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A Genetic and Environmental Analysis of the California Psychological Inventory Using Adult Twins Reared Apart and Together

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Abstract

The California Psychological Inventory (CPI) was administered to a sample of 71 pairs of monozygotic and 53 pairs of dizygotic twins reared apart (MZA, DZA, adult twins) and 99 pairs of monozygotic and 99 pairs of dizygotic twins reared together (MZT, DZT, adult male twins). The twin reared apart data was age and sex corrected. The twin reared together data represented one sex and a narrow age range and was not standardized. The CPI was scored using the 1996 scoring keys, for its 20 folk scales, three vector scales, and 11 special purpose scales. The correlations for the four groups were subjected to model-fitting and the following four parameters estimated: (i) additive genetic variance (V_a), (ii) dominance variance (V_d), (iii) shared environmental variance (V_c), and (iv) idiosyncratic environmental variance (V_e). This design has considerable power to detect V_c. The average estimate of V_c for all variables was essentially zero. The average estimate of genetic influence ($V_a + V_d$) for all variables was 0.46. Consistent with these results either the MZT or the MZA correlations alone would have provided quite good estimates of the heritability of the traits. Measures of contact between the twins reared apart were unrelated to twin similarity. These findings are highly consistent with the larger behavior genetic literature on genetic and environmental influences on personality. A mean spousal

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correlation of 0.20 for the 34 scales based 111 pairs suggests that there is only modest assortative mating for the CPI scales. © *1998 John Wiley & Sons, Ltd.*

INTRODUCTION

The California Psychological Inventory (CPI; Gough, 1996), one of the most widely used psychological assessment instruments (Aiken, 1997), has been analyzed in a number of previous behavioral genetic studies of personality (Bouchard and McGue, 1990; Gottesman, 1996; Horn, Plomin and Rosenman, 1976; Loehlin, 1986; Loehlin and Nichols, 1976; Nichols, 1966). When averaged across studies, heritability estimates for the CPI scales are remarkably consistent and very similar to those obtained with other personality measures. For example, Loehlin and Nichols (1976) in a sample of 490 reared together monozygotic (MZT) and 317 reared together dizygotic (DZT) high school twin pairs found average twin correlations of 0.49 and 0.29 for the MZT and DZT samples, respectively. Horn *et al.* (1976) in a sample of 99 pairs each of MZT and DZT middle aged male twins reported average twin correlations of 0.44 and 0.19 for the MZT and DZT samples, respectively. Although the adult twins in the study of Horn *et al.* (1976) had lived apart for an average of 25 years they were only a little less similar than the adolescent twins in the study of Loehlin and Nichols (1976). Bouchard and McGue (1990) reported age- and sex-corrected intraclass correlations of 0.45 and 0.18 for an adult sample of monozygotic and dizygotic twins reared apart (MZA and DZA), figures virtually identical to those of Horn *et al.* (1976).

Twin studies with the CPI are similar to the results of a meta-analysis of the twin personality data presented by Nichols (1978), as well as to model fitting of reared-apart and reared-together twin data for the Multidimensional Personality Questionnaire (MPQ) (Tellegen, Lykken, Bouchard, Wilcox, Segal and Rich, 1988) and findings with the Eysenck Personality Questionnaire (Eaves, Eysenck and Martin, 1989). Bouchard (1997) recently reviewed the behavior genetic literature on personality.

In the current study we report a biometric analysis of the CPI in a sample which combines the reared-together male twins from the study of Horn *et al.* (1976) with the reared-apart twins from the Minnesota Study of Twins Reared Apart (MISTRA). The MISTRA sample has nearly doubled in size since the previous report by Bouchard and McGue (1990). In addition to the new standard scales we report findings for the new vector scales and the special purpose scales described in the most recent CPI manual (Gough, 1996).

Loehlin and Gough (1990) reported estimates of heritability, shared environmental influence, and nonshared environmental influence on the vector scales based on the adolescent twin sample from the National Merit Twin Study. Their findings are of interest because, while Vector 1 (Internality) and Vector 3 (Self-Realization) yielded results that are typical for personality scales, heritabilities of 0.66 and 0.58 with virtually no shared family environmental influence, Vector 2 (Norm-Favoring) yielded a heritability of only 0.18 and a shared environmental component of 0.32. This shared environmental component is by far one of the largest reported for a personality variable from a twin study with a large sample

size. Loehlin and Gough (1990) suggest, however, that their results may not generalize to adult twins who have lived apart for many years. Our data will allow a test of that speculation.

