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Shared environmental influences on personality: A combined twin and adoption approach

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Abstract

In the past, shared environmental influences on personality traits have been found to be negligible in behavior genetic studies (e.g., Bouchard & McGue, 2003). However, most studies have been based on biometrical modeling of twins only. Failure to meet key assumptions of the classical twin design could lead to biased estimates of shared environmental effects. Alternative approaches to the etiology of personality are needed. In the current study we estimated the impact of shared environmental factors on adolescent personality by simultaneously modeling both twin and adoption data. We found evidence for significant shared environmental influences on Multidimensional Personality Questionnaire (MPQ) Absorption (15% variance explained), Alienation (10%), Harm Avoidance (14%), and Traditionalism (26%) scales. Additionally, we found that in most cases biometrical models constraining parameter estimates to be equal across study type (twins versus adoptees) fit no worse than models allowing these parameters to vary; this suggests that results converge across study design despite the potential (sometimes opposite) biases of twin and adoption studies. Thus, we can be more confident that our findings represent the true contribution of shared environmental variance to personality development.

Keywords

shared environment; personality; method biases

Personality is an important area of psychological research, as personality traits are significant predictors of many outcomes of interest. In their review, Roberts et al. (2007) reported effect sizes of personality traits on mortality, divorce, and occupational attainment that were comparable to those of socioeconomic status and cognitive ability. Likewise, meta-analyses have shown personality to be useful in predicting longevity (Kern and Friedman 2008) and job performance (Barrick et al. 2001). Researchers have also considered personality traits to be risk factors, diagnostic indicators, and predictors of psychopathology onset, severity, and outcome (Terracciano et al. 2010).

Given these relationships, much interest has turned to the etiology of personality traits, utilizing many research designs to decompose trait variance into that of environmental and genetic origin. Briefly, environmental variance encompasses both shared environment (C, which contributes c^2 to phenotypic variance; that which makes reared-together siblings similar) and nonshared environment (E, which contributes e^2 to phenotypic variance; that which makes siblings different) while genetic variance encompasses both additive (A, which

contributes a^2 to phenotypic variance) and nonadditive influences (dominance, D , which contributes d^2 , and epistasis, I , which contributes i^2). Researchers typically use structural equation modeling to fit data from genetically informative samples to etiological models and estimate the contribution of these influences to phenotypes of interest.

Over the past few decades, results of most of these kinds of studies have supported the conclusion that personality traits are moderately heritable and more surprisingly that shared environmental influences account for very little to no variance in most traits in the studied populations (e.g., Bouchard and McGue 2003, Finkel and McGue 1997). However, there is room for doubt about this finding, as some studies have found a shared environmental effect on at least some personality traits (e.g., Baker et al. 1992, Beer et al. 1998, Bergeman et al. 1993, Hahn et al. 2012, Loehlin and Gough 1990, Tellegen et al. 1988). Developmental personality researchers have utilized a variety of assessments and study designs, and it is not clear if or how different methods affect the results of such studies. Might there truly be important shared environmental influences on some aspects of personality, or are these studies biased in some way?

Perhaps the most obvious possible explanation for discrepant findings is the use of different personality measures across studies. Such measures are based on theories that propose the existence of differing numbers of higher-order dimensions; the Five Factor Model (FFM), for example, proposes five major domains of personality including Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness (Goldberg 1993) while Tellegen's "Big Three" model (Tellegen 1982) posits only three major domains—Positive Emotionality, Negative Emotionality, and Constraint. However, there is general consensus about how specific traits are hierarchically organized (Bouchard and McGue 2003), and Markon et al. (2005) have successfully integrated alternative models into a replicable structure that illustrates the relationships among these higher-order dimensions. What we can conclude from this is that the same constructs are assessed across different measures of personality, but they are organized in slightly different ways. Still, slight differences in organization may lead to very different results if some aspects of a domain are influenced by shared environmental factors while others are not. Tellegen et al. (1988), for example, found significant shared environmental effects (22%) on the super-factor Positive Emotionality (most closely related to FFM Extraversion) as measured by the Multidimensional Personality Questionnaire (MPQ; Tellegen and Waller 2008); c^2 influence was observed on the primary scale of Social Closeness but not on Achievement, Social Potency, or Well Being scales (other aspects of Positive Emotionality). The extent to which FFM Extraversion captures variance in Social Closeness relative to other facets of positive affect may influence how similar results of biometrical studies will turn out.

Secondly, most of the previous studies were based on twins only. Bouchard and McGue (2003) pointed out in their review that personality analyses based only on twin samples consistently resulted in higher heritability estimates and smaller c^2 estimates than those including family and adoption data as well as twin data, which could point to either the presence of nonadditive genetic effects (because of inflated resemblance of monozygotic (MZ) twins) or study design bias. Perhaps the biggest concern of the classical twin design is that it cannot concurrently estimate both shared environmental influence and nonadditive genetic influence, so either an ACE or an ADE model can be fit but not an ACDE model. If both c^2 and d^2 significantly contribute to the phenotype, heritability may be overestimated while c^2 may be underestimated when fitting the ACE model. Indeed, many studies have supported the presence of nonadditive genetic effects on personality (e.g., Eaves et al. 1999, Finkel and McGue 1997), so we should be cautious when interpreting the small c^2 estimates from twin analysis.

Additionally, an important assumption is that MZ twins do not share more similar environments than do dizygotic (DZ) twins; this is known as the equal environments assumption (EEA). If the EEA is violated (and the difference in environmental similarity is associated with the phenotype of interest), then heritability may be overestimated and c^2 may be underestimated. Though much research supports the validity of the EEA across many domains (e.g., Derks et al. 2006, Eaves et al. 2003, Kendler et al. 1993, Loehlin and Nichols 1976, Plomin et al. 1976), some critics remain unconvinced (e.g., Richardson and Norgate 2005, Tishler and Carey 2007). Another issue is the possibility that personality development in twins may differ from that of nontwins, which, if true, would limit the generalizability of twin research on personality. There is evidence, however, that personalities of twins and nontwins do not differ significantly (Johnson et al. 2002). Finally, twin-specific environments may exist that contribute to the development of a phenotype. That is, twins (MZ and DZ) may be more similar than biological nontwin pairs because they share the same prenatal environment, are the same age, or any number of other reasons related to their 'twinness' (for example, twins may be treated more similarly than nontwin siblings). If there are twin-specific environments, the classical twin design may again be biased but this time in the opposite direction (i.e., an overestimation of c^2). Some studies have provided evidence of twin-specific environmental influence on phenotypes such as cognitive ability (Koeppen-Schomerus et al. 2003), psychoticism (Keller et al. 2005), and substance use (Rhee et al. 2003).

