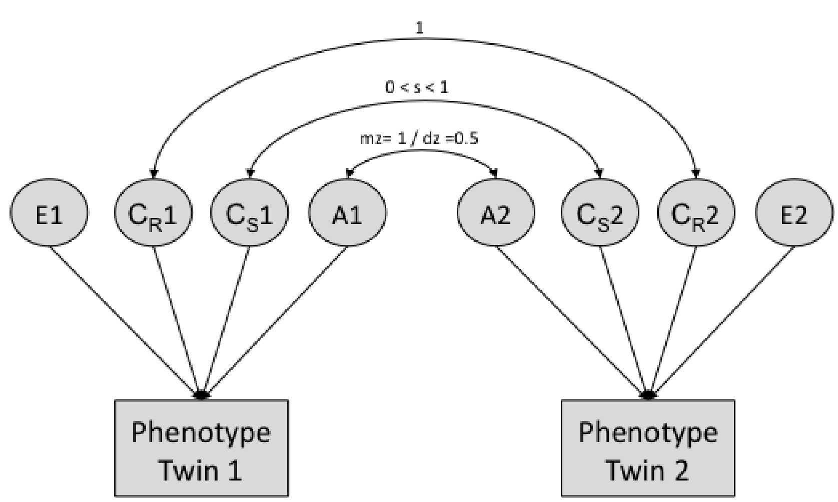

FIGURE 1.

The ACCE Model. A1 denotes latent additive genetic effect correlated with cotwin's corresponding (A2) effect perfectly (1) for MZ and 50% (.5) for DZ twins. E denotes uncorrelated unique environmental components. CS denotes specified common or familial environment correlation, based on the magnitude of similarity on the tested variable for each twin pair, and CR is the residual common environmental component correlated perfectly for both MZ and DZ twins.

https://doi.org/10.1375/twin.15.1.6 Published online by Cambridge University Press

renamed as C_R. The cotwin correlation for the C_R factors is still fixed at 1 for all twin pairs, but the correlation for the C_S factors varies across each family, and is based on the twins' similarity scores (denoted in Figure 1 by *s*). It is important to note that the ACE model is nested within the ACCE model with 1 degree of freedom for the estimated impact of C_R on the phenotype. For Kendler and colleagues (1993, 1994), the similarity score was defined by the perceived zygosity. Hettema et al. (1995) used the same model to control for physical similarity assessed by the parents. I use this model to test how the commonality of specific, explicitly measured environmental components (or C_S) influences the classical A, C (or in the ACCE model C_R), and E estimates for the phenotypes.

Data

To test the existence of the EEA on political attitudes, I rely on a Wilson-Patterson (WP) type questionnaire. The WP presents short, politically relevant statements and solicits agreement, disagreement, or uncertainty from the respondents. Lacking specific theoretical propositions, the WP is the best place to start testing EEA violations because the article that started the initial debate within political science tested the heritability of a version of the WP items. The Minnesota Twins Political Survey included 27 of the WP questions in a slightly updated form. (See Table 1 for the list, and the introductory chapter of this special issue for an extensive description of the Minnesota Twins Political Survey.) First, some statements were replaced with newer and timelier ones. Second, beyond the initial *agree/disagree/uncertain* options, the respondents were asked a follow-up question to see if their agreement or disagreement was *very strong, strong* or *not strong*. The responses to the two questions were converted into a 7-point scale.

The specific explicitly measured environmental components were self-reports on whether the respondent (1) shared a bedroom, (2) had the same friends, (3) dressed alike, and (4) had the same classes as their cotwin. Conveniently, these are also the most often possible EEA violations cited by the critics mentioned above. The 5-point responses were averaged across the twin pairs and linearly transformed to be scaled between 0 and 1. In addition to the measured environmental variables, the impact of a combined specific common environmental component was also tested. The four specific explicitly measured environmental items were factor-analyzed to produce the best combined environmental similarity measure, given the available data. Loadings were (respectively) 0.232, 0.546, 0.681, and 0.732. The resulting factor was scaled to have a mean of 0 and a standard deviation of 1, and was transformed to fall between 0 and 1 by taking the percentiles of their z distribution.