METHOD

Subjects

The samples of twins come from two independent studies. The reared-apart monozygotic (MZA) and dizygotic (DZA) twins are from MISTRA. They participated in that study between 1979 and 1997. Bouchard and McGue (1990) previously reported CPI results for a subset of this sample. The twin sets in the present reared-apart sample include 37 same-sex dizygotic (SS-DZA) pairs, 16 opposite-sex dizygotic (OS-DZA) pairs, 43 female MZA pairs, and 28 male MZA pairs. Except for one MZA pair, whose zygosity was established by physical similarity, twin zygosity was established serologically with blood group antigens and protein markers throughout most of the study, but supplemented by DNA polymorphisms most recently. Lykken (1978) has shown that methods like those used in MISTRA result in a misclassification rate of less than 0.001.

Descriptive statistics for age, three measures of contact/separation, and percentage of females for the reared-apart twins are given in Table 1.

Table 1. Means and standard deviations for age, measures of contact, and percentage of females for MZA and DZA twins

	Age (years)	Time together prior to separation (days)	Time apart (separation to first reunion) (years)	Total contact time (weeks)	% females
MZA ($N = 71$)					
Mean	40.17	156.89	30.45	94.44	61
SD	12.99	261.26	15.05	191.00	
DZA ($N = 53$)					
Mean	45.64	336.75	41.77	52.11	62
SD	13.41	437.51	13.59	61.44	

Note: MZA, monozygotic twins reared apart; DZA, dizygotic twins reared apart. One male MZA triplet set entered as three sets. One reared-apart triplet set (two MZA females and one male) entered as one MZA pair and two DZA sets. The DZA sample includes a total of 16 unlike-sex sets.

Most of the reared-apart twins were between 30 and 55 years of age when assessed. The analysis is restricted to cases over 17 years of age in order to maintain an adult sample. On average, the MZA twins were assessed about ten years after they met and the DZA twins were studied about 4 years after they first met. Some twin pairs were reunited in Minneapolis when they came to participate in the study, and a good number were assessed within a few months of their reunion.

The reared-together twins from the study of Horn *et al.* (1976) were identified through the twin registry maintained by the Medical Follow-Up Agency of the

National Research Council (Jablon, Neel, Gershowitz and Atkinson, 1967). The twins were all males between 45 and 55 years of age, and had been living apart for about 25 years. Loehlin (1985) has reported other behavior genetic analyses of the CPI involving this sample in conjunction with other kinships.

Measures

Both studies used the 480-item form of the CPI. The items and direction of scoring for the scales were provided by Harrison Gough, author of the CPI. All the scales are described in the 1996 manual (Gough, 1996).

Analytical procedures

Analysis of the influence of separation and contact

The similarity of twins reared apart has sometimes been asserted to be due to contact between the twins (Faber, 1981). Reared-apart twin studies are not truly randomized experiments because the twins vary in their degree of separation and their degree of contact. As indicated in Table 1, the reared-apart twins were separated at various ages and had varying degrees of contact prior to participation in the MISTRA assessment. The separation/contact measures in Table 1 were based on detailed interviews with both twins and a review of available records. The influence of these variables was evaluated by correlating each measure with twin pair absolute differences on the CPI scales. If twin contact accounts, at least in part, for twin similarity, then twin pair differences should be negatively correlated with indices of time spent together and positively correlated with time spent apart. Because of the large number of comparisons we limited this analysis to the folk and vector scales.

Age-and sex-correction of measures

As the existence of age and sex effects can bias the analysis of twin similarity (McGue and Bouchard, 1984), raw scores on the CPI for the reared-apart twin sample were corrected for age, age^2, and age $\times$ sex and age^2 $\times$ sex using the regression procedures described by McGue and Bouchard (1984) and standardized to a mean of zero and standard deviation of one. The standardization sample consisted of the MZA and DZA twins as well as their spouses and a few additional relatives and friends of the twins who participated in MISTRA ($N = 419$). Individual age data was not available for the sample of Horn *et al.* (1976), but the age range was small and corresponded roughly to the average age of the reared-apart twin sample.

