Heritability of the Big Five Personality Dimensions and Their Facets: A Twin Study

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ABSTRACT The genetic and environmental etiology of the five-factor model of personality as measured by the revised NEO Personality Inventory (NEO-PI-R) was assessed using 123 pairs of identical twins and 127 pairs of fraternal twins. Broad genetic influence on the five dimensions of Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness was estimated at 41%, 53%, 61%, 41%, and 44%, respectively. The facet scales also showed substantial heritability, although for several facets the genetic influence was largely nonadditive. The influence of the environment was consistent across all dimensions and facets. Shared environmental influences accounted for a negligible proportion of the variance in most scales, whereas nonshared environmental influences accounted for the majority of the environmental variance in all scales.

The five-factor approach has emerged as possibly the most widely accepted model of personality structure (Digman, 1990; Goldberg, 1993). The popularity of this approach is attributable to its parsimony and

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heuristic value in unifying personality structure and to the robustness of the structure across different languages and inventories (Amelang & Borkenau, 1982; Birenbaum & Montag, 1986; Bond, Nakazato, & Shiraishi, 1975). The five factors have been referred to by several different labels, with the most popular labels coming from McCrae and Costa's (1985, 1987) investigations: Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness. These or similar factors have been reported by a number of authors (e.g., Trapnell & Wiggins, 1990), but not by others (e.g., Eysenck, 1991, 1992), which has generated a considerable body of research and controversy.

Recently, researchers have attempted to establish the underlying etiological structure of the five dimensions by decomposing observed trait variance into genetic and environmental components (see Plomin, Defries, & McClearn, 1990). The principal genetic effects are additive, symbolized by the heritability coefficient, h^2, indicating the extent to which parents and offspring genetically resemble one another, and nonadditive effects due to dominance (d^2) when two genes at the same locus on a homologous chromosome interact. Environmental variance is routinely decomposed into shared environmental factors (c^2), those features that distinguish the general environment of one family from another, e.g., gross paternal income, and nonshared environmental factors (e^2), reflecting differences in experiences of siblings from the same home, e.g., differential parental treatment.

Loehlin (1992) estimated the genetic and environmental components on each of the five dimensions and obtained results typical of other self-report personality scales. Total genetic effects accounted for approximately 30% to 50% of the variance in all scales, shared environment accounted for no more than 10%, and the greatest variance was attributed to nonshared environmental influences and error. Nonadditive genetic effects were also detected for all five dimensions, the median effect being 14%. Bouchard's (1994) review of twin studies of personality also reported similar estimates. Both Loehlin (1992) and Bouchard (1994) adopted a meta-analytic approach that computed the heritability estimates on several different personality scales administered to twins during the past two decades. Furthermore, the personality scales were arranged in accordance with the five-factor framework. This arrangement was necessary because the NEO-PI (Costa & McCrae, 1985), arguably the most popular direct measure of the five dimensions, has received limited attention from behavioral geneticists. This is unfortunate, because the NEO-PI not only provides a direct measure of the

five broad dimensions but also includes measures of the facets defining Neuroticism, Extraversion, and Openness. In addition, recent revision to the scale (NEO-PI-R; Costa & McCrae, 1992) includes facet scales for Agreeableness and Conscientiousness.

The one published behavioral genetic analysis of the NEO-PI only evaluated three dimensions: Openness, Conscientiousness, and Agreeableness (Bergeman et al., 1993). Two samples were examined: twins reared apart and twins reared together. The monozygotic (MZ) and dizygotic (DZ) twins reared apart correlated .43 and .23, respectively, for Openness, .15 and −.03 for Conscientiousness, and .19 and .10 for Agreeableness. For MZ and DZ twins reared together, the correlations were slightly higher: for Openness, .51 and .14, for Conscientiousness, .41 and .23, and for Agreeableness, .47 and .11, respectively. Total genetic influences estimated using model fitting techniques accounted for 40%, 12%, and 29% of the variance for Openness, Agreeableness, and Conscientiousness, respectively. Dominance effects comprised the total genetic effect for Agreeableness and Conscientiousness. Shared environmental effects accounted for only 6%, 21%, and 11% of the variance for Openness, Agreeableness, and Conscientiousness, whereas nonshared environmental effects accounted for 54%, 67%, and 60% of the variance, respectively. The observation of relatively large common environmental effects and small genetic effects in the case of Agreeableness is inconsistent with the results of earlier studies of similar dimensions (Tellegen et al., 1988) and differs from the results observed for most personality traits, which typically show heritability estimates of about 40%. Examination of the genetic effects for the facets defining Agreeableness may shed light on this discrepancy, but the facet scores were not examined by Bergeman et al. (1993).