Analyses

The analyses were conducted with Mplus 6.1 structural equation modeling software, using a maximum likelihood estimator (Muthen & Muthen, 2010). Asymmetric confidence intervals of the estimates were Bollen-Stine bootstrapped. This procedure produces comparable results to the likelihood-ratio-based confidence intervals derived using MX (Bollen & Stine, 1992; Neale & Miller, 1997). Cases with missing data on any of the relevant variables were excluded from the analysis. In the absence of severe distributional violations (the absolute value of the skew and the kurtosis were below 2 and 7, respectively) all phenotypes were treated as continuous and normal.

Results

Table 1 presents the Chi-squared nested model test between the five ACCE models (four explicit measures of environmental commonality, plus the factor that combines the four) and the ACE model. Note that, for each phenotype, the ACE model is invariant to the five ACCE models. In Figure 1, the ACCE models are bolded where the ACE model fit was significantly worse than the ACCE model at $p < .1$.

Apparently, the inclusion of dressing alike, and, to a lesser extent ($p < .1$), having the same friends, significantly improves the fit of the ACCE model over the ACE model for abortion rights. Dressing alike also influences thoughts on biblical truth, the protection of gun rights, and abstinence-only sex education. Finally, the combined factor of environmental similarity measures (but not any of the individual subcomponents) significantly influenced people's approval of globalization, strict pollution control, and allowing the torture of terrorism suspects.

Turning to how the estimates differed between the ACE and ACCE models (see also Table 2), the insignificant additive genetic effect increased with the inclusion of the relevant specific factors for abortion and gun rights (though remained insignificant when having the same friends was included for the abortion rights model). For globalization and allowing the torture of terrorism suspects, an insignificant estimate of A decreased somewhat and remained insignificant, but for abstinence-only sex education, the dip of the insignificant A estimate became significant with the added control. The significant (and relatively large) A estimates for biblical truth remained roughly the same across the two models; however, the significant (but not so large) A of strict pollution control vanished when the combined specific environmental control was included.

Limitations

Although the results are straightforward evidence against the widespread EEA violations that Charney (2008) and

TABLE 1

Maximum Likelihood Comparison of Model Fit Testing the Difference Between the ACCE and the ACE Models

School prayer	***-2LL***	***Chi-Sq***	***p-value***
ACE	4695.22		
ACCE - Share Bedroom	4695.22	0	1
ACCE - Same Friends	4695.22	0	1
ACCE - Dressed Alike	4695.2	0.02	0.89
ACCE - Same Classes	4694.86	0.36	0.55
ACCE - Factor	4695.16	0.06	0.81

Pacifism	***-2LL***	***Chi-Sq***	***p-value***
ACE	4003.12		
ACCE - Share Bedroom	4001.92	1.2	0.27
ACCE - Same Friends	4002.36	0.76	0.38
ACCE - Dressed Alike	4002.54	0.58	0.45
ACCE - Same Classes	4003.08	0.04	0.84
ACCE - Factor	4003.12	0	1

Socialism	***-2LL***	***Chi-Sq***	***p-value***
ACE	4275.1		
ACCE - Share Bedroom	4275.1	0	1
ACCE - Same Friends	4275	0.1	0.75
ACCE - Dressed Alike	4275.1	0	1
ACCE - Same Classes	4272.5	2.6	0.11
ACCE - Factor	4275.1	0	1

Pornography	***-2LL***	***Chi-Sq***	***p-value***
ACE	3937.5		
ACCE - Share Bedroom	3937.5	0	1
ACCE - Same Friends	3937.5	0	1
ACCE - Dressed Alike	3936.74	0.76	0.38
ACCE - Same Classes	3937.5	0	1
ACCE - Factor	3937.04	0.46	0.5

Stop illegal immigration	***-2LL***	***Chi-Sq***	***p-value***
ACE	4292.66		
ACCE - Share Bedroom	4292.66	0	1
ACCE - Same Friends	4292.66	0	1
ACCE - Dressed Alike	4292.6	0.06	0.81
ACCE - Same Classes	4291.96	0.7	0.4
ACCE - Factor	4292.66	0	1

Women's equality	***-2LL***	***Chi-Sq***	***p-value***
ACE	3135.98		
ACCE - Share Bedroom	3135.98	0	1
ACCE - Same Friends	3135.98	0	1
ACCE - Dressed Alike	3135.98	0	1
ACCE - Same Classes	3135.98	0	1
ACCE - Factor	3134.88	1.1	0.29