Twin intraclass correlations

Twin intraclass correlations were computed for the MZA and DZA twins using the standard formula $r = (\text{MSB} - \text{MSW})/(\text{MSB} + \text{MSW})$, where MSB and MSW are, respectively, the mean squares between and within twin pairs derived from a one-way ANOVA.

Model-fitting

The quantitative genetic model used in this study assumes that observed phenotypic variance (V_p) is a linear function of additive genetic (V_a), dominance (V_d), shared environmental (V_c), and nonshared environmental (V_e) variances. Symbolically,

$$V_p = V_a + V_d + V_c + V_e$$

From the quantitative genetic theory, we can derive the expected covariance between any two relatives as a function of the variance components given above. The expected covariances between the MZA and DZA twin pairs will be

$$\mathrm{COV}_{(\mathrm{MZA})} = V_a + V_d$$

$$\mathrm{COV}_{(\mathrm{DZA})} = 0.5V_a + 0.25V_d$$

For twins reared together the expected covariances will be,

$$\mathrm{COV}_{(\mathrm{MZT})} = V_a + V_d + V_c$$

$$\mathrm{COV}_{(\mathrm{DZT})} = 0.5V_a + 0.25V_d + V_c$$

The general assumptions in the model are that (i) there is no genotype–environment correlation or interaction, (ii) genetic effects include both additive effects and dominance effects, (iii) mating is random with regard to the traits under study, (iv) no selective placement of reared-apart twins on trait relevant factors has occurred, and (v) shared environmental influences are the same in MZT and DZT twins. We test the assumption of random mating below. Extensive discussions of the other assumptions in behavioral genetic designs are available elsewhere (Bouchard, Lykken, McGue, Segal and Tellegen, 1990; Bouchard and McGue, 1990; Plomin, DeFries and McClearn, 1990). For reasons discussed below we have analyzed the correlations rather than the covariances.

The correlations for the reared-apart and reared-together twins were fit using a maximum likelihood estimation procedure in Mx (Neale, 1995). We fit an ADCE model for each scale; additive variance (V_a), dominance variance (V_d), shared environmental variance (V_c), and nonshared environmental variance plus measurement error (V_e).

RESULTS

Descriptive statistics

The means and standard deviations based on the raw scores for the samples as well as the spouses of the twins reared apart are shown in Table 2.

The means and standard deviations for all groups are reasonably comparable to normal adult samples of the same sex, as reported in the new CPI manual. The MZA and DZA twins, who are mostly adoptees, are also similar to the spouses who have been recruited in a similar way and not adopted. There are, however, significant differences between the means and variances of the four groups, which makes is unreasonable to attempt to fit the variances in a combined analysis. The reared-apart versus reared-together comparison yielded 32 significant mean difference ($p \leqslant 0.05$)

Table 2. Means and standard deviations of the scales of the California Psychological Inventory for MZA, DZA, MZT, and DZT twins and spouses of reared-apart twins