This article reports the results of a twin study designed to estimate the magnitude of the additive and nonadditive genetic and shared and nonshared environmental influences underlying each broad dimension and each dimension's defining facets as measured by the NEO-PI-R.

METHOD

Participants

Participants were volunteer twin pairs recruited from the Vancouver area, British Columbia, Canada, through newspaper advertisements and media stories (see also Livesley, Jang, Jackson, & Vernon, 1993). Twin pairs were eligible for participation if they were 16 years old or over and raised together

in the same home. Participants consisted of 123 monozygotic twin pairs (85 sister pairs and 38 brother pairs; mean age = 30.9 years, *SD* = 11.8, range = 16 to 68 years) and 127 dizygotic twin pairs (71 sister pairs, 18 brother pairs, 38 sister-brother pairs; mean age = 31.7 years, *SD* = 11.7, range = 16 to 68 years). Zygosity was determined by questionnaire (Kasriel & Eaves, 1976; Nichols & Bilbro, 1966).

Measures

Twin pairs completed the NEO-PI-R, Form S (Costa & McCrae, 1992) as part of a battery of questionnaires at home, a common methodology for general population twin studies (e.g., Baker & Daniels, 1990). Participants were instructed to complete the questionnaire independently of one another in a distraction-free setting. The NEO-PI-R contains 240 items that yield dimension scores for Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness. Each dimension is composed of six defining facet scales: Anxiety, Angry Hostility, Depression, Self-Consciousness, Impulsiveness, and Vulnerability for Neuroticism; Warmth, Gregariousness, Assertiveness, Activity, Excitement Seeking, and Positive Emotions for Extraversion; Fantasy, Aesthetics, Feelings, Actions, Ideas, and Values for Openness; Trust, Straightforwardness, Altruism, Compliance, Modesty, and Tender-Mindedness for Agreeableness; and Competence, Order, Dutifulness, Achievement, Self-Discipline, and Deliberation for Conscientiousness.

Heritability estimation. The distributions of each facet and scale score were examined for departures from normality. Square root or natural logarithmic transformations were performed where necessary to obtain adequate symmetry. McGue and Bouchard (1984) demonstrated that because monozygotic and same-sex dizygotic pairs share gender and age, any similarity between these twins will be spuriously increased if gender and age effects are present for the variable in question. One correction for this possible bias is to conduct gender-by-genotype analyses (see Neale & Cardon, 1992). These analyses were not possible in the present study because of the small number of male dizygotic and opposite-sex dizygotic twin pairs available to us. Instead, the effects of gender and age were removed prior to heritability estimation by computing the standardized residual scores from the simultaneous multiple regression of each of the dimensions on age and gender as suggested by McGue and Bouchard (1984).

Covariances and Pearson *r*s were computed between co-twins separately for MZ and DZ twins using the computer program PRELIS 2 (Jöreskog & Sörbom, 1993a), and univariate genetic structural equation models (Neale & Cardon, 1992) were fit to the covariances by maximum likelihood estimation procedures using the computer program LISREL 8 (Jöreskog & Sörbom,

1993b). The purpose of these analyses was to estimate the variance in each NEO-PI-R scale attributable to additive genetic factors (A), shared environmental factors (C), and nonshared environmental factors (E). Nonadditive (dominance) genetic factors (D) were also estimated for scales where these effects were indicated by a ratio of the MZ correlation to the DZ correlation greater than two (see Plomin, Chipuer, & Loehlin, 1990). It is not possible to estimate simultaneously all four A, D, C, and E effects with data obtained from reared-together twins because it would result in underidentification of the univariate genetic structural equation models. A model is underidentified if the number of free parameters is greater than the number of different statistics that it predicts (Neale & Cardon, 1992, p. 105). The similarity (r) of reared-together twins is attributable to only three distinct parameters: shared additive and nonadditive genetic influences (for MZs: A + D effects; DZs: $\frac{1}{2}$A + $\frac{1}{4}$D effects) and common environment (C). Note that nonshared environmental effects (E) are not estimated directly but are simply the residual variance after the effects of A, D, and C have been removed. Thus, data from twins reared together are short one distinct parameter to uniquely estimate all four A, D, C, and E effects.