Death penalty	***-2LL***	***Chi-Sq***	***p-value***
ACE	4820.18		
ACCE - Share Bedroom	4820.18	0	1
ACCE - Same Friends	4820.18	0	1
ACCE - Dressed Alike	4820.18	0	1
ACCE - Same Classes	4820.18	0	1
ACCE - Factor	4817.92	2.26	0.13

Increase welfare spending	***-2LL***	***Chi-Sq***	***p-value***
ACE	4339.7		
ACCE - Share Bedroom	4339.2	0.46	0.5
ACCE - Same Friends	4339.7	0	1
ACCE - Dressed Alike	4339.7	0	1
ACCE - Same Classes	4339.7	0	1
ACCE - Factor	4339.7	0	1

Protect gun rights	***-2LL***	***Chi-Sq***	***p-value***
ACE	4745.8		
ACCE - Share Bedroom	4745	0.8	0.37
ACCE - Same Friends	4745.2	0.6	0.44
ACCE - Dressed Alike	**4740**	**5.96**	**0.02**
ACCE - Same Classes	4744.8	1.06	0.3
ACCE - Factor	4745.8	0	1

Premarital sex	***-2LL***	***Chi-Sq***	***p-value***
ACE	4612.08		
ACCE - Share Bedroom	4612.08	0	1
ACCE - Same Friends	4612.08	0	1
ACCE - Dressed Alike	4610.04	2.04	0.15
ACCE - Same Classes	4611.84	0.24	0.62
ACCE - Factor	4612.08	0	1

Gay marriage	***-2LL***	***Chi-Sq***	***p-value***
ACE	5002.3		
ACCE - Share Bedroom	5002.3	0	1
ACCE - Same Friends	5002.3	0	1
ACCE - Dressed Alike	5000.56	1.74	0.19
ACCE - Same Classes	5002.3	0	1
ACCE - Factor	5002.3	0	1

Abortion rights	***-2LL***	***Chi-Sq***	***p-value***
ACE	5132.4		
ACCE - Share Bedroom	5131.7	0.7	0.4
ACCE - Same Friends	**5128.86**	**3.54**	**0.06**
ACCE - Dressed Alike	**5122.02**	**10.38**	**0**
ACCE - Same Classes	5127.9	4.5	0.03
ACCE - Factor	5132.4	0	1

Evolution	***-2LL***	***Chi-Sq***	***p-value***
ACE	4803.24		
ACCE - Share Bedroom	4803.22	0.02	0.89
ACCE - Same Friends	4803.24	0	1
ACCE - Dressed Alike	4801.6	1.64	0.2
ACCE - Same Classes	4803.24	0	1
ACCE - Factor	4803.24	0	1

Patriotism	***-2LL***	***Chi-Sq***	***p-value***
ACE	3383.34		
ACCE - Share Bedroom	3383.34	0	1
ACCE - Same Friends	3383.34	0	1
ACCE - Dressed Alike	3383.34	0	1
ACCE - Same Classes	3383.34	0	1
ACCE - Factor	3382.86	0.48	0.49

Biblical truth	***-2LL***	***Chi-Sq***	***p-value***
ACE	4473.82		
ACCE - Share Bedroom	4473.82	0	1
ACCE - Same Friends	4473.82	0	1
ACCE - Dressed Alike	**4469.54**	**4.28**	**0.04**
ACCE - Same Classes	4473.8	0.02	0.89
ACCE - Factor	4473.82	0	1

Iraq War	***-2LL***	***Chi-Sq***	***p-value***
ACE	4828.14		
ACCE - Share Bedroom	4828.04	0.1	0.75
ACCE - Same Friends	4828.14	0	1
ACCE - Dressed Alike	4828.14	0	1
ACCE - Same Classes	4828.14	0	1
ACCE - Factor	4827.7	0.44	0.51

School standards	***-2LL***	***Chi-Sq***	***p-value***
ACE	4008.5		
ACCE - Share Bedroom	4008.5	0	1
ACCE - Same Friends	4008.5	0	1
ACCE - Dressed Alike	4008.5	0	1
ACCE - Same Classes	4008.5	0	1
ACCE - Factor	4008.5	0	1