Scales	MZA $N = 71$	DZA $N = 53$	MZT $N = 99$	DZT $N = 99$	Spouses of reared-apart twins $N = 111$
Folk scales					
Dominance	20.2 (6.9)	18.6 (7.0)	22.8 (6.2)	21.8 (6.4)	18.9 (6.9)
Capacity for status	15.6 (4.0)	14.3 (5.2)	16.5 (3.9)	15.9 (3.8)	14.9 (4.7)
Sociability	20.6 (5.0)	18.0 (5.9)	20.7 (5.0)	19.4 (5.5)	18.7 (5.2)
Social presence	24.7 (5.4)	22.3 (5.5)	24.4 (5.0)	23.8 (4.6)	23.2 (4.9)
Self-acceptance	16.4 (4.6)	14.4 (4.8)	16.7 (4.2)	15.7 (4.4)	14.7 (4.3)
Independence	16.4 (4.3)	15.1 (5.0)	18.1 (3.5)	17.7 (3.5)	16.1 (4.7)
Empathy	20.3 (4.8)	18.4 (5.7)	20.2 (4.6)	18.9 (4.1)	19.0 (5.2)
Responsibility	23.2 (4.9)	23.4 (5.6)	26.3 (4.2)	26.9 (4.2)	24.4 (5.0)
Socialization	29.2 (6.0)	28.5 (6.2)	32.4 (4.8)	32.5 (4.6)	31.4 (5.2)
Self-control	20.6 (7.1)	21.1 (6.1)	23.5 (5.9)	25.0 (5.6)	23.5 (5.3)
Good impression	19.0 (6.7)	18.4 (6.0)	20.5 (5.8)	21.9 (5.7)	20.5 (5.6)
Communality	34.7 (2.3)	34.8 (2.5)	35.7 (2.1)	35.7 (2.0)	34.8 (2.6)
Well-being	30.0 (5.5)	28.5 (6.2)	33.2 (4.2)	33.4 (3.5)	31.1 (4.7)
Tolerance	20.7 (5.3)	20.3 (5.8)	21.9 (4.3)	21.9 (4.1)	21.7 (5.4)
Achievement via conformance	24.9 (5.0)	24.5 (5.4)	27.9 (4.4)	27.8 (4.4)	26.2 (4.7)
Achievement via independence	20.7 (5.5)	20.1 (6.5)	22.2 (5.1)	22.1 (5.0)	21.3 (6.3)
Intellectual efficiency	27.3 (5.2)	26.3 (6.5)	29.8 (4.7)	29.3 (4.6)	28.1 (5.7)
Psychological-mindedness	15.1 (3.7)	14.4 (3.8)	16.7 (3.2)	16.5 (3.1)	15.6 (4.1)
Flexibility	13.1 (4.2)	11.6 (4.7)	11.5 (4.4)	10.9 (4.2)	11.9 (4.7)
Femininity/masculinity	18.3 (5.0)	18.6 (4.8)	14.2 (2.9)	14.4 (3.1)	17.5 (4.7)
Vector scales					
V1 Internality	17.4 (7.3)	19.3 (6.4)	17.6 (6.8)	19.7 (6.6)	20.4 (6.6)
V2 Norm-favoring	21.3 (5.3)	21.3 (5.1)	23.2 (4.6)	24.0 (5.0)	22.5 (5.3)
V3 Self-realization	34.5 (8.8)	32.6 (10.3)	36.3 (8.1)	36.3 (8.3)	34.8 (10.0)
Special purpose scales					
Managerial potential	19.5 (5.8)	18.2 (6.1)	22.5 (5.4)	22.1 (5.4)	20.1 (6.4)
Work orientation	28.3 (5.6)	27.4 (5.9)	32.3 (4.1)	32.6 (3.8)	30.4 (4.4)
Creative temperament	20.1 (5.3)	19.1 (6.7)	19.1 (5.8)	18.0 (5.3)	19.2 (5.9)
Leadership potential	45.9 (9.6)	42.6 (11.6)	51.7 (8.6)	50.3 (8.6)	45.8 (10.0)
Amiability	22.1 (6.8)	21.1 (6.0)	25.7 (5.2)	26.7 (4.4)	24.6 (5.2)
Law enforcement orientation	24.3 (4.1)	23.8 (3.7)	26.8 (3.9)	27.4 (3.9)	24.2 (4.1)
Tough-mindedness	21.6 (5.8)	20.4 (6.1)	25.8 (4.7)	25.3 (4.8)	22.6 (5.8)
Baucom scale for masculinity	33.4 (9.4)	29.9 (9.9)	39.7 (7.4)	38.3 (7.5)	32.8 (9.6)
Baucom scale for femininity	29.3 (7.2)	29.5 (5.2)	29.2 (4.5)	29.6 (3.8)	30.5 (5.5)
Anxiety	5.8 (2.3)	6.5 (2.6)	4.8 (2.0)	4.8 (1.7)	5.4 (2.0)
Narcissism	23.1 (8.0)	22.7 (6.8)	21.7 (7.0)	20.1 (6.7)	20.7 (6.1)

out of 38 comparisons. In addition, in all instances the reared-apart twins have larger variances than the reared-together twins. Only eight of the 38 comparisons did not attain statistical significance. The comparison of MZ versus DZ twins yielded four significant variance differences and 12 significant mean differences. All of these differences were modest in magnitude. Because of the significant differences that

resulted from the above comparisons we modeled the correlations rather than the covariances.