Goodness-of-fit was assessed with χ^2 and Akaike's Information Criterion (AIC = $\chi^2 - 2\,df$; Akaike, 1987). The latter yields a superior indication of fit in models with few parameters (Bollen, 1989). Statistical significance of the effect size attributable to A, D, C, or E was tested by comparing the χ^2 obtained from the full ACE or ADE model against the χ^2 obtained from a reduced model that systematically sets a component of variance in the full model to zero. Three reduced models were tested to determine (*a*) if any C effects were significant ("AE" model); (*b*) if the effects of A were significant ("CE" model); or (*c*) if the effects of E alone ("E" model) could account for the phenotypic variance. The AIC criterion was used to decide between models that both fit the data adequately based on the chi-square criterion. In addition to the statistical criteria, an additional requirement was that the best-fitting model should also explain the data with the fewest number of parameters. The standardized maximum likelihood parameter estimates from the best-fitting model were squared to provide the h^2, d^2, e^2, and c^2 estimates.

RESULTS

The sample means and standard deviations (Table 1) of the raw dimensions and facet scores based on twin individuals by gender are comparable to the male and female norms reported in Costa and McCrae (1992). Age and gender effects were significant ($p < .05$) for most scales, but they accounted for only a small proportion of the variance (r^2_{ADJUSTED} range: .001 to .191, median .034). Significant mean

Table 1
Means and Standard Deviations by Gender for the Dimensions and Facets of the Revised NEO Personality Inventory (NEO-PI-R)

	Males[a]		Females[b]	
Dimension and facets	Mean	*SD*	Mean	*SD*
Neuroticism	82.61	22.21	89.39	23.62
Anxiety	14.43	5.08	18.80	5.40
Angry Hostility	13.21	5.04	13.61	5.22
Depression	13.23	5.66	14.49	6.03
Self-Consciousness	15.11	4.77	16.21	5.07
Impulsiveness	16.70	4.20	16.95	4.44
Vulnerability	9.93	4.34	11.34	4.62
Extraversion	111.07	18.79	113.90	18.71
Warmth	21.67	4.23	23.61	4.00
Gregariousness	16.69	5.08	17.60	5.23
Assertiveness	15.48	4.96	14.71	5.23
Activity	17.81	4.23	18.27	4.32
Excitement Seeking	18.78	4.97	17.97	5.36
Positive Emotions	20.65	4.82	21.74	4.91
Openness	116.58	16.82	117.20	20.52
Fantasy	18.39	4.56	18.27	5.43
Aesthetics	18.93	5.39	19.54	5.76
Feelings	21.31	4.15	21.95	4.22
Actions	15.97	3.31	16.84	3.97
Ideas	20.17	5.20	18.45	5.65
Values	21.81	4.24	22.15	4.05
Agreeableness	119.47	19.92	127.97	16.96
Trust	20.17	4.44	21.42	4.65
Straightforwardness	20.57	5.01	22.65	4.84
Altruism	23.26	3.87	25.03	3.45
Compliance	17.29	4.68	18.48	4.70
Modesty	17.47	4.89	18.88	4.23
Tender-Mindedness	20.71	3.94	21.50	3.93
Conscientiousness	116.51	19.96	118.87	20.57
Competence	21.37	3.67	21.47	3.91
Order	18.07	4.37	18.85	4.82
Dutifulness	21.83	4.50	22.21	4.57
Achievement Striving	18.11	4.38	18.19	4.63

Table 1
Continued

Dimension and facets	Males[a]		Females[b]	
	Mean	*SD*	Mean	*SD*
Self-Discipline	20.17	4.65	20.74	5.06
Deliberation	16.95	4.52	17.43	4.71

a. $N = 150$ male twin individuals.
b. $N = 250$ female twin individuals.

differences due to zygosity were not detected on any scale ($p \geq .05$, two-tailed t test).

The MZ and DZ twin correlations and estimates of additive and nonadditive genetic and shared and nonshared environmental effects for the five dimensions and 30 facet traits are presented in Table 2. Pearson correlations for the MZ twins exceeded those for the DZ twins for all scales except Modesty and Self-Discipline; this suggests a genetic influence on most NEO-PI-R scales. For several scales the magnitude of the correlations for MZ twins was greater than twice that of the DZ twins, indicating that a proportion of the overall or broad genetic influence could be due to dominance effects.