Foreign aid	***-2LL***	***Chi-Sq***	***p-value***
ACE	4343.26		
ACCE - Share Bedroom	4342.24	1.02	0.31
ACCE - Same Friends	4343.24	0.02	0.89
ACCE - Dressed Alike	4343.14	0.12	0.73
ACCE - Same Classes	4343.26	0	1
ACCE - Factor	4343.26	0	1

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https://doi.org/10.1375/twin.15.1.6 Published online by Cambridge University Press

TABLE 1 (CONTINUED)

Maximum Likelihood Comparison of Model Fit Testing the Difference Between the ACCE and the ACE Models

Increase military spending	*-2LL*	*Chi-Sq*	*p-value*
ACE	4579.3		
ACCE - Share Bedroom	4579.3	0	1
ACCE - Same Friends	4579.3	0	1
ACCE - Dressed Alike	4579.3	0	1
ACCE - Same Classes	4579.1	0.12	0.73
ACCE - Factor	4578.8	0.44	0.51

Allow warrantless searches	*-2LL*	*Chi-Sq*	*p-value*
ACE	4272		
ACCE - Share Bedroom	4272	0	1
ACCE - Same Friends	4272	0	1
ACCE - Dressed Alike	4272	0	1
ACCE - Same Classes	4272	0	1
ACCE - Factor	4269.8	2.26	0.13

Globalization	*-2LL*	*Chi-Sq*	*p-value*
ACE	4191.2		
ACCE - Share Bedroom	4191.2	0	1
ACCE - Same Friends	4191.2	0	1
ACCE - Dressed Alike	4191.2	0	1
ACCE - Same Classes	4191.2	0	1
ACCE - Factor	**4185**	**5.86**	**0.02**

Strict pollution control	*-2LL*	*Chi-Sq*	*p-value*
ACE	4172.5		
ACCE - Share Bedroom	4172.4	0.06	0.81
ACCE - Same Friends	4172.5	0	1
ACCE - Dressed Alike	4172.5	0	1
ACCE - Same Classes	4172.5	0	1
ACCE - Factor	**4166**	**6.54**	**0.01**

Small government	*-2LL*	*Chi-Sq*	*p-value*
ACE	4247.6		
ACCE - Share Bedroom	4247.6	0	1
ACCE - Same Friends	4247.6	0	1
ACCE - Dressed Alike	4247.6	0.02	0.89
ACCE - Same Classes	4247.6	0.02	0.89
ACCE - Factor	4247.3	0.3	0.58

Lower taxes	*-2LL*	*Chi-Sq*	*p-value*
ACE	4347.64		
ACCE - Share Bedroom	4347.64	0	1
ACCE - Same Friends	4347.64	0	1
ACCE - Dressed Alike	4347.64	0	1
ACCE - Same Classes	4347.56	0.08	0.78
ACCE - Factor	4347.58	0.06	0.81

Stem cell research	*-2LL*	*Chi-Sq*	*p-value*
ACE	4649.16		
ACCE - Share Bedroom	4649	0.16	0.69
ACCE - Same Friends	4649.16	0	1
ACCE - Dressed Alike	4649.16	0	1
ACCE - Same Classes	4649.16	0	1
ACCE - Factor	4648.66	0.5	0.48

Abstinence-only sex education	*-2LL*	*Chi-Sq*	*p-value*
ACE	4787.36		
ACCE - Share Bedroom	4787.36	0	1
ACCE - Same Friends	4784.76	2.6	0.11
ACCE - Dressed Alike	**4779.96**	**7.4**	**0.01**
ACCE - Same Classes	4786.02	1.34	0.25
ACCE - Factor	4787.36	0	1

Allow torture of terrorism suspects	*-2LL*	*Chi-Sq*	*p-value*
ACE	4691.38		
ACCE - Share Bedroom	4691.38	0	1
ACCE - Same Friends	4691.38	0	1
ACCE - Dressed Alike	4691.38	0	1
ACCE - Same Classes	4691.38	0	1
ACCE - Factor	**4686.24**	**5.14**	**0.02**

Note: Bolded means significant difference between the ACCE and the ACE model on the Chi-square difference test at $p<0.1$

