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GENETIC AND SHARED ENVIRONMENTAL INFLUENCES ON LEISURE-TIME INTERESTS IN MALE ADOLESCENTS

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Summary—The present study explored genetic and environmental influences on individual differences in adolescent leisure-time interests. One hundred and ninety identical and 100 fraternal male twin pairs, aged 17 and 18 years, all participants in the ongoing Minnesota Twin Family Study, completed 120 items of the Leisure-Time Interests (LTI) inventory. A principal components analysis with varimax rotation of the 120 items of the LTI yielded nine interpretable factors (Intellectual Activities, Sports, Music and Artistic Activities, Handicrafts, Hunting and Outdoor Activities, Foreign Travel, TV Viewing, Dating and Social Activities, and Religious Activities). Correlation and biometrical analyses indicated that: (1) both genetic and shared environmental factors contributed to individual differences in adolescent leisure-time interests, although the relative magnitude of the contribution of the two factors varied across different leisure-time interests, and (2) approximately half of the variance in adolescent leisure-time interests was associated with nonshared environmental influences. The results are discussed in the context of developmental changes in genetic and shared environmental influences on leisure-time interests. Copyright © 1996 Elsevier Science Ltd.

INTRODUCTION

Recently, behavioral geneticists have demonstrated the existence of significant genetic influences on occupational and leisure-time interests (Loehlin & Nichols, 1976; Grotevant, Scarr & Weinberg, 1977; Waller, Kojetin, Bouchard, Lykken & Tellegen, 1990; Moloney, Bouchard & Segal, 1991; Lykken, Bouchard, McGue & Tellegen, 1993). In an extensive review of over 100 twin studies, Nichols (1978) found that the difference between weighted average correlations for monozygotic (MZT) and dizygotic (DZT) reared-together twins ranged from 0.11 to 0.22 across interest scales, suggesting heritability estimates of 22–44%, based on the Falconer formula (i.e. twice the difference between the MZT and DZT correlations).

Comparing familial resemblance among adoptive and biological relatives, Grotevant *et al.* (1977) found evidence of a genetic contribution to each of the six Holland interest styles (Realistic, Investigative, Artistic, Social, Enterprising and Conventional), as measured by the Strong–Campbell Interest Inventory. Correlations for 75 pairs of same sex biological siblings ranged from 0.26 to 0.51, with all of the correlations achieving statistical significance. In contrast, correlations among adoptive sibling pairs were generally lower, ranging from −0.21 to 0.43, and achieved statistical significance in only two of 23 cases. The average sibling correlation was 0.36 for biological pairs and 0.11 for adoptive pairs.

Moloney *et al.* (1991) examined similarity among 52 pairs of monozygotic (MZA) and 27 pairs of dizygotic (DZA) reared-apart twins on the Strong Vocational Interest Blank-Strong Campbell Interest Inventory (SVIB-SCII) and the Jackson Vocational Interest Survey (JVIS). The average MZA intraclass correlation was 0.38 and 0.47 for the SVIB-SCII and JVIS scales, respectively. The average DZA correlation was 0.05 and 0.06 for the SVIB-SCII and JVIS scales, respectively. Because MZA correlations directly estimate heritability, these results suggest a heritability of about 40–50% for interests. Thus, findings from a variety of behavioral genetic studies converge on the conclusion that individual differences in interests are strongly associated with genetic factors.

Most behavioral genetic studies on interests have been conducted on vocational interests, with considerably less attention directed towards the inheritance of leisure-time interests, particularly in

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adolescence. The paucity of behavioral genetic research on leisure-time interests in adolescence is due perhaps to a belief that adolescents' leisure-time activities are predominantly determined by shared family leisure rather than individual inclination.

A few available behavioral genetic studies which have examined leisure-time interests in adults, however, suggest that leisure-time interests, like many other interest variables, are heritable traits. For example, Waller, Lykken and Tellegen (in press), in a sample of reared-apart and reared-together adult twins, examined genetic and environmental influences on both leisure-time interests and vocational interests, and found the heritabilities in the two interest domains to be remarkably similar. In this study, 148 pairs of male and 273 pairs of female MZT, 119 pairs of male and 228 pairs of female DZT, and 33 pairs of male and female MZA twins (not reported separately by sex) completed the adult version of the Leisure-Time Interests inventory used in the present investigation and also an occupational interests inventory. For the 17 occupational interest scales, the median male and female MZT correlations were 0.43 and 0.44, respectively. The corresponding median correlations for the 18 Leisure-Time Interests scales were 0.50 and 0.46. The median male and female DZT correlations for the 17 occupational interests scales were 0.18 and 0.21, respectively, and 0.19 and 0.18 for the 18 Leisure-Time Interests scales. The sex–age corrected median MZA correlation was 0.40 for the 17 occupational interests scales and 0.46 for the 18 Leisure-Time Interests scales. These results indicate that, as with vocational interests, genetic factors account for about 40–50% of the variance in leisure-time interests in adulthood.