Goodness-of-fit statistics are presented in Table 3. For all scales, either the full ACE or ADE model provided a satisfactory fit to the data by χ^2. The shared environmental component could be removed from the full ACE model without a significant increase in χ^2 for all but two facets, Modesty and Self-Discipline, indicating that only these facets have significant shared environmental components. A nonshared environment alone model (E-only model) did not provide an adequate account of the variance in any scale. Nonadditive genetic effects were observed for Openness and for the facets Angry Hostility, Warmth, Assertiveness, Excitement Seeking, Aesthetics, Ideas, Compliance, and Tender-Mindedness. Genetic variance was not required to explain the phenotypic variance on Feelings, Modesty, Order, Self-Discipline, and Deliberation.

Estimates of heritability and environmental effects based on the best-fitting model determined by AIC are presented in Table 2. Total genetic influences accounted for 41%, 53%, 61%, 41%, and 44% of the variance in Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness, respectively. Genetic dominance effects were only substantial

Table 2
Twin Correlations and Heritability Estimates of the Revised NEO Personality Inventory (NEO-PI-R) Dimensions and Facets

Dimension and facets	r_{MZ}	r_{DZ}	h^2	SE_A	d^2	SE_D	c^2	SE_C	e^2	SE_E
Neuroticism	.41	.18	.41	.06					.59	.04
Anxiety	.26	.13	.26	.08					.74	.05
Angry Hostility	.37	−.01			.33	.07			.67	.05
Depression	.33	.14	.31	.07					.69	.05
Self-Consciousness	.38	.19	.38	.06					.62	.04
Impulsiveness	.36	.21	.36	.07					.64	.04
Vulnerability	.45	.17	.44	.06					.56	.04
Extraversion	.55	.23	.53	.05					.47	.04
Warmth	.43	.14			.43	.06			.57	.05
Gregariousness	.56	.19	.52	.05					.48	.04
Assertiveness	.42	.10			.42	.06			.58	.05
Activity	.29	.14	.29	.07					.71	.05
Excitement Seeking	.42	.02			.41	.06			.59	.05
Positive Emotions	.38	.24	.39	.06					.61	.04
Openness	.58	.21			.61	.05			.39	.04
Fantasy	.32	.22	.34	.07					.66	.05
Aesthetics	.60	.14			.57	.05			.43	.04
Feelings	.44	.35					.39	.05	.61	.03
Actions	.42	.21	.44	.06					.56	.04
Ideas	.53	.09			.52	.06			.48	.04
Values	.49	.27	.51	.06					.49	.04
Agreeableness	.41	.26	.41	.06					.59	.04
Trust	.27	.21	.30	.07					.70	.05
Straight-forwardness	.47	.17	.47	.06					.53	.04
Altruism	.34	.18	.34	.07					.66	.05
Compliance	.33	.10			.34	.07			.66	.05
Modesty	.30	.36					.33	.06	.67	.04
Tender-Mindedness	.41	.15			.45	.06			.55	.04
Conscientiousness	.37	.27	.44	.06					.56	.04
Competence	.37	.13	.34	.07					.66	.05

Table 2
Continued

Dimension and facets	r_{MZ}	r_{DZ}	h^2	SE_A	d^2	SE_D	c^2	SE_C	e^2	SE_E
Order	.25	.23					.24	.07	.76	.04
Dutifulness	.42	.23	.44	.06					.56	.04
Achievement Striving	.41	.18	.42	.06					.58	.04
Self-Discipline	.30	.37					.34	.06	.66	.04
Deliberation	.26	.18					.23	.07	.77	.04

Note. *N*s = 123 monozygotic (MZ) pairs, 127 dizygotic (DZ) pairs; heritability estimates are based on the squared maximum-likelihood parameter estimates from the best-fitting model by AIC (Akaike's Information Criterion; Akaike, 1987); SE_A, SE_D, SE_C, and SE_E are the standard errors of the maximum-likelihood parameter estimates for additive genetic, nonadditive genetic, shared environmental, and nonshared environmental components of variance, respectively.

for Openness, and shared environmental effects were negligible for all five dimensions. The largest proportion of environmental variance for all five dimensions was attributable to nonshared environmental effects, which ranged from 39% to 59%.