Beckwith and Morris (2008) warned about, it is important to point out that EEA violations can still be present in twin models of political behavior. The model presented in this article only tested the 27 Wilson-Patterson items, which allows for the possibility of EEA violations in other political phenotypes (such as political behaviors). Also, the measured environmental components used in this study only partially control for average differences of the environment across MZ and DZ twins. As part of a direct response to the cited critics, this is less of an issue. They criticized the Alford et al. (2005) article, which used a Wilson-Patterson battery. These critics cited the exact mechanisms for possible EEA violations for which the presented model corrected. Additionally, the combined measure of differential environments utilizes the common underlying variation across the four items. If we consider the four items as a sample of environmental measures, the results should generalize to other aspects of the twins' environments. Obviously, there are limits to how far this generalization can be taken, especially given that the measures are nonrandom selections, the sample size (or environmental measures) is $N = 4$, and the factor model's loadings did not suggest a single underlying factor with good model fit.

Second, although this study intended to address the critiques of Charney (2008) and Beckwith and Morris (2008), it cannot do so with complete accuracy. The Alford et al. (2005) article they criticized was based on a different sample that was more age representative, and from a different region and time period. In fact, even the WP items used here to assess the twins' ideology were slightly different at times; both sets of WP questions attempted to measure ideology, and therefore the items were adjusted to represent the different issues of the day in the 1990s and in 2008. Because the critics pose a timeless argument that they extrapolate to all twin studies of all social traits ever conducted, it is not unreasonable to claim that the results presented here provide a valid response to the critics of twin studies within political science.

Third, the specific environmental measures could be biased due to a retrospective recall of personal and family histories dating back 40–50 years. The problems associ-

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TABLE 2
ACE and ACCE results for models where ACE model showed significantly worse fit