Two other findings from the Waller *et al.* study are notable. First, the Leisure-Time Interests scales included a wide variety of adult leisure-time activities such as Intellectual Interests, Politics, Gambling and so forth. Except for the Foreign Travel (27%) and Danger Seeking scales (26%) for males, and the Gambling scale (20%) for females, the level of heritability was similar for all leisure-time interests, ranging from 32% to 63% in the male sample and from 30% to 63% in the female sample. Second, reared-together MZ twins were no more similar than reared-apart MZ twins, suggesting that shared environmental factors do not influence variation in leisure-time interests in adulthood.

Although research is consistent in indicating genetic influences on interests in adulthood, the relative size of genetic and environmental variance can vary throughout the life span as, for example, the effects of early influences diminish while new influences emerge (McCartney, Harris & Bernier, 1990). When compared to adults' leisure choices, however, it seems likely that adolescents' leisure-time activities are more affected by contextual factors like parents' interests, sibling influences and peer group characteristics. Consequently, genetic factors are expected to be less influential and shared environmental factors more influential on leisure-time interests in adolescence as compared to adulthood. Moreover in adolescence, the influence of contextual factors on a specific leisure-time interests would be expected to be limited to the extent that the leisure activity is ability-based. That is, the encouragement of parents and peers might not stimulate interest in activities for which the adolescent has little talent. In this paper, we present the first report of estimates of genetic and shared environmental influences on leisure-time interests in an adolescent sample. We expect that interest in ability-based leisure activities will be more heritable than in non-ability-based leisure activities, and conversely that shared environmental factors will be greater for the latter than the former.

METHODS

Sample

The sample was drawn from male adolescent twin participants in the ongoing Minnesota Twin Family Study (MTFS).* The MTFS is a longitudinal, population-based study of genetic and environmental influences on adolescent adjustment and development. Twins are ascertained from birth records obtained through the Minnesota State Health Department and are then located and recruited by mail and phone. Two cohorts of twins and their parents are being assessed at three-

* Although the MTFS also includes a sample of adolescent female twins, assessments of the female sample began after the male sample so that the LTI data for the female sample are not yet ready for a statistical analysis.

year intervals; the initial evaluation is conducted when the twins reach either the sixth or 12th grade in school. Twins and their parents who are willing to participate in the study are brought to the laboratory at the University of Minnesota Psychology Department for a one-day comprehensive psychophysiological and psychological assessment. Additionally, twins competed through the mail a battery of self-report inventories including the inventory of Leisure-Time Interests (LTI) used in the present study.

Although two cohorts of male twins are participating in the MTFS, the LTI inventory has only been mailed to the group composed of high school seniors when they were 17 or 18 years old. The present analyses were based on 190 monozygotic (MZ) and 100 dizygotic (DZ) male twin pairs, where both members completed the LTI. The lower rate of participation for DZ as compared to MZ twin pairs is consistent with the rates of DZ and MZ twin births in the state of Minnesota (Hur, McGue & Iacono, 1995), and does not necessarily represent a sampling bias.

Zygosity was determined from the twins' parents' responses to a zygosity questionnaire which included questions concerning physical similarities and the frequency with which the twins were confused by family members and others. This method has been previously demonstrated to be 95% accurate in determining zygosity, when compared to results from blood analyses (Lykken, Bouchard, McGue & Tellegen, 1990).

Measures

The LTI consists of 120 items designed to cover a wide range of leisure-time interests in activities including intellectual, physical, social and other activities that are commonly identified among adolescents. All items contain descriptions of specific activities and have a five-point rating scale (1. Never, 2. Seldom, 3. Sometimes, 4. Frequently, 5. Often as possible). Because the LTI is an inventory of expressed preferences, rather than current leisure practices, twins were asked "How often would you engage in each of the following leisure time activities if you had the time and the money to do what you want?... when considering each items, pretend that you are not limited to time, or money, or by age or health."