For some dimensions, the type of genetic effect varied across facets. The greatest consistency was observed for the Neuroticism facets, all of which were affected in a similar way by genetic and environmental factors except Angry Hostility, for which additive genetic effects were small. The magnitude of the additive genetic components on three Extraversion facets ranged from 29% to 52%, whereas nonadditive effects ranged between 41% and 43% for the remaining three facets. Among the Openness facets, additive genetic effects were detected on three facets, Fantasy, Actions, and Values, ranging from 34% to 51%, whereas two facets, Aesthetics and Ideas, were largely influenced by nonadditive genetic effects, estimated at 57% and 52%, respectively. The variance in the remaining facet, Feelings, could be accounted for by environmental factors alone. The six Agreeableness facets also showed a somewhat mixed etiology. The genetic component for Compliance and Tendermindedness was largely nonadditive at 34% and 45%, respectively, and genetic effects were not significant for Modesty. Additive effects were detected on Trust, Straightforwardness, and Altruism (30%, 47%, and 34%, respectively). The etiology of the Conscientiousness facets was also mixed, with the variance in Order, Self-Discipline,

Table 3
Model-Fitting Chi-Square Goodness-of-Fit Statistics

	Parameters in model[a,b]		
Dimensions and facets	ACE/ADE ($df = 3$)	AE ($df = 4$)	CE ($df = 4$)
Neuroticism	0.01	0.11	0.70
Anxiety	1.48	1.48	2.59
Angry Hostility[c]	2.79	4.95	2.79
Depression	0.19	0.27	0.58
Self-Consciousness	0.86	0.86	4.19
Impulsiveness	1.65	1.83	3.14
Vulnerability	0.92	1.20	1.40
Extraversion	6.96	7.22	8.00
Warmth[c]	0.52	1.29	0.64
Gregariousness	6.34	6.69	7.02
Assertiveness[c]	0.16	1.47	0.16
Activity	1.78	1.84	2.18
Excitement Seeking[c]	4.58	7.93	4.58
Positive Emotions	2.23	2.55	3.77
Openness[c]	1.52	3.04	1.90
Fantasy	0.00	0.46	0.71
Aesthetics[c]	1.36	3.84	1.38
Feelings[d]	0.34	2.14	1.65
Actions	5.17	5.25	6.17
Ideas[c]	1.48	4.76	1.48
Values	5.89	5.89	12.33*
Agreeableness	7.31	7.82	8.86
Trust	5.08	5.38	5.72
Straightforwardness	0.46	0.81	0.93
Altruism	7.07	7.26	8.98
Compliance[c]	4.76	5.23	4.79
Modesty[d]	1.23	5.84	1.23
Tender-Mindedness[c]	2.32	3.25	2.44
Conscientiousness	3.98	4.13	6.60
Competence	2.29	2.51	2.59
Order[d]	3.37	4.35	3.95
Dutifulness	2.03	2.03	6.28
Achievement Striving	1.33	1.61	1.88

Table 3
Continued

	Parameters in model[a,b]		
Dimensions and facets	ACE/ADE ($df = 3$)	AE ($df = 4$)	CE ($df = 4$)
Self-Discipline[d]	2.58	7.09	2.58
Deliberation[d]	4.75	5.07	5.06

a. A = additive genetic effects; D = nonadditive genetic effects; C = shared environmental effects; E = nonshared environmental effects.
b. Goodness-of-fit statistics not shown for E-only models because all were significant ($p < .05$). The best-fitting model by AIC (Akaike's Information Criterion; Akaike, 1987) is the AE-only model, except where noted.
c. ADE model.
d. CE model.
*$p < .05$.

and Deliberation being largely accounted for by shared and nonshared environmental factors. Additive influences on the remaining three facets ranged from 34% to 44%.

DISCUSSION

The broad estimates of genetic influence on the five factors measured directly by the NEO-PI-R are similar to those reported by Loehlin (1992) based on indirect measures of the five dimensions. The Neuroticism scale of the NEO-PI-R yielded a broad heritability of 41%, an estimate identical to that presented by Loehlin's (1992) estimate of the Neuroticism scale from the Eysenck Personality Questionnaire (EPQ; Eysenck & Eysenck, 1975). Our estimate of the broad heritability of Extraversion is 53%, paralleling Loehlin's estimate of 49%. Several other studies of twins reared apart and twins reared together have found considerable evidence for genetic nonadditivity on this dimension (Heath, Eaves, & Martin, 1989; Pedersen, Plomin, McClearn, & Friberg, 1988). These effects were also found in the present data, although they were only significant at the facet level. Our estimates of the heritability of Agreeableness and Conscientiousness are also consistent with Loehlin's, at 41% versus 35% and 44% versus 38%, respectively. In the case of Openness, however, our estimates differ substantially from Loeh-