Analysis of the influence of separation and contact

For all 124 reared-apart pairs, across the 20 folk scales, the average correlations for the three measures of contact (see Table 1) were 0.04, 0.01, and −0.06. Of the sixty correlations only one (0.23, between Time apart and Socialization differences scores) was statistically significant. If the analysis is restricted to the 71 pairs of MZA twins, we find average correlations of 0.04, 0.04, and −0.04 for the folk scales with three of 60 correlations reaching statistical significance: Total contact time with Self-control difference scores (0.24), Time together prior to separation with Communality differences scores (0.40), and Time together prior to separation with Well-being difference scores (0.25). While these significant correlations are not trivial in magnitude, in every case, the sign of the correlation is opposite that expected if pair contact contributed to twin pair similarity. Moreover, the correlation between Time apart and Socialization differences scores found in the larger sample dropped to 0.04 in the MZA sample, and none of the correlations of contact time with the vector scale difference scores were statistically significant in either group. There is thus no consistent evidence that all or part of reared-apart twin similarity could be attributed to the extent to which these twins were in contact with one another.

Genetic analysis

Table 3 gives the twin intraclass and spousal correlations for the 20 CPI standard scales, the three vector scales, and the 11 special purpose scales.

For the 20 folk scales the mean correlations for the MZA and MZT twins are 0.46 and 0.47, while the mean correlation is 0.27 for DZA and 0.18 for DZT twins. The mean correlation for the SS-DZA twins is 0.18 ($N = 37$ pairs), and virtually identical to the SS-DZT group, but the mean correlation for the OS-DZA twins is 0.50 ($N = 16$ pairs), and unexpectedly higher than the mean correlation for the same-sex reared-apart twins. The mean OS-DZA correlation for the vector ($r = 0.26$) and special purpose ($r = 0.48$) scales is also higher than the mean SS-DZA correlation for these scales (0.02 and 0.04 respectively). Because we did not, *a priori*, expect differences in OS-DZA and SS-DZA correlations, we analyzed the combined DZA sample here.

The three vector scales give slightly different results than the standard scales, with the MZA twins being more similar than the MZT twins (0.47 versus 0.41), and the mean DZA correlations being slightly lower than the mean DZT correlations (0.10 versus 0.17). The MZT correlation for Vector 2 (0.18) is the lowest of any of the CPI scales for that group. The DZA correlation of −0.22 for Vector 2 should perhaps best be interpreted as zero. It is the most extreme negative correlation for any scale and we have found in the twins reared-apart study that as the sample sizes increase negative DZA correlates tend to converge on zero (cf. the data in this report with Bouchard and McGue, 1990).

The special purpose scales yield mean correlations for the MZA and MZT groups comparable to the correlations for the folk scales. The mean DZA and DZT correlations are, however, both somewhat lower than they are for the folk scales (0.16 and 0.10 versus 0.27 and 0.18).

Table 3. Intraclass correlations for the scales of the California Psychological Inventory for MZA, DZA, DZT, and MZT twins and spouses of twins reared apart

	MZA $N = 71$	DZA $N = 53$	MZT $N = 99$	DZT $N = 99$	Spouses of reared-apart twins $N = 111$
Folk scales					
Dominance	46	12	49	26	05
Capacity for status	57	47	54	20	51
Sociability	38	33	41	16	22
Social presence	45	38	58	17	23
Self-acceptance	54	20	46	23	15
Independence	30	15	50	17	22
Empathy	50	50	54	05	26
Responsibility	54	40	41	34	31
Socialization	56	28	48	21	19
Self-control	61	−04	47	08	00
Good impression	54	−13	41	11	01
Communality	33	06	24	01	04
Well-being	49	18	56	04	20
Tolerance	43	43	53	15	25
Achievement via conformance	50	32	42	12	13
Achievement via independence	51	49	54	27	51
Intellectual efficiency	45	56	55	32	41
Psychological-mindedness	30	51	42	29	42
Flexibility	32	15	55	14	27
Femininity	51	13	29	20	−07
Mean	46	27	47	18	22
Vector scales					
V1 Internality	46	18	58	21	13
V2 Norm-favoring	41	−22	18	08	14
V3 Self-realization	55	34	46	22	28
Mean	47	10	41	17	18
Special purpose scales					
Managerial potential	55	28	58	16	31
Work orientation	54	21	55	10	12
Creative temperament	50	29	76	12	34
Leadership potential	47	29	51	18	30
Amiability	64	24	69	13	12
Law enforcement orientation	28	−03	22	20	28
Tough-mindedness	45	13	42	12	17
Baucom scale for masculinity	53	20	50	09	20
Baucom scale for femininity	62	22	72	08	11
Anxiety	26	−01	30	−25	09
Narcissism	53	−02	45	11	03
Mean	49	16	52	09	19

Note: Leading zeros have been omitted.