Responses from the 120 items of the LTI were submitted to a principal components analysis with varimax rotation in order to generate specific scales. The principal components analysis yielded nine interpretable factors. Determination of the number of factors was based upon interpretability and eigenvalue distribution. Factor scale scores for each factor were computed by summing items (1) that loaded 0.30 or greater on that factor, (2) that loaded no more than 0.29 on any other factor, and (3) whose inclusion increased the alpha reliability of the scale. The resulting nine scales were Intellectual Activities, Sports, Foreign Travel, Handicrafts, Music and Artistic Activities, Hunting and Outdoor Activities, Dating and Social Activities, Television Viewing, and Religious Activities. Individuals who skipped more than 15% of the items on a scale were eliminated from analyses on that scale. For individuals who skipped less than 15% of the items on a scale, a prorated scale score was computed by multiplying the obtained score by the ratio of number of items in the scale to number of items completed. These procedures resulted in different sample sizes for different scales, but it was never necessary to drop more than six twin pairs from any one analysis. For all scales, higher scores correspond to higher level of interest. The internal consistency reliabilities, as measured by Cronbach's alpha, ranged from 0.64 to 0.90, with an average of 0.81. The Appendix provides a listing of item content and the internal consistency reliability estimate for each scale.

Analytical procedure

Analysis of the data included computation of descriptive statistics and intraclass correlations and the fitting of univariate biometrical models. Biometrical model-fitting analysis helped identify the variance components that contributed to phenotypic variance.

Intraclass correlations. Intraclass correlations were computed from mean squares between (MSB) and within (MSW) twin pairs according to the standard formula: $(MSB-MSW)/(MSB+MSW)$. Statistical comparisons of twin correlations were made using the Fisher z-transformation method, which yields a chi-square test statistic (Donner & Rosner, 1980).

Model-fitting analyses. Estimation of genetic and environmental influences through the analysis of correlations does not provide a framework for testing either the goodness-of-fit of the model or the significance of specific parameters in the model. Consequently, biometrical model-fitting has

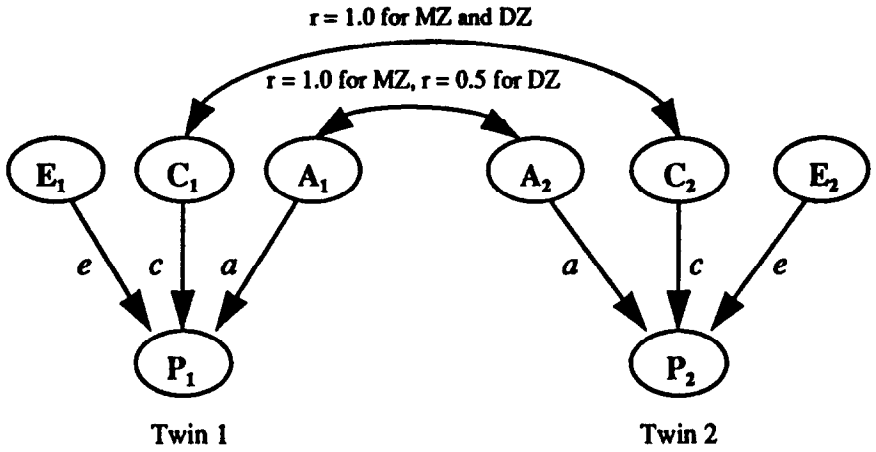

Fig. 1. Univariate genetic model. P_1, A_1, C_1 and E_1, denote the phenotype, additive genetic effects, and shared and nonshared environmental effects for the first twin; P_2, A_2, C_2, and E_2 denote the corresponding variables for the second twin. See text for identification of parameters, *a*, *c*, and *e*.

become the standard analytical approach in the field of behavioral genetics (Neale & Cardon, 1992), and is consequently, the approach used here.

Under the standard univariate biometrical model (Fig. 1), a quantitative phenotype, P can be expressed as a linear additive function of a latent additive genetic component (A), a shared (C, i.e. those environmental factors that are shared by both members of a twin pair and thus contribute to their similarity) and a nonshared environmental component (i.e. those environmental factors that are not shared by the members of a twin pair and thus contribute to their dissimilarity): $P = A+C+E$. Assuming further that the genetic and environmental components are uncorrelated, the phenotypic variance, *Vp*, can be similarly decomposed as

$$Vp = Va + Vc + Ve, \tag{1}$$

where, *Va*, *Vc* and *Ve* are the variances associated with, respectively, additive genetic, shared environmental and nonshared environmental factors. Dividing both sides of the equation by the phenotypic variance norms the variance to 1.0 and thus represents the individual components as proportions of the total variance, or