lin's. We estimated the broad heritability of this dimension at 61%, with the variance being largely attributable to nonadditive genetic effects. Loehlin, however, reports the broad heritability at 45%, with nonadditive effects comprising only 2%, which is corroborated by Bouchard (1994). This difference may reflect the different way Openness was measured. Openness is the domain for which the greatest differences in interpretation exist (Goldberg, 1993), and the Openness scale of the NEO-PI-R may assess different behaviors from those assessed in the scales reported by Loehlin (1992).

Although our estimates of the heritability of most dimensions compare closely with those reported by Loehlin (1992), there are substantial differences between our estimates and those reported in Bergeman et al. (1993). The discrepancies for Openness, Agreeableness, and Conscientiousness might be due to the age differences between the two samples. The estimates reported in Bergeman et al. are based on samples drawn from the Swedish Adoption/Twin Study on Aging (SATSA), which had a mean age of 59 years, whereas our sample was considerably younger with a mean age of 31 years. Bergeman et al. report the broad genetic influence on Openness, Agreeableness, and Conscientiousness as 40%, 12%, and 29%, respectively. Shared environmental influences were reported to be 6%, 21%, and 11%, and nonshared environmental influences were 54%, 67%, and 60%, respectively. Our estimates were based on age-corrected data. In order to compare the effects of age on these three dimensions, we reestimated heritability on our data uncorrected for age. Broad heritability was estimated at 58%, 37%, and 45%; shared environmental effects were 0%, 7%, and 2%; and nonshared environmental effects were 42%, 56%, and 53%, for Openness, Agreeableness, and Conscientiousness, respectively. Although cross-sectional in design, the comparison of the samples suggests that the influence of the environment on Openness, Agreeableness, and Conscientiousness increases with age.

As noted earlier, a novel finding in the present data is the greater evidence for nonadditive effects than reported by Loehlin (1992). There are several possible explanations for this difference. First, twin data typically have low power to detect reliable nonadditive genetic effects (see Plomin, Defries, & McClearn, 1992). It is possible, therefore, that the nonadditive effects detected in the present data will not be replicated in another sample, so the present results should be considered tentative. Second, some of the very low DZ twin correlations may be due to "contrast effects," in which the shared environment of twins

may cause twins to be dissimilar rather than similar. The presence of these effects may be tested by reestimating the genetic path models on a variable that is influenced by significant shared environmental effects so that these influences are set to operate in opposite directions for each twin of a pair. Contrast effects are present if the sign of the parameter estimate is different in the two models (see Loehlin, 1992). In the present data, however, the presence of contrast effects is difficult to test because only five of the NEO-PI-R facets show any evidence of shared environmental influence. As such, we reiterate that the present results are tentative until replicated. Third, the nonadditive genetic effects detected here may be spurious because of the inclusion of opposite-sex DZ twins in our analyses. The correlations between these twins are smaller than those computed on the same-sex DZ twins, which will reduce the overall DZ correlation when they are pooled. To test this possibility, the model-fitting analyses were repeated using same-sex DZ data only, which produced very similar best-fitting model estimates of h^2, d^2, e^2, and c^2.

Estimates of genetic and environmental effects observed in this study are in the range typically reported for other self-report measures of personality, irrespective of the scales' underlying theoretical basis. The analyses of the facet scales, however, provides additional information on the genetic basis of personality that is not apparent when the broad dimensions are examined. Our results suggest that genetic and environmental effects are not uniform across all facets of a dimension. For example, our data suggest that not all facets of Conscientiousness are influenced to the same degree by genetic factors. Individual differences in Order, Self-Discipline, and Deliberation appear to be largely determined by environmental influences. The implication is that some of the broad dimensions may not be etiologically homogeneous. The results of even more detailed analyses, such as the item level analyses of Heath et al. (1989) of the EPQ, may be fruitful and reveal additional information about the genetic structure of personality. If this tentative general finding is replicated on a larger sample, it may provide a different perspective on the structure of personality and help resolve some of the controversies surrounding the number of broad dimensions required to conceptualize personality (e.g., Zuckerman, 1992; Zuckerman, Kuhlman, & Camac, 1988).

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