The spouse correlations average about 0.20 for all three subsets of scales varying from a high of 0.51 (Capacity for status and Achievement via independence) to a low of zero (Self-control and Femininity). This average correlation is somewhat higher than spouse personality similarity reported in other studies (Bouchard, 1997).

Model-fitting

Resemblance for the MZA twins includes both additive and nonadditive genetic effects and thus provides a direct estimate of total genetic influence (broad heritability). Nonadditive genetic effects involve interactions among alleles at a single locus (i.e., dominance) as well as interactions among alleles at different loci (epistasis). Whereas monozygotic twins share all nonadditive genetic effects, dizygotic twins share approximately a quarter of genetic effect due to dominance and some indeterminate fraction of genetic effect due to epistasis. Thus, if nonadditive genetic effects are important for a particular trait, the correlation for dizygotic twin correlations will be less than half the correlation for monozygotic twins (Plomin *et al.*, 1990). The comparison of the MZA and MZT with DZA and DZT twin correlations in the present design allows for a test of genetic effects due to dominance, but with the sample sizes in this study it lacks statistical power.

The results of fitting the ADCE model are shown in Table 4. Because of the large number of comparisons we use $p = 0.01$ as the critical value for determining statistical significance.

The most striking result in Table 4 is that the best estimate of shared environmental influence for most scales is essentially zero.

If an ACE model is fitted to the MZT/DZT data alone three variables have meaningful V_c values, i.e., Responsibility (0.28), Intellectual efficiency (0.15), and Psychological-mindedness (0.21). With observations on reared-together twins only, both V_c and V_d can not be simultaneously estimated. It is relatively common in studies of reared-together twins to fit an ACE model

For the four group design the ADCE model fails to fit for two of these variables, Intellectual efficiency and Psychological-mindedness. The failure of fit is clearly due to the relatively high DZA correlations which for two of the scales even exceeded the MZA correlation. Curiously, while they are not as high as the DZA correlations, the DZT correlations for Responsibility, Intellectual efficiency, and Psychological-mindedness also are the highest for that group of twins. Doubling them would yield values much higher than those of the MZT or MZA twins.

The ADCE model is rejected for the Empathy scale because the DZA and DZT correlations differ dramatically. The lowest estimate of genetic influence among the folk scales is for Communality. This is not surprising as this scale was designed to detect invalid protocols and has little personological significance.

Among the three vector scales the model does not fit for Norm-favoring. This is due to a combination of a large negative DZA correlation and a very low MZT correlation (actually the very lowest of all the MZT correlations). The curious negative correlation for the DZAs is the same for both the SS-DZAs and OS-DZAs.

Among the special purpose scales the model is rejected only for the Anxiety scale. It is also rejected for Anxiety when the ACE model is fit to the MZT/DZT data and when the ADE model is fit to the MZA/DZA data. The estimate of genetic influence is the smallest of all the scales.

DISCUSSION

In general, this study replicates findings from numerous previous twin studies of personality. The lack of any substantive differences in the correlations for the MZA

Table 4. parameter estimates and 95% confidence intervals for additive (V_a), dominance (V_d), genetic ($V_g = V_a + V_d$), shared environmental (V_c) and nonshared environmental (V_e) variance component, chi square test of model fit, and significance levels of fit for the 20 standard scales, the three vector scales and the ten special scales of the California Psychological Inventory based on MZA, DZA, MZT, and DZT twin correlations