$$1.0 = a^2 + c^2 + e^2, \tag{2}$$

where $a^2 = Va/Vp$ or the proportion of variance associated with additive genetic effects (i.e. the heritability), $c^2 = Vc/Vp$, or the proportion of variance associated with shared environmental effects, and $e^2 = Ve/Vp$, or the proportion of variance associated with nonshared environmental effects (McGue, Vaupel, Holm & Harvald, 1993). Under the standard assumptions that: (1) all genetic effects are additive, (2) there is no assortative mating, (3) there is no genotype–environment correlation (G–E correlation) and/or interaction (G–E interaction), and (4) common environments are equal for MZ and DZ twins (equal environmental similarity assumption), we can express the correlations between MZ and DZ twins, respectively, as:

$$r_{mz} = a^2 + c^2 \quad \text{and} \quad r_{dz} = 1/2a^2 + c^2. \tag{3}$$

Additive genetic effects correspond to genetic effects that add across all loci. It is the sum of the average effects of all the genes that influence a character. Nonadditive genetic effects involve interactions among alleles at a single locus and at different loci. Although behavioral geneticists have demonstrated the importance of nonadditive genetic effects for some variables such as personality traits (Tellegen, Lykken, Bouchard, Wilcox, Segal & Rich, 1988), we did not distinguish between additive and nonadditive genetic effects in our analyses given the low power to detect nonadditive genetic effects in the classical twin study (Martin, Eaves & Davies, 1978).

The second premise assumes that there is no assortative mating in leisure-time interests. Assort-

ative mating adds to the correlation for DZ twins and therefore, if it exists, will result in an overestimation of shared environmental factors and an underestimation of heritability.

G–E interaction refers to the possibility that individuals of different genotypes may respond differently to environments (Plomin, DeFries & Loehlin, 1977). For human behavior, it is difficult to assess the importance of G–E interaction, and research to date, has not uncovered many genotype–environment interactions in humans (e.g. Capron & Duyme, 1989). G–E correlation reflects non-random distribution of genotypes across environments. Although there are various mechanisms for generating G–E correlation, of particular relevance is what Scarr and McCartney (1983) called reactive and active kinds of G–E correlation. The former refers to experiences of the child that derive from reactions of other people to the child's genetic propensities. The latter occurs, for example, when children actively select or create environments that are correlated with their genetic propensities (Scarr & McCartney, 1983). It is important to note that in the present analysis, variance associated with both active and reactive kinds of G–E correlation is estimated as genetic variance.

The equal environmental similarity assumption holds that MZ twins are no more likely than DZ twins to share trait-relevant environmental factors. Empirical studies generally support the validity of this assumption by demonstrating that in those cases where MZ twins do show greater environmental similarity than DZ twins, the greater environmental similarity of MZ twins is either unrelated to their greater phenotypic similarity (Loehlin & Nichols, 1976), or a consequence rather than a cause of their greater phenotypic similarity (Lytton, Martin & Eaves, 1977).

For additional discussion on the applicability of these assumptions, one can refer to standard behavioral genetic text books (e.g. Plomin, DeFries & McClearn, 1990).

RESULTS

Descriptive statistics

Means and standard deviations for the LTI scales are reported separately by zygosity in Table 1. The means for MZ and DZ twins were not significantly different except for the Hunting and Outdoor Activities scale, where the mean for MZ twins was modestly, but significantly higher than the mean for DZ twins ($t = 2.13$, $P < 0.03$, standardized effect size = 0.19). F tests comparing MZ vs DZ twins yielded no significant variance difference for any of the scales, consistent with the assumption in the twin analysis that MZ and DZ twins variances are equal (cf. Eq. 1).

Intraclass correlations

Table 2 reports the MZ and DZ intraclass correlations for the nine LTI scales. Also reported in the table are the results of the statistical comparisons of the correlations by zygosity. In five of the nine scales, the MZ correlation significantly exceeded the DZ correlation at $P < 0.05$, suggesting that genetic factors influence individual differences on Intellectual Activities, Sports, Music and Artistic Activities, Handicrafts, and Hunting and Outdoor Activities. For three of these five scales,

Table 1. Means and standard deviations for the nine Leisure-Time Interests scales

	MZ			DZ		
Scale	*N*	Mean	SD	*N*	Mean	SD
Intellectual Activities	380	26.68	8.31	200	25.63	7.82
Sports	380	34.71	7.61	200	33.74	8.08
Music & Artistic Activities	380	15.49	5.37	200	15.56	5.22
Handicrafts	368	12.87	4.66	196	12.20	4.60
Hunting & Outdoor*	380	29.33	10.35	200	27.40	10.48
Foreign Travel	380	10.72	5.23	198	10.08	5.30
TV Viewing	378	13.16	2.76	194	13.55	2.81
Dating & Social Activities	380	41.68	7.56	200	42.40	7.07
Religious Activities	374	8.09	3.04	200	7.82	3.02

Note. MZ = identical twins, DZ = fraternal twins.
* The mean for MZ twins was significantly different from the mean for DZ twins at $P < 0.05$, two-tailed test.