The adoption design offers an alternative method of testing environmental effects that is direct and avoids the assumptions of the classical twin design. It is not without its own limitations, however. One assumption that must be made is that families with adopted children are representative of all families. If there is restriction of range in adoptive homes on trait-relevant environmental factors such as socioeconomic status (McGue et al. 2007, Stoolmiller 1999), c^2 may be underestimated. Even if adoptive homes are not range restricted, adoptive families still may differ from nonadoptive families in trait-relevant ways. For example, Rueter et al. (2009) found that family interactions differed between adoptive and nonadoptive families such that greater family conflict was reported in adoptive families. If we compare results from adoption and twin designs and find that results converge on the same conclusions, we can have more confidence that our findings reflect the true etiology of personality. If results differ, however, additional research will be required to elucidate the true etiology.

A recent meta-analysis in a related domain, psychopathology (Burt 2009), included adoption and family studies in addition to twin studies. Burt found that despite previous consensus that the shared environment plays a minor role in the development of most disorders, shared environmental influences could actually explain 10-19% of the variance in specific internalizing and externalizing disorders. When she compared estimates of shared environmental influence across twin and adoption studies, she found that estimates did not differ for the most part. However, the c^2 estimate for anxiety disorders obtained from adoption studies was significantly larger than that obtained from twin studies. It should be noted that there were many more twin studies than adoption studies in the Burt (2009) review. Moreover, the typical adoption study in the review had a much smaller sample size than the typical twin study, suggesting that additional adoption studies, and especially adoption studies with relatively large samples, are needed. Importantly, this review suggested that methodology can affect results of behavior genetic studies; extension of this research to include normal-range variation in personality traits would likely result in obtaining a larger number of non-twin samples which may be used to test for method bias.

Beer et al. (1998) demonstrated that parameter estimates from studies of personality traits can differ by research design; they combined data from an earlier twin study on the MMPI

factor scales (Rose 1988) with their data from the Texas Adoption Project (TAP) to estimate the effects of genes and shared environment. They reported results across adoption-only, twins-only, and combined analyses. First, they reported estimates of shared environmental effects and heritability as calculated from correlations between different kinds of family members from the TAP (adoption only). Then, they used structural equation modeling so that they could make estimates based on both TAP data and data from the earlier twin study in one analysis (combined). Finally, they mentioned results from Rose (1988), who only reported Falconer estimates and did not use structural equation modeling in his analyses (twins only). Shared environmental effects on Religious Orthodoxy were strong ($c^2 > .25$) across all three analyses (adoption-only, twins-only, and combined), but results differed for other scales. Whereas estimates of shared environmental influence on the Extraversion, Intellectual Interests, and Masculinity-Femininity scales were substantial in the twins-only study, estimates neared zero when examining adoptive relatives. On the other hand, the estimate of genetic effects on the Inadequacy scale was smaller in the latter analyses and the parameter estimate for shared environment was larger ($\sim .1$). Although this study was advantaged by the fact that the same measure was used across samples (which is not always the case in meta-analyses), it was limited by the fact that parent-offspring and sibling pairs are not identical in age whereas twin pairs are identical in age. It is impossible to rule out age and generational effects as causes of discrepancies across studies rather than study design.

Perhaps a better demonstration that the results of biometrical studies may differ by design was recently published. Hahn and colleagues (2012) compared results from biometrical analyses of personality based on the classical twin design with results from a genetically sensitive multi-group design (GSMGD). The latter design incorporated information from independent groups of genetic relatives, including MZ and DZ twins, nontwin siblings, mother-child pairs, and grandparent-child pairs. Including these different kinds of relationships allowed them to concurrently test for nonadditive genetic and shared environmental influences on personality and also for cultural transmission and twin-specific environmental influences. They found that when they modeled twins only, an AE model fit best for FFM Neuroticism, Extraversion, Agreeableness, and Conscientiousness domains, and an ADE model fit best for Openness. However, results differed greatly when they used the GSMGD. They found that parameter estimates could be constrained to be equal across twins, nontwin siblings, and intergenerational pairs (IPs) for Extraversion and Neuroticism, but Agreeableness, Conscientiousness, and Openness could not be equated without significant loss of model fit. While Extraversion was best explained by an ADE model, an ACDE model fit best for Neuroticism with c^2 accounting for 7% of the variance. For Agreeableness and Conscientiousness, they found that shared environmental estimates could be constrained across siblings and IPs but not twins; estimates were zero for twins but were larger (15% and 12%, respectively) as calculated from nontwins. Additionally, they found that estimates of environmental influence on Openness could not be equated across twins, siblings, or IPs; the twin estimate of c^2 was still zero while the estimate from siblings was 7% and the estimate from IPs was 27%. Importantly, this study suggests that the inability to concurrently estimate c^2 and d^2 effects in the classical twin design is a serious limitation when used to investigate the etiology of personality because nonadditive genetic effects were evident in all traits and shared environmental effects were evident in most traits in this study. Additionally, results suggest that (for at least one domain) the inclusion of mother-child and grandparent-child pairs significantly influences the results of biometrical studies.

Unfortunately, many research groups lack the extended family data that were available to Hahn and colleagues (2012). Rhee and Waldman (2002) approached the question with meta-analysis; unlike Burt (2009), however, they went beyond simply comparing the parameter estimates produced by each study type. After combining results of 51 studies of antisocial

behavior, they examined the fit of a model in which parameters were free to vary across twin and adoption studies and a model in which parameters were constrained to be equal. They found a significant difference in model fit as well as more familial similarity in twin studies (as evidenced by higher genetic and shared environmental parameter estimates). However, this difference was due entirely to the parent-offspring adoption samples, as estimates from adopted sibling studies agreed with those from twin studies, suggesting that the source of the difference may be age or cohort rather than a fundamental difference between twin and adoption study designs. This finding underscores the concern of age and cohort differences as possible confounds in past studies. However, if pair differences in age are minimized in adoption studies (i.e., comparing siblings close in age rather than parent-offspring pairs), this approach appears well suited to assess the impact of study design on the results of biometrical analyses of normal as well as abnormal variation in personality.