Abortion rights	***A***	***C specified***	***C residual***	***E***
ACE	**0.152**	**-**	**0.261**	**0.587**
95% CI	(0.000, 0.443)	-	(0.000, 0.428)	(0.503, 0.674)
90% CI	(0.000, 0.415)	-	(0.028, 0.416)	(0.514, 0.662)
ACCE - Same Friends	**0.251**	**0.337**	**0.094**	**0.318**
95% CI	(0.000, 0.432)	(0.000, 0.696)	(0.000, 0.375)	(0.001, 0.594)
90% CI	(0.000, 0.412)	(0.012, 0.652)	(0.000, 0.351)	(0.047, 0.561)
ACCE - Dressed Alike	**0.229**	**0.443**	**0**	**0.328**
95% CI	(0.046, 0.437)	(0.167, 0.723)	(0.000, 0.174)	(0.140, 0.485)
90% CI	(0.093, 0.408)	(0.215, 0.696)	(0.000, 0.112)	(0.167, 0.461)
Biblical truth	***A***	***C specified***	***C residual***	***E***
ACE	**0.451**	**-**	**0.074**	**0.475**
95% CI	(0.135, 0.611)	-	(0.000, 0.332)	(0.378, 0.570)
90% CI	(0.200, 0.593)	-	(0.000, 0.286)	(0.395, 0.557)
ACCE - Dressed Alike	**0.427**	**0.216**	**0**	**0.357**
95% CI	(0.234, 0.578)	(0.000, 0.426)	(0.000, 0.252)	(0.239, 0.511)
90% CI	(0.265, 0.554)	(0.000, 0.399)	(0.000, 0.193)	(0.257, 0.491)
Protect gun rights	***A***	***C specified***	***C residual***	***E***
ACE	**0.18**	**-**	**0.214**	**0.606**
95% CI	(0.000, 0.452)	-	(0.000, 0.386)	(0.510, 0.692)
90% CI	(0.000, 0.418)	-	(0.000, 0.366)	(0.526, 0.679)
ACCE - Dressed Alike	**0.262**	**0.323**	**0**	**0.416**
95% CI	(0.091, 0.433)	(0.091, 0.562)	(0.000, 0.067)	(0.278, 0.554)
90% CI	(0.130, 0.409)	(0.124, 0.528)	(0.000, 0.000)	(0.294, 0.533)
Globalization	***A***	***C specified***	***C residual***	***E***
ACE	**0.208**	**-**	**0.043**	**0.749**
95% CI	(0.000, 0.366)	-	(0.000, 0.242)	(0.636, 0.862)
90% CI	(0.000, 0.345)	-	(0.000, 0.223)	(0.000, 0.847)
ACCE - Factor	**0.043**	**0.359**	**0**	**0.597**
95% CI	(0.000, 0.298)	(0.076, 0.540)	(0.000, 0.258)	(0.460, 0.750)
90% CI	(0.000, 0.272)	(0.146, 0.527)	(0.000, 0.256)	(0.476, 0.721)
Strict pollution control	***A***	***C specified***	***C residual***	***E***
ACE	**0.277**	**-**	**0**	**0.723**
95% CI	(0.181, 0.385)	-	(0.000, 0.000)	(0.614, 0.819)
90% CI	(0.194, 0.363)	-	(0.000, 0.000)	(0.637, 0.805)
ACCE - Factor	**0.025**	**0.409**	**0**	**0.566**
95% CI	(0.000, 0.283)	(0.127, 0.600)	(0.000, 0.000)	(0.402, 0.723)
90% CI	(0.000, 0.258)	(0.183, 0.576)	(0.000, 0.000)	(0.432, 0.693)
Abstinence-only sex education	***A***	***C specified***	***C residual***	***E***
ACE	**0.236**	**-**	**0.096**	**0.668**
95% CI	(0.000, 0.416)	-	(0.000, 0.324)	(0.560, 0.762)
90% CI	(0.000, 0.403)	-	(0.000, 0.302)	(0.578, 0.745)
ACCE - Dressed Alike	**0.179**	**0.344**	**0**	**0.477**
95% CI	(0.008, 0.343)	(0.062, 0.612)	(0.000, 0.297)	(0.313, 0.656)
90% CI	(0.037, 0.324)	(0.099, 0.548)	(0.000, 0.297)	(0.337, 0.622)
Allow torture of terrorism suspects	***A***	***C specified***	***C residual***	***E***
ACE	**0.252**	**-**	**0.09**	**0.658**
95% CI	(0.000, 0.434)	-	(0.000, 0.299)	(0.547, 0.757)
90% CI	(0.000, 0.411)	-	(0.000, 0.286)	(0.562, 0.740)
ACCE - Factor	**0.131**	**0.315**	**0.022**	**0.532**
95% CI	(0.000, 0.387)	(0.034, 0.556)	(0.000, 0.242)	(0.384, 0.680)
90% CI	(0.000, 0.359)	(0.080, 0.535)	(0.000, 0.216)	(0.409, 0.658)

Note: 95% and 90% Confidence Intervals were Bollen-Stine Bootstrapped.

https://doi.org/10.1375/twin.15.1.6 Published online by Cambridge University Press

ated with relying on memory for such long-distance information recall are well known (Belli & Loftus, 1999). However, having a relatively fixed age cohort in the Minnesota sample and more than one person (the twins) reporting on these childhood histories provides some control for the errors associated with these measures.

Finally, Table 2 presents many insignificant estimates for heritability and the common environmental components. Because the paper is only concerned with the impact of EEA violation, and not the actual estimation of heritability proportions, this is acceptable. If the study had a substantive interest in determining the heritabilities of the WP items, additional model testing would be necessary (for example, testing the AE, CE and E models). Because this is beyond the scope of the paper, the insignificant results from the ACE model need to be taken at face value: a demonstration that the EEA violations do not systematically decrease estimates of heritability in any one direction. With the additional model reductions (or with a larger sample), no doubt, more of the results would be significantly different from 0.

Discussion

The test of an EEA for 27 phenotypes using four specific and one combined environmental measure produced little evidence of an EEA violation. Findings follow no particular pattern for which of the 27 variables and 5 environmental measures yield an improvement in model fit, and which ones do not. In this nonresult lies the problem posed by the social science critique on the issue of the EEA violation. It contains few theoretical or empirical specifics, but always concludes that twin modeling is therefore useless. When specifics are cited by the critics, it is most often the exact environmental differences that could emerge between MZ and DZ twins that are tested in this study, though even these instances lack the specific mechanism on exactly how the EEA violation influences the specific phenotype.