Scales	Parameter estimates and confidence intervals					Model-fitting tests	
	V_a	V_d	V_g	V_c	V_e	$\chi^2_{(1)}$	p
Folk scales							
Dominance	17	27	44	10	46	0.14	0.71
	00–56	00–56	27–58	00–27	36–59		
Capacity for status	54	00	54	00	46	3.50	0.06
	05–62	00–50	43–62	00–09	38–56		
Sociability	37	06	43	03	54	2.02	0.16
	00–54	00–53	27–54	00–21	42–67		
Social presence	48	00	48	00	52	1.92	0.17
	00–57	00–54	34–57	00–15	42–63		
Self-acceptance	37	15	52	00	48	0.12	0.73
	00–60	00–60	37–61	00–16	39–59		
Independence	00	34	34	13	53	0.53	0.47
	00–47	00–48	17–49	00–29	42–68		
Empathy	36	10	46	00	54	8.95	0.00
	00–54	00–55	34–56	00–07	44–66		
Responsibility	49	00	49	00	51	5.37	0.02
	19–58	00–30	37–58	00–12	42–61		
Socialization	45	05	50	00	49	1.13	0.29
	00–59	00–66	38–59	00–11	40–60		
Self-control	00	50	50	00	50	4.06	0.04
	00–39	09–59	39–59	00–08	41–61		
Good impression	00	45	45	00	55	3.63	0.06
	00–40	03–55	31–55	00–11	45–67		
Communality	00	26	26	00	74	1.00	0.32
	00–34	00–38	11–38	00–11	62–88		
Well-being	00	44	44	00	56	2.42	0.12
	00-46	00-54	32–54	00–08	46–68		
Tolerance	47	00	47	00	53	4.21	0.04
	00–56	00–43	35–57	00–12	43–64		
Achievement via conformance	35	11	46	00	54	2.94	0.09
	00–54	00–55	34–56	00–09	44–66		
Achievement via independence	53	00	53	01	47	3.92	0.05
	17–61	00–35	39–61	00–15	38–57		
Intellectual efficiency	50	00	50	06	45	8.20	0.00
	18–61	00–28	34–61	00–21	36–56		
Psychological-mindedness	37	00	37	07	57	8.06	0.01
	06–50	00–28	19–50	00–24	46–69		
Flexibility	00	38	38	11	51	1.36	0.24
	00–48	00–52	22–52	00–26	40–65		
Femininity/masculinity	26	16	42	00	58	2.07	0.15
	00–51	00–52	28–52	00–13	48–71		
Vector scales							
V1 Internality	15	32	47	07	47	0.09	0.76
	00–57	00–59	30–59	00–24	36–60		
V2 Norm-favoring	00	28	28	00	72	6.36	0.01
	00–32	00–40	12–40	00–13	60–86		
V3 Self-realization	52	00	52	00	48	0.66	0.42
	00–61	00–57	40–61	00–12	39–58		
Special purpose scales							
Managerial potential	24	33	57	00	43	0.74	0.39
	00–62	00–65	44–65	00–15	33–53		
Work orientation	08	44	52	00	48	0.56	0.45
	00–56	00–60	39–60	00–12	39–59		
Creative temperament	00	55	55	07	38	2.80	0.09
	00–61	00–65	42–65	00–21	29–50		
Leadership Potential	42	07	49	00	51	0.46	0.50
	00–58	00–57	34–59	00–18	39–62		
Amicability	10	47	57	00	43	3.10	0.08
	00–60	00–65	47–65	00–07	36–53		
Law enforcement orientation	13	09	21	06	73	2.00	0.16
	00–36	00–37	01–37	00–26	59–88		
Tough-mindedness	06	39	45	00	55	0.05	0.83
	00–50	00–54	29–55	00–16	44–68		
Baucom scale for masculinity	01	55	56	00	44	2.52	0.11
	00–58	00–64	46–64	00–08	36–54		
Beaucom scale for femininity	00	66	66	04	31	2.52	0.11
	00–42	24–73	55–73	00–16	23–40		
Anxiety	00	20	20	00	80	9.90	0.00
	00–20	00–33	05–33	00–06	67–95		
Narcissism	00	45	45	00	55	2.16	0.14
	00–44	00–55	31–55	00–11	45–67		

Note: Decimal points omitted for parameter estimates and confidence intervals. Variance component estimates derived from analysis of the correlation and thus satisfy the constraint that $V_a + V_d + V_c + V_e = 1.0$.

twins versus the MZT twins and the model-fitting results re-affirm the now well known finding that, in adulthood, the influence of shared environment is essentially zero for most personality traits (Bouchard, 1997; Finkel and McGue, 1997). While these results still surprise some psychologists they are now so commonplace that most behavior geneticists would be extremely surprised if the results turned out otherwise. The contribution of the present study, which includes twins reared apart, is that it confirms the CPI findings that were previously established predominantly with twins reared together. Given the lack of shared environmental influence it is not surprising that contact time does not explain the similarity between the reared-apart twins. In studies that have found a statistically significant association between contact time and twin similarity in reared-together twins, the magnitude of effects are small and scale specific (Rose, Kaprio, Williams, Viken and Obremski, 1990). Moreover, among reared-together twins it is not altogether clear whether greater contact leads to increased personality similarity or conversely greater personality similarity leads to increased contact (Lykken, McGue, Bouchard and Tellegen, 1990).