In the current study, we sought to determine whether twin studies consistently produce estimates of c^2 effects that are lower than those produced from adoption studies. Additionally, because we can be more confident in our results when they converge across different methods of inquiry, we used both twin and adoption samples to estimate the effects of the shared environment on personality. We compared personality similarity between unrelated siblings, biological nontwin siblings, and both MZ and DZ twins without the inclusion of parent-offspring pairs, which has the advantage of eliminating the possibility of cohort effects. Furthermore, both samples consisted of participants in mid-late adolescence, making comparisons developmentally appropriate. Another advantage of the current study is that, unlike meta-analyses, samples were ascertained and assessed in a similar manner, including the use of the same personality inventory. We fitted models similar to Rhee and Waldman (2002) for each of the primary scales of the MPQ and, in order to increase our power to detect differences across methods and to assess whether such differences are systematic, we simultaneously estimated parameters for all MPQ scales and calculated the averages of these parameters. We then examined how ACE estimates compared across all primary scales based on twin-only, adoption-only, and combined samples of adolescents. Also, we wanted to know if twin-specific influences significantly impact personality, so we included them in the combined analyses. Finally, we included a dominance parameter in the model because the likelihood of nonadditive genetic influences on at least some personality traits is substantial, and as previously mentioned, the contribution of shared environmental influences can be underestimated in the presence of nonadditivity. Although it is possible that epistasis contributes significantly to nonadditive genetic influence on personality, our choice to model nonadditivity as dominance was based on our limited sample size. Eaves et al. (1998) emphasized the difficulty in distinguishing the different kinds of nonadditive gene action as sample sizes need to be quite large and include parent-offspring pairs, which our sample does not.

We hypothesized that, by utilizing sibling relationships beyond twins and by including a dominance parameter in our models, we would find evidence of nonadditive genetic effects on most personality traits and shared environmental effects on at least some traits in addition to additive genetic effects. Past research has suggested the possibility of c^2 influences on Agreeableness (Bergeman et al. 1993, Hahn et al. 2012), positive affect (Baker et al. 1992, Tellegen et al. 1988), and religiosity (Beer et al. 1998), so we expected to find c^2 influence on MPQ Alienation, Social Closeness, and Traditionalism scales due to their conceptual similarities to the former traits.

Method

Sample

The current study included two samples, a twin sample from the Minnesota Twin Family Study (MTFS) and a sample of biological and adoptive families from the Sibling Interaction and Behavior Study (SIBS). The MTFS is an ongoing longitudinal study of reared-together, same-sex twins and their parents. Its primary focus is to identify the genetic and environmental bases of substance abuse and related psychopathology. Twins were recruited at approximately ages 11 and 17 from publicly available Minnesota birth certificates. Participants were followed up approximately every three to four years through their 20s. At intake, approximately 83% of recruited families agreed to participate. Adoptive SIBS families were recruited from infant placements made by the three largest, private adoption agencies in Minnesota. Families were selected if they included an adopted adolescent between the ages of 11 and 21 who had been placed in the adoptive home permanently before age 2 ($M = 4.7$ months, $SD = 3.4$ months) and either another adopted or a biological adolescent no more than five years apart in age. Approximately 63% of recruited families agreed to participate at intake. Biological SIBS families were recruited through Minnesota state birth records and selected to have a pair of full siblings of comparable age and gender to the adoptive sibling pairs. At intake, about 57% of these families agreed to participate. SIBS participants were followed up approximately three and six years later. Participation rates for both the twin and adoption samples were greater than 90% at follow-up assessments. Exclusion criteria for both samples required living within a day's drive of Minneapolis and absence of any mental or physical handicap that would preclude completing the assessment. Additional information about the SIBS sample can be found in McGue et al. (2007), and additional information about the MTFS sample can be found in Iacono and McGue (2002).

For this analysis, follow-up 2 data from the 11-year-old twin cohort were combined with intake data from the 17-year-old twin cohort, as age was similar at these assessments (combined, $M = 17.96$ years, $SD = 0.92$). Resulting data included 984 complete MZ pairs (47% male), 545 complete DZ pairs (45% male), and 106 unmatched twins. The sample was representative of the demographics of Minnesota at the time such that the twins were primarily Caucasian (over 95%). SIBS data included in the analyses may have been collected from any of the three assessments to attain the maximum amount of data for both siblings. This is because personality data were not usually collected from participants younger than age 14. In addition, if participants had not yet reached the age of 16 at the assessment, they received a version of the MPQ that contained fewer scales (see below). No age cutoff was established for inclusion in the current analyses, but because of data collection practices, ages ranged from 10.9 to 23.9. However, most participants (75% and 100% of the adoption and twin samples, respectively) were over 16 at the time of assessment. To be more comparable, data were chosen from the same assessment for each member of the sibling pair. The assessment chosen for each pair depended on the data available. If full data (all scales) were available for both siblings at the first assessment then those data were included in the analyses. If not, the next assessment's data were considered and then the next. If no assessment included full data for both siblings, then incomplete data from the first assessment were included in the analyses. In most cases this meant that one or both of the siblings had partially missing data (the missing scales from the shortened version of the MPQ described below). In a few cases this meant that data were entirely missing for one sibling. Resulting data included 405 complete unrelated sibling pairs (44% male), 204 complete (49% male) biological nontwin pairs (combined ages, $M = 17.38$ years, $SD = 2.13$), and 5 unmatched siblings. Like the twin sample, over 95% of the biological nontwin

siblings were Caucasian. However, 74% of the adoptees were born outside of the United States (mainly South Korea), and 21% of the domestic adoptees were not Caucasian.

Measures

Personality was assessed with the 198-item version of the MPQ in participants 16 and older and with the 133-item Personality Booklet--Youth, Abbreviated (PBYA; developed specifically for the MTFS) in participants younger than 16. Items and scale composition are identical in these assessments, but the PBYA has fewer scales (scales included in this measure are identified in Table I). The MPQ is a self-report personality inventory derived from factor analysis. It measures 11 primary personality traits and three higher-order factors. The higher-order factors are thought to represent the behavioral and emotional regulation that contributes to particular traits; they include positive emotionality, negative emotionality, and constraint. This version of the MPQ and the PBYA include four answer choices where 1 = Definitely True, 2 = Probably True, 3 = Probably False, and 4 = *Definitely False*; many items are reverse-coded such that higher primary scale scores denote higher trait levels. Higher-order factors are not simple sums of different primary scale scores but rather are derived from specific algorithms that take into account all of the scales to some degree (see Tellegen & Waller 2008). However, scales are weighted to represent the most relevant scales most highly (e.g., Aggression, Alienation, and Stress Reaction have the heaviest weights in the calculation of Negative Emotionality). In the current study, the 11 primary scales and three higher-order factors were examined.