Table 2. Twin intraclass correlations for the nine Leisure-Time Interests scales

Scale	MZ	DZ
Intellectual Activities†	0.59**	0.21*
Sports†	0.67**	0.40**
Music & Artistic†	0.52**	0.21*
Handicrafts†	0.49**	0.29**
Hunting & Outdoor†	0.65**	0.48**
Foreign Travel	0.23**	0.03
TV Viewing	0.34**	0.32**
Dating & Social	0.39**	0.31**
Religious Activities	0.58**	0.61**

Note. MZ = identical twins, DZ = fraternal twins. N = 184–190 pairs for MZ, N = 97–100 pairs for DZ.

* Significantly different from zero at $P < 0.05$, two-tailed test.** Significantly different from zero at $P < 0.01$, two-tailed test

† $r_{mz} > r_{dz}$ at $P < 0.05$, one-tailed test.

Sports, Handicrafts, and Hunting and Outdoor Activities, the DZ correlations exceeded half of the MZ correlations, suggesting that shared environmental factors also influence variances of these scales (cf. Eq. 3). For TV Viewing, Dating and Social Activities, and Religious Activities, the MZ and DZ correlations were approximately equal, suggesting that shared environmental factors were more important than genetic factors for these scales. Although the MZ correlation exceeded the DZ correlation for the Foreign Travel scale, this difference was not statistically significant, and both the MZ and DZ correlations were relatively low, indicating that neither genetic nor shared environmental factors were substantial.

Model-fitting analyses

Our model-fitting analyses were based on the observed variance and covariance matrices computed separately for MZ and DZ twin pairs. We employed LISREL VII (Joreskog & Sorbom, 1989) to obtain maximum likelihood parameter estimates and standard errors for the parameters. For all nine scales, we fit the general model that included the three sources of variance given in Eq. 2 (i.e. A, C and E). Parameter estimates were judged to be significant if they were greater than twice their standard errors.

Table 3 summarizes the results of the biometrical model-fitting analysis. A satisfactory fit of the ACE model, indicated by a chi-square value with $P > 0.05$, was obtained for all of the scales.

Table 3. Maximum-likelihood parameter estimates. Standard errors and variance components for the nine Leisure-Time Interests scales in the full model with additive genetic effects (A) and shared (C) and nonshared (E) environmental effects

	Parameter estimates ± standard errors			Fitness index	
Scale	A	C	E	χ^{2}*	P
Intellectual Activities	6.12(±0.38)	0†	5.37(±0.26)	3.32	0.35
% variance	57%	0%	43%		
Sports	5.68(±0.91)	2.97(±1.64)	4.40(±0.22)	1.26	0.74
% variance	53%	15%	32%		
Music & Artistic	3.80(±0.26)	0†	3.73(±0.18)	3.31	0.35
% variance	51%	0%	49%		
Handicrafts	2.84(±0.79)	1.49(±1.34)	3.35(±0.17)	2.81	0.42
% variance	38%	10%	52%		
Hunting & Outdoor	6.36(±1.37)	5.48(±1.52)	6.17(±0.31)	0.09	0.99
% variance	37%	28%	35%		
Foreign Travel	2.44(±0.39)	0†	4.66(±0.22)	1.18	0.76
% variance	21%	0%	79%		
TV Viewing	0.84(±1.00)	1.39(±0.53)	2.26(±0.11)	1.52	0.68
% variance	9%	25%	66%		
Dating & Social	2.02(±2.78)	4.06(±1.22)	5.84(±0.29)	3.13	0.37
% variance	7%	30%	62%		
Religious Activities	0†	2.33(±0.14)	1.95(±0.08)	2.13	0.55
% variance	0%	59%	41%		

* df = 3.

† Boundary solution; therefore, standard error not estimated.

Genetic influences were significant and substantial for Intellectual Activities ($a^2 = 57\%$), Sports ($a^2 = 53\%$), and Music and Artistic Activities ($a^2 = 51\%$); moderate for Handicrafts ($a^2 = 38\%$), Hunting and Outdoor Activities ($a^2 = 37\%$), and Foreign Travel ($a^2 = 21\%$); and negligible for TV Viewing ($a^2 = 9\%$), Dating and Social Activities ($a^2 = 7\%$), and Religious Activities ($a^2 = 0\%$). The proportion of variance associated with shared environmental influences was zero for Intellectual Activities, Music and Artistic Activities, and Foreign Travel; modest for Handicrafts ($c^2 = 10\%$) and Sports ($c^2 = 15\%