The significant shared environmental influence reported for Vector 2 by Loehlin and Gough (1990) was due to a relatively high DZT correlation (0.41). Although we find a lower heritability for this scale ($V_g = 0.28$), the low heritability is due to a low MZT and not a high DZT correlation, and our estimate of V_c is 0.00. Consequently our findings do not conform the previous results. It must, however, be kept in mind that the model for Vector 2 was rejected.

The average degree of genetic influence across all scales is 0.46. We note here that the Swedish Adult Twin Study of Aging (SATSA) finds lower MZA correlations for its personality measures than MISTRA and reports somewhat lower heritabilities. The reasons for this discrepancy are not obvious (Bouchard, 1997; Bouchard and Pedersen, in press). The results reported in this paper are, however, virtually identical to findings based on large-scale studies of reared-together twins (Eaves *et al.*, 1989; Jang, Livesley and Vernon, 1996; Loehlin, 1992; Nichols, 1978). Recently Finkel and McGue (1997) reported an average heritability of 0.44 for the eleven scales of the Multidimensional Personality Questionnaire (MPQ) in an analysis of 4300 kin pairs from four kinships (MZT, DZT, siblings, parent–offspring).

Because there is little evidence of shared environmental effects, either the MZA or the MZT correlations alone should provide an unbiased estimate of the heritability of a scale. For the standard scales the average signed deviation of either the MZA or MZT correlation from the heritability is only -0.02. Although this finding may surprise some readers it is not unique to this study. Lykken, Bouchard, McGue and Tellegen (1993) reported a similar finding for vocational interests and the study of Finkel and McGue (1997) yielded MZT correlations for each sex (220 pairs of male MZs and 406 pairs of female MZs) which alone were extremely precise estimates of the broad heritabilities estimated in the full sample. The same finding has also been reported for a variety of other phenotypes. In the Virginia 30,000, where data from 20,000 relatives (parents, siblings, spouses, and offspring) have been added to data from 10,000 twins, point estimates of total genetic and environmental influence on body weight and adiposity are basically the same as those derived from using the twin data alone (Maes, Neale and Eaves, 1997; Truet, Eaves, Walters, Heath, Hewitt, Meyers, Silberg, Neale, Martin and Kendler, 1994). These results illustrate the great power of the twin method relative to other methods (Martin, Boomsma and Machin, 1997; Martin, Eaves, Kearsey and Davies, 1978).

A number of limitations of the present study should be kept in mind. First, there were numerous significant differences in means and variances between the four types of twins leading us to analyze the correlations rather then the co-variances. The causes of these differences are unknown. Second, the high degree of similarity of the OS-DZA twins was unexpected and its cause is unknown. Unlike-sex twins, however, are infrequently studied by behavior geneticists and deserve more scrutiny (Miller, 1994). Third, neither the MISTRA twin sample nor the NAS–NRC twin sample are true random samples. Fourth, the NAS–NRC sample was all male while the MISTRA sample contained males and females. All of these factors could have distorted our results in an unknown manner.

The spouse correlations found in this sample are a little higher than those reported recently in the personality literature. The average spouse correlation for ten MPQ scales (Traditionalism with $r = 0.48$, was deleted) based on 1185 spouse pairs is 0.08 (Lykken and Tellegen, 1993). Spouse correlations are much higher, however, for IQ where figures between 0.35 and 0.40 are typical (Bouchard and McGue, 1981; Mascie-Taylor, 1989). The CPI scales with higher than average spouse correlations (Achievement via independence, Intellectual efficiency, Psychological-mindedness) all correlate with IQ (Gough, 1996). The one exception is Capacity for status with a spouse correlation of 0.51. It has a much less regular pattern of correlations with intellectual abilities.

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