Analyses

Raw MPQ scale scores were adjusted for age and sex separately for twins and nontwins. This was accomplished by regressing scores on age and sex and using the residuals in the following analyses. Mx statistical software (Neale et al. 2002) was used to estimate correlations between siblings and to fit raw data to models with full-information maximum-likelihood estimation, which addresses missing data. Model fitting has the advantage of being able to simultaneously examine many samples and is thus ideal for the current study. When fitting models to raw data, parameters are freely estimated by minimizing minus twice the log-likelihood ($-2LL$), and the $-2LL$ of more restricted models are compared to this with a likelihood-ratio chi-square test of goodness of fit. For each individual scale, we compared the fit of an ACE model where all parameters were free to vary across twin and adoption samples with an ACE model where the standardized estimates a^2 and c^2 were constrained to be equal across samples. We also compared the fit of the model when the average standardized a^2 and c^2 estimates for the 11 scales were estimated freely versus constrained to be equal across the twin and adoption samples. A significant drop in model fit in the constrained model would indicate that the adoption and twin methods produce different parameter estimates. We included an estimate of twin-specific environmental effects in the combined analyses. Additionally, we fit an ACDE model to the combined data to obtain parameter estimates that more accurately reflect the contribution of shared environmental and nonadditive genetic influences to personality variation. Inspection of parameter estimates and their confidence intervals indicated significance of genetic and environmental effects.

Results

Means and variances were similar across the samples on all MPQ scales as well as age and can be viewed in Table I. An ANOVA identified differences across sibling type on eight scales and all three factor scores as statistically significant, but effect sizes were negligible for all but SP and TR; even in these cases, effects were very small (partial $\eta^2 < .02$). We suspected that the large presence of Asian adoptees in our sample (11.4%) might be

responsible for these differences, so we compared MPQ scores across ethnicity (including Native American, Black, Hispanic, and Other/Mixed as well as Asian and White). An ANOVA identified seven scales as statistically different across ethnicities, but effect sizes were negligible for all but two scales (again SP and TR) for which effect sizes were very small (all partial $\eta^2 < .02$). Sibling pair correlations were calculated for each scale, and these can be found in Table II. Upon examination of 95% confidence intervals, we determined that all twin correlations were statistically different from zero, with exception of the Control scale in DZ twins. Similarly, all biological non-twin sibling correlations were significant with exception of the Constraint, Control, and Social Potency scales. Alternatively, all adopted sibling correlations were not distinguishable from zero with exception of the Absorption, Alienation, Harm Avoidance, and Traditionalism scales. To address the possibility of an effect of ethnicity on SP and TR, we compared correlations between unrelated siblings of the same ethnicity ($N = 130$ pairs) with unrelated siblings of different ethnicities ($N = 72$ pairs); we found that correlations did not differ for either phenotype.

For each MPQ scale, we compared the fit of an ACE model in which the standardized parameters were freely estimated across twin and adoption samples to a reduced model in which standardized parameters were constrained across samples, increasing the degrees of freedom by two. As shown in Table III, model fit was not significantly reduced in the more parsimonious constrained model for the overall average across scales or for any individual scale except Control, $\Delta\chi^2(2) = 10.73$, $p = .005$. Thus, with one possible exception, results were similar regardless of study design. Table IV presents parameter estimates calculated from an ACE model of the adoption sample only, the twin sample only, and the combined twin and adoption sample (with twin-specific effects) for each scale as well as for the average across scales. Estimates of twin-specific effects were not different from zero for any scale. Finally, Table V gives parameter estimates from an ACDE model for all scales, including an estimate of total heritability. Estimates of additive genetic influences ranged from .00 to .43, but none were statistically significant (all 14 confidence intervals included zero). However, significant dominance effects were observed on the Absorption (.34 [.01, .44]), Achievement (.33 [.02, .49]), Constraint (.43 [.15, .53]), Control (.38 [.27, .43]), Harm Avoidance (.34 [.02, .46]), Social Closeness (.38 [.09, .49]), and Social Potency (.46 [.12, .53]) scales. Additionally, combined additive and nonadditive estimates were significant for all scales, ranging from .32 to .52. Significant shared environmental effects were observed on the Absorption (.15 [.03, .22]), Alienation (.10 [.01, .20]), Harm Avoidance (.14 [.04, .21]), and Traditionalism (.26 [.12, .34]) scales.

Discussion

When we included both additive and dominance genetic factors in the model, we did find evidence of d^2 influence on some traits, but we did not find evidence of significant a^2 influence on any personality trait. However, as Keller and Coventry (2005) pointed out, A and D are highly negatively correlated which makes their estimates imprecise when both are included in the model, and it is biologically implausible for dominance effects to exist without additive effects. Thus, we also estimated broad-sense heritability in these analyses. We have provided evidence for a moderate heritability of personality with combined additive and nonadditive estimates near .40, which are similar to those reported by Bouchard and McGue (2003) for FFM traits. Additionally, the current study indicates that for most traits, shared environment does not contribute significantly to the similarity between siblings. However, the best estimates of c^2 (using the combined sample and ACDE model) reached statistical significance on the scales of Absorption, Alienation, Harm Avoidance, and Traditionalism. Past research with the MPQ has not found these significant c^2 effects; while Tellegen and colleagues' (1988) estimates were similar to ours for Alienation and Traditionalism, they were not significantly different from zero. Likewise, Finkel and McGue

(1997) found no statistically significant evidence of c^2 effects on any scale. However, the sample size of Tellegen et al. was much smaller than that of the current study; it is possible that important shared environmental effects could not be detected due to lack of power. In the latter study, participants included parents, which makes it impossible to rule out generational effects.

In contrast, some research on related personality traits has produced significant c^2 estimates. Bergeman et al. (1993), for example, found significant shared environmental effects on FFM Agreeableness ($c^2 = .21$) where others have not (see Bouchard and McGue 2003); Hahn et al. (2012) also found a significant effect on Agreeableness ($c^2 = .15$) as well as on Conscientiousness ($c^2 = .12$), Openness ($c^2 = .07$), and Neuroticism ($c^2 = .07$). Church (1994) demonstrated that Agreeableness and MPQ Alienation shared variance to a moderate degree, so this research seems to support our findings. Additionally, Beer et al. (1998) found a large shared environmental component for the Religious Orthodoxy scale of the MMPI ($c^2 = .50$). This scale obviously relates to Traditionalism as those scoring high on this trait endorse high moral standards and religious values, though no study has directly compared these scales. Also, Loehlin and Gough (1990) reported significant shared environmental effects on the Norm Favoring vector of the California Psychological Inventory ($c^2 = .32$), which they described as assessing the acceptance of normative sanctions and correlating negatively with flexibility. Although no study has directly examined the relationship between Norm Favoring and Traditionalism, they seem conceptually similar.