It is difficult not to notice that, while I ran 135 model comparisons, I found 7 significant differences at $p < .05$. Seven is exactly 5.2% of the models. If I add the one comparison with $p < .06$, I have exactly 5.9% of the models. If these phenotypes were independent of each other, I could completely dismiss the results because they are exactly what are expected by chance. Because neither the phenotypes nor the specific environments measured are entirely independent of each other, I concede that the results provide some extremely weak evidence that an EEA violation could be real and present. It is also fair to conclude that the EEA violation is extremely rare, and its impact on the estimates does not necessarily follow the pattern suggested by the critics of the twin design. The impact on the heritability estimates does not necessarily suggest an upward bias; rather, they are entirely uncertain.

Based on the results presented, it is safe to dismiss the *broad* claims that possible EEA violations, such as the friends twins have or even how they dress, completely invalidate the results of the twin design in studies of social behavior (or behavior in general). That is obviously not the case. On the other hand, the possibility of an EEA violation biasing results cannot be ruled out completely in any twin study. This study should, by no means, be taken as evidence that the EEA is not a possible problem in twin studies of political phenotypes. When there is a solid, theoretically grounded cause for concern, the data should be collected to empirically address those concerns, and assessments similar to the one presented here are warranted. Researchers need to think about possible mechanisms of EEA violations and control for them when possible. But, in absence of theoretically grounded mechanisms, the prior of no EEA violation is justified.

These results should not, and I anticipate that they will not, convince the critics of twin studies. Rather, I expect, corroborating evidence that broad claims that the EEA does not invalidate the findings of twin studies will shift the critics' focus towards other assumptions made. To this, I respond that all empirical models make assumptions; also, most of the assumptions can be tested empirically and incorporated into the classical twin model. (For another example of how the assumptions of the classical twin design can be modified and tested, see Hatemi et al., 2010). Everyone with a reasonable understanding of the classical twin design knows that the model is not perfect. But there is no such thing as a perfect model in any facet of empirical research. From Box's famous statement, we know that 'all models are wrong, but some are useful' (Box & Draper, 1987). And the classical twin model has been extremely useful in pointing out that over a hundred years of political science tradition might have missed an important class of predictors of behavior. This special issue demonstrates well how this general claim can be turned into specific findings, and how twin modeling can advance our understanding of our own discipline.

The literature lacks clear theoretical work on the mechanism of EEA violations. Future work should produce theories on the *specific mechanisms* of how EEA violations could bias our estimates of the *specific dependent variables* used within a twin-modeling framework. This task is extremely difficult because social scientists are trained to see the impact of the 'environment' everywhere, even when it is an illusion. It is no surprise that very few specific theories were proposed regarding the mechanism of how a specific component of the environment might lead to an EEA violation bias of heritability in a specific dependent variable. Only broad generalizations were presented in the critiques. Such specific propositions are the theories that are needed to advance both behavior genetics and political science. These are the theories that guide our data collection efforts, and subsequently allow us to explicitly test specific hypotheses without the demonstrated exercise of 'inductively shooting in the dark' producing few interpretable findings.

Acknowledgments

Special thanks go to the editor, Nick Martin, and the special issue editor, Peter Hatemi, for this special issue of Twin Research and Human Genetics. The guest editor and the University of Southern Denmark research team, especially Asbjørn Sonne Nørgaard, deserve extra special thanks for financially supporting the publication of this special issue and this paper. I also would like to extend my gratitude to all the instructors at the Boulder twin and family studies workshops, with special acknowledgment of Mike Neale, who pointed me to the Kendler EEA model at the 2006 workshop. I am extremely indebted to the twins who participated in the Minnesota Twins Political Survey, to the scholars who led the data collection effort, and for the training sessions, in one of which I had the opportunity to participate as an instructor. I also wish to thank Paul Weith, Zoltán Fazekas, and Sebastian Adrian Popa for their helpful comments. Finally, many thanks to the Mplus team, especially to Tihomir Asparouhov, who helped me put the scripts together and tweaked (or beat) them into submission (convergence). The data for this paper were collected with the financial support of the National Science Foundation (SES-0721378: Hibbing, Alford, Eaves, Funk, Hatemi, and Smith). Data analysis was also supported by the NSF (1047687 and 0921008: Hatemi).

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