Considering these studies, it appears that there may in fact be important shared environmental influences on the development of traits related to the way individuals behave within a social group. Agreeableness describes how individuals respond to others including how they react to conflict and to what extent they trust, cooperate with, and care for others, and thus refers to individual differences in social behavior. Tellegen and colleagues (1988) suggested that traits with an interactive and communicative nature may be more responsive to the social climate, which may explain why we have found evidence for a significant shared environmental influence on Agreeableness-related traits. It seems plausible, for example, that cooperative behavior is likely to evoke cooperative behavior from others such that individuals who experience cooperation consistently will be more likely to be consistently cooperative themselves. Individuals' ideas about what kinds of behaviors are socially acceptable may also be shaped in part by social learning as Altemeyer (1988) pointed out. In fact, social attitudes have at times been explicitly defined as learned. It seems reasonable that individuals' understanding of morality and ideal social behavior would be significantly impacted by culture and family rearing environment, especially when offspring still reside with their parents. Thus, it is not surprising that Traditionalism and related traits show significant shared environmental influence. We must of course be careful in our interpretation of such results, though, as these studies represent only a small slice of the behavioral genetic research that has been conducted in the last few decades. Furthermore, it is possible that assortative mating for these traits has driven up the c^2 estimate by inflating the DZ correlation. Bouchard and Loehlin (2001) pointed out that while research has shown assortative mating for personality to be relatively low in most cases, studies have uncovered substantial assortative mating for antisocial behavior and social attitudes, so we cannot rule this out as a possible explanation.

As previously discussed, behavior genetic research designs may be limited in generalizability and accuracy of results. This is because assumptions are required for each research design that, if violated, can significantly bias results. While the full extent to which this occurs remains unknown, we found that variance component estimates often converged across methodology. This occurred for 7 out of 11 primary scales, for all three factor scores, and for the average of scores across scales (see Table IV). However, it is clear that the

classic twin design is less sensitive to detecting shared environmental effects than is the adoption design. The twins-only analyses produced no significant c^2 results (though there were two nonzero estimates: Alienation and Traditionalism). In addition, the average c^2 estimate from the adoption sample was slightly larger than that of the twin sample (.10 vs. .07). This is not a large difference, but consider the fact that the adoption sample was much smaller than that of the twins. The power to detect small effects is more limited in a sample this size, yet estimates from the adoption-only analyses were nonzero for 11 of 14 MPQ scales (including four whose confidence intervals did not include zero). Larger adoption samples would be ideal for future research to clarify whether power is indeed an important limitation here. In any case, it is probably the classical twin design's inability to estimate both C and D effects simultaneously that accounted for some of the null effects. In the case of the Absorption scale, for example, the adoption-only analysis produced a substantial effect that the twins-only analysis did not; when adding a D parameter to the model with the combined sample, however, both nonadditive genetic and shared environmental effects were uncovered.

In the curious case of the Control scale, correlations among all sibling types except MZ twins were not significantly different from zero. Biometrical modeling of this scale with an adoption design therefore attributed all variance to the nonshared environment while modeling with a twin design attributed variance to nonadditive genetic and nonshared environmental influences, which directly reflects the MZ correlation. When we fit the ACDE model to this scale, we found that all genetic influence on Control could be attributed to dominance with no additive effects. The finding of a significant contribution of nonadditive effects is not unexpected as Tellegen and colleagues (1988) also found evidence of nonadditivity on Control. Additionally, Finkel and McGue (1997) found significant nonadditive genetic influence on nearly all MPQ scales; interestingly, however, the effect on the Control scale was significant only for men in their study ($d^2 = .45$).

Another important consideration regarding discrepancies across studies is age. In the current study, participants were all adolescents living at home. Because of this, shared environmental effects may be larger than those in other studies where siblings do not live together. For example, many of the studies cited by Bouchard and McGue (2003) sampled either adults or a mixture of adults and adolescents and did not find significant shared environmental effects. Conversely, other researchers have also utilized samples of adults or families and found shared environmental effects anyway (Baker et al. 1992, Beer et al. 1998, Bergeman et al. 1993, Hahn et al. 2012, Tellegen et al. 1988), and Loehlin et al. (1998) sampled high school juniors (who were very similar in age to the current sample) and did not find evidence of such effects. In addition, Hopwood et al. (2011) found that estimates did not change from adolescence to early adulthood in a longitudinal sample derived from the twin sample used in the current study, even though participants would have moved out of their parents' homes between assessments. Thus, it is difficult to say with certainty whether age (or residing within the same home) significantly contributes to the results of personality studies. Future research should explore this question further.

Yet another important consideration is whether the multidimensional nature of personality constructs greatly influences results. We may be able to elucidate the true nature of genetic and environmental influences on traits by considering narrower definitions of them (i.e., by examining facet-level traits rather than domains). It could be the case that some aspects of trait domains share an underlying component that is significantly influenced by shared environmental factors whereas other aspects of those domains are more genetically influenced. To investigate this possibility, it is possible to partition variance of traits into common, specific, and error components and then model the genetic and environmental contributions to each type of trait variance. A handful of studies have done such an analysis

(Heath et al. 1989, Jang et al. 2002, Jang et al. 1998, Johnson and Krueger 2004, Kandler et al. 2010). Results of these studies suggested that common variance is moderately to highly heritable (40 – 70%) and not significantly influenced by shared environmental factors. Despite the latter finding, specific variance of some facet-level traits did show significant influence of shared environmental factors in some of these studies. Kandler and colleagues (2010) found that a substantial portion of variance in NEO-PI-R facets Gregariousness (E), Openness to Values (O), Altruism (A), Tender-mindedness (A), and Competence (C) could be explained by shared environment; in fact, shared environmental influences accounted for 89% of the specific variance in Altruism and Tender-mindedness. This is in stark contrast to the 0% estimate of shared environmental influence on other facets of Agreeableness, such as Straightforwardness and Compliance. Similarly, Jang et al. (1998) found that Altruism (A), Modesty (A), Achievement Striving (C), and Deliberation (C) were substantially influenced by shared environment while other facets of Agreeableness and Conscientiousness were not. The evidence of shared environmental influence on Openness to Values and the Agreeableness facets are interesting in light of findings in the current study; it appears there is some corroboration of the importance of shared environment in the development of Traditionalism and Alienation that we observed in our sample. Future research could investigate whether or not the shared environmental factors that influence Traditionalism and Alienation are the same as those that influence the specific variance of FFM traits.

In summary, we found evidence for shared environmental influence on four personality traits measured by the MPQ, and we did not find evidence that methodology significantly influences the results of biometrical analyses of personality. However, we did demonstrate that the inability of the classical twin design to estimate both shared environmental and nonadditive genetic effects can hide c^2 influences due to their contrasting effects on DZ correlations (the case of the Absorption scale). In order for us to have confidence that a research finding is a true reflection of reality, we must replicate that finding across different measures, samples, and study designs. An advantage of the adoption design used here is that it bypasses the assumptions and limitations of the classical twin design. It directly estimates shared environmental influence on personality with the correlations among nonbiological family members because they do not share (segregating) genes but they do share a common environment. Of course, it too has its own limitations as previously discussed. Despite the advantages and disadvantages of each respective design, results have converged on the same conclusion: shared environment does not significantly influence most personality traits, but it may be important for traits related to Absorption, Alienation, Harm Avoidance, and Traditionalism.

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Table I

Descriptive statistics of MPQ scores and age.

	MZs		DZs		Bio Sibs		Adopt Sibs	
	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N
AC^a								
Males	49.70 (7.83)	948	49.85 (8.42)	512	48.82 (8.47)	157	47.30 (8.74)	251
Females	48.15 (8.62)	1070	48.11 (8.11)	618	49.73 (8.40)	174	49.15 (9.05)	327
SC^a								
Males	52.60 (7.34)	952	52.48 (8.17)	514	52.11 (8.13)	157	53.70 (8.24)	253
Females	56.38 (8.48)	1074	54.72 (8.94)	618	56.62 (7.93)	175	55.02 (9.14)	328
SP^a								
Males	45.83 (7.82)	951	46.42 (7.80)	513	48.62 (8.10)	157	47.68 (8.23)	253
Females	44.85 (8.45)	1071	45.37 (8.36)	615	47.51 (8.50)	174	47.91 (9.32)	328
WB								
Males	54.82 (7.18)	949	55.34 (7.24)	511	56.23 (7.99)	202	55.61 (7.94)	354
Females	55.93 (8.56)	1069	55.12 (8.12)	615	56.82 (7.92)	213	56.10 (8.21)	460
AG								
Males	41.88 (8.95)	950	41.13 (9.25)	512	42.37 (10.04)	202	42.12 (9.94)	353
Females	34.37 (9.11)	1072	34.20 (8.93)	617	33.95 (8.78)	214	34.72 (8.87)	461
AL								
Males	35.53 (8.31)	951	36.31 (8.46)	513	35.02 (9.41)	202	35.55 (8.58)	354
Females	34.64 (9.15)	1072	34.95 (8.90)	617	33.80 (8.51)	214	34.17 (8.92)	459
SR								
Males	41.26 (8.69)	949	41.39 (8.66)	513	39.45 (9.24)	202	39.98 (8.65)	354
Females	44.06 (9.58)	1070	45.43 (9.24)	617	42.93 (9.70)	214	44.05 (9.29)	461
CN								
Males	46.74 (6.98)	951	46.55 (7.58)	512	45.51 (8.57)	202	45.18 (8.20)	353
Females	48.08 (7.88)	1069	47.69 (8.33)	616	47.93 (7.36)	213	47.99 (8.79)	460
HA								
Males	42.78 (9.48)	951	42.73 (9.72)	511	41.78 (10.12)	202	44.91 (10.68)	352
Females	50.17 (10.09)	1070	48.96 (10.2)	619	47.65 (10.66)	214	48.97 (10.46)	460
TR^a								
Males	50.88 (6.79)	943	50.46 (6.89)	507	49.41 (8.06)	157	48.02 (6.96)	253
Females	52.15 (7.04)	1064	51.35 (7.11)	610	51.76 (7.35)	173	49.55 (7.33)	325
AB^a								
Males	42.02 (8.83)	949	42.73 (9.32)	512	43.75 (8.83)	157	42.82 (9.43)	253
Females	42.58 (9.85)	1072	43.89 (9.17)	614	43.53 (10.07)	173	44.05 (9.20)	328
PEM								
Males	123.30 (12.23)	939	124.46 (12.56)	504	125.43 (12.66)	157	122.96 (13.92)	251
Females	122.72 (14.58)	1055	122.37 (13.34)	603	126.38 (13.70)	170	124.22 (13.66)	324
NEM								

	MZs		DZs		Bio Sibs		Adopt Sibs	
	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N
Males	89.86 (13.63)	939	90.18 (13.82)	504	88.39 (15.62)	157	88.18 (14.36)	251
Females	87.27 (14.99)	1055	88.67 (13.88)	603	85.04 (13.01)	170	87.08 (14.09)	324
CON								
Males	129.72 (14.74)	939	129.68 (15.31)	504	125.69 (17.42)	157	125.45 (16.28)	251
Females	138.08 (16.10)	1055	136.45 (16.54)	603	136.54 (15.49)	170	135.11 (17.61)	324
Age								
	17.93 (0.91)	2030	18.02 (0.93)	1134	17.62 (1.97)	416	17.25 (2.20)	815

Note. AC = Achievement, SC = Social Closeness, SP = Social Potency, WB = Well Being, AG= Aggression, AL = Alienation, SR = Stress Reaction, CN = Control, HA= Harm Avoidance, TR = Traditionalism, AB = Absorption, PEM = Positive Emotionality, NEM = Negative Emotionality, CON = Constraint.

^aThese scales are not included in the PBYA (version of MPQ given to participants below age 16).

Table II

MPQ correlations (95% Confidence Interval) between sibling pairs by group.

	MZs	DZs	Bio Sibs	Adopt Sibs
AC	.44 (.41-.47)	.11 (.02-.18)	.23 (.04-.34)	-.03 (-.21-.09)
SC	.42 (.38-.45)	.11 (.03-.18)	.29 (.13-.39)	-.02 (-.20-.10)
SP	.50 (.47-.52)	.12 (.04-.19)	.17 (-.02-.28)	.01 (-.17-.13)
WB	.50 (.47-.52)	.20 (.12-.26)	.22 (.09-.31)	.00 (-.11-.09)
AG	.50 (.47-.52)	.23 (.15-.28)	.27 (.15-.36)	.09 (-.01-.17)
AL	.50 (.47-.52)	.32 (.26-.37)	.25 (.12-.33)	.12 (.01-.19)
SR	.43 (.40-.46)	.18 (.10-.24)	.17 (.02-.26)	.06 (-.05-.15)
CN	.37 (.34-.41)	.05 (-.05-.12)	-.05 (-.25-.08)	-.04 (-.16-.06)
HA	.52 (.49-.54)	.23 (.16-.29)	.34 (.23-.41)	.15 (.06-.22)
TR	.58 (.55-.60)	.36 (.31-.41)	.37 (.24-.45)	.25 (.13-.33)
AB	.49 (.46-.52)	.22 (.14-.28)	.28 (.13-.37)	.17 (.03-.27)
PEM	.53 (.50-.56)	.22 (.14-.28)	.31 (.13-.41)	.02 (-.18-.15)
NEM	.49 (.45-.51)	.21 (.12-.27)	.27 (.08-.38)	.08 (-.10-.19)
CON	.52 (.49-.54)	.20 (.11-.26)	.19 (-.03-.32)	.14 (-.04-.26)

Note. AC = Achievement, SC = Social Closeness, SP = Social Potency, WB = Well Being, AG= Aggression, AL = Alienation, SR = Stress Reaction, CN = Control, HA= Harm Avoidance, TR = Traditionalism, AB = Absorption, PEM = Positive Emotionality, NEM = Negative Emotionality, CON = Constraint.

Table III

Fit statistics when ACE estimated separately and constrained equal in twin and adoption samples.

Phenotype	-2LL	DF	AIC	$\Delta\chi^2 (2)$	p
AC					
Free	28484.80	4041	20402.80	.06	.97
Constrained	28484.86	4043	20398.86		
SC					
Free	28550.59	4057	20436.59	1.73	.42
Constrained	28552.32	4059	20434.32		
SP					
Free	28377.06	4048	20281.06	.27	.83
Constrained	28377.33	4050	20277.33		
WB					
Free	30190.67	4359	21472.67	.60	.74
Constrained	30191.27	4361	21469.27		
AG					
Free	31432.32	4367	22698.32	2.58	.28
Constrained	31434.91	4369	22696.91		
AL					
Free	31086.41	4368	22350.41	1.82	.40
Constrained	31088.23	4370	22348.23		
SR					
Free	31561.67	4367	22827.67	1.31	.52
Constrained	31562.98	4369	22824.98		
CN					
Free	30285.48	4362	21561.48	10.73	.005
Constrained	30296.21	4364	21568.21		
HA					
Free	32259.60	4365	23529.60	4.99	.08
Constrained	32264.59	4367	23530.59		
TR					
Free	26662.61	4015	18632.61	1.89	.39
Constrained	26664.50	4017	18630.50		
AB					
Free	29304.75	4044	21216.75	4.25	.12
Constrained	29309.00	4046	21217.00		
PEM					
Free	31767.76	3989	23789.76	.78	.68
Constrained	31768.53	3991	23786.53		
NEM					
Free	32287.41	3989	24309.41	1.28	.53
Constrained	32288.69	3991	24306.69		

Phenotype	-2LL	DF	AIC	$\Delta\chi^2 (2)$	p
CON					
Free	33170.41	3989	25192.41	4.22	.12
Constrained	33174.63	3991	25192.63		
Average					
Free	307182.75	44613	217956.75	4.79	.09
Constrained	307187.54	44615	217957.54		

Note. -2LL = -2 log likelihood, DF = degrees of freedom, AIC = Akaike Information Criterion, Free = a model where variance components are estimated separately for the twin sample and adoption sample, Constrained = a model where variance component estimates are constrained to be equal across samples, AC = Achievement, SC = Social Closeness, SP = Social Potency, WB = Well Being, AG= Aggression, AL = Alienation, SR = Stress Reaction, CN = Control, HA= Harm Avoidance, TR = Traditionalism, AB = Absorption, PEM = Positive Emotionality, NEM = Negative Emotionality, CON = Constraint.

Table IV

Standardized biometric parameter estimates (95% Confidence Interval) for each MPQ scale estimated by an ACE model for each research design: adoption-only, twin-only, or twin-adoption.

	a^2	c^2	e^2	t^2
AC				
Adoption-only	.47 (.07-.79)	.00 (.00-.10)	.53 (.21-.90)	-
Twin-only	.43 (.35-.47)	.00 (.00-.06)	.57 (.53-.62)	-
Twin-Adoption	.43 (.36-.47)	.00 (.00-.04)	.57 (.53-.62)	.00 (.00-.06)
SC				
Adoption-only	.65 (.24-.94)	.00 (.00-.11)	.35 (.06-.72)	-
Twin-only	.41 (.35-.46)	.00 (.00-.04)	.59 (.54-.64)	-
Twin-Adoption	.42 (.35-.47)	.00 (.00-.04)	.58 (.53-.64)	.00 (.00-.04)
SP				
Adoption-only	.36 (.00-.72)	.02 (.00-.16)	.63 (.28-.99)	-
Twin-only	.47 (.41-.52)	.00 (.00-.05)	.53 (.48-.57)	-
Twin-Adoption	.47 (.41-.52)	.00 (.00-.05)	.53 (.48-.58)	.00 (.00-.05)
WB				
Adoption-only	.37 (.04-.67)	.03 (.00-.13)	.59 (.33-.88)	-
Twin-only	.49 (.39-.54)	.00 (.00-.09)	.51 (.46-.55)	-
Twin-Adoption	.49 (.40-.53)	.00 (.00-.07)	.51 (.47-.56)	.00 (.00-.09)
AG				
Adoption-only	.37 (.05-.67)	.10 (.00-.19)	.54 (.29-.81)	-
Twin-only	.49 (.39-.54)	.00 (.00-.09)	.51 (.46-.55)	-
Twin-Adoption	.44 (.34-.53)	.05 (.00-.13)	.51 (.47-.56)	.00 (.00-.07)
AL				
Adoption-only	.23 (.00-.54)	.09 (.01-.19)	.68 (.42-.92)	-
Twin-only	.40 (.23-.54)	.10 (.00-.25)	.50 (.46-.55)	-
Twin-Adoption	.41 (.32-.51)	.08 (.01-.16)	.51 (.46-.55)	.07 (.00-.20)
SR				
Adoption-only	.24 (.00-.55)	.05 (.00-.15)	.71 (.45-.96)	-
Twin-only	.42 (.31-.47)	.00 (.00-.10)	.58 (.53-.63)	-
Twin-Adoption	.42 (.31-.47)	.00 (.00-.08)	.58 (.53-.63)	.00 (.00-.11)
CN				
Adoption-only	.00 (.00-.17)	.00 (.00-.04)	1.00 (.83-1.00)	-
Twin-only	.36 (.30-.41)	.00 (.00-.04)	.64 (.59-.70)	-
Twin-Adoption	.34 (.28-.39)	.00 (.00-.02)	.66 (.61-.72)	.00 (.00-.07)
HA				
Adoption-only	.36 (.05-.66)	.14 (.04-.23)	.50 (.26-.77)	-
Twin-only	.52 (.41-.56)	.00 (.00-.09)	.48 (.44-.53)	-
Twin-Adoption	.43 (.34-.53)	.08 (.01-.16)	.49 (.44-.53)	.00 (.00-.05)
TR				
Adoption-only	.15 (.00-.53)	.26 (.12-.38)	.59 (.30-.80)	-

	a^2	c^2	e^2	t^2
Twin-only	.44 (.28-.60)	.14 (.00-.28)	.42 (.38-.46)	-
Twin-Adoption	.38 (.28-.49)	.19 (.09-.28)	.43 (.39-.47)	.00 (.00-.12)
AB				
Adoption-only	.23 (.00-.61)	.17 (.03-.30)	.60 (.30-.86)	-
Twin-only	.49 (.37-.53)	.00 (.00-.10)	.51 (.47-.56)	-
Twin-Adoption	.42 (.30-.52)	.07 (.00-.16)	.52 (.47-.56)	.00 (.00-.07)
PEM				
Adoption-only	.65 (.21-.96)	.01 (.00-.15)	.34 (.04-.72)	-
Twin-only	.52 (.40-.56)	.00 (.00-.11)	.48 (.44-.52)	-
Twin-Adoption	.53 (.42-.57)	.00 (.00-.09)	.47 (.43-.52)	.00 (.00-.08)
NEM				
Adoption-only	.35 (.00-.74)	.08 (.00-.21)	.57 (.26-.91)	-
Twin-only	.47 (.35-.51)	.00 (.00-.10)	.53 (.49-.58)	-
Twin-Adoption	.45 (.33-.51)	.02 (.00-.12)	.53 (.49-.58)	.00 (.00-.09)
CON				
Adoption-only	.10 (.00-.54)	.14 (.00-.27)	.75 (.41-.95)	-
Twin-only	.52 (.44-.56)	.00 (.00-.06)	.48 (.44-.53)	-
Twin-Adoption	.51 (.41-.56)	.00 (.00-.09)	.49 (.44-.53)	.00 (.00-.07)
Average				
Adoption-only	0.32	0.10	0.59	
Twin-only	0.40	0.07	0.54	
Twin-Adoption	0.37	0.09	0.54	

Note. AC = Achievement, SC = Social Closeness, SP = Social Potency, WB = Well Being, AG= Aggression, AL = Alienation, SR = Stress Reaction, CN = Control, HA= Harm Avoidance, TR = Traditionalism, AB = Absorption, PEM = Positive Emotionality, NEM = Negative Emotionality, CON = Constraint, a^2 = additive genetic effects, c^2 = shared environmental effects, e^2 = nonshared environmental effects, t^2 = twin-specific effects.

Table V

Standardized biometric parameter estimates of an ACDE model (95% Confidence Interval) for each MPQ scale estimated from the combined sample.

	a^2	c^2	d^2	e^2	h^2
AC	.11 (.00 – .41)	.00 (.00 – .08)	.33 (.02 – .49)	.56 (.51 – .61)	.44 (.34 – .49)
SC	.06 (.00 – .34)	.00 (.00 – .08)	.38 (.09 – .49)	.56 (.51 – .61)	.44 (.34 – .49)
SP	.01 (.00 – .36)	.02 (.00 – .10)	.46 (.12 – .53)	.51 (.47 – .56)	.47 (.37 – .53)
WB	.21 (.00 – .52)	.03 (.00 – .13)	.26 (.00 – .51)	.50 (.46 – .55)	.47 (.36 – .54)
AG	.12 (.00 – .49)	.10 (.00 – .18)	.28 (.00 – .46)	.50 (.46 – .55)	.40 (.30 – .51)
AL	.31 (.00 – .51)	.10 (.01 – .19)	.09 (.00 – .40)	.50 (.46 – .55)	.40 (.29 – .51)
SR	.11 (.00 – .45)	.05 (.00 – .13)	.27 (.00 – .45)	.57 (.52 – .62)	.38 (.28 – .47)
CN	.00 (.00 – .10)	.00 (.00 – .02)	.38 (.27 – .43)	.62 (.57 – .68)	.38 (.32 – .43)
HA	.04 (.00 – .43)	.14 (.04 – .21)	.34 (.02 – .46)	.48 (.43 – .52)	.38 (.30 – .49)
TR	.07 (.00 – .47)	.26 (.12 – .34)	.25 (.00 – .39)	.42 (.38 – .46)	.32 (.22 – .47)
AB	.00 (.00 – .41)	.15 (.03 – .22)	.34 (.01 – .44)	.51 (.46 – .55)	.34 (.25 – .47)
PEM	.43 (.00 – .57)	.01 (.00 – .15)	.09 (.00 – .48)	.47 (.43 – .52)	.52 (.37 – .57)
NEM	.11 (.00 – .50)	.08 (.00 – .18)	.28 (.00 – .47)	.53 (.48 – .58)	.40 (.28 – .51)
CON	.00 (.00 – .35)	.09 (.00 – .17)	.43 (.15 – .53)	.47 (.43 – .52)	.43 (.34 – .55)

Note. AC = Achievement, SC = Social Closeness, SP = Social Potency, WB = Well Being, AG= Aggression, AL = Alienation, SR = Stress Reaction, CN = Control, HA= Harm Avoidance, TR = Traditionalism, AB = Absorption, PEM = Positive Emotionality, NEM = Negative Emotionality, CON = Constraint, a^2 = additive genetic effects, c^2 = shared environmental effects, d^2 = dominance effects, e^2 = nonshared environmental effects, h^2 = total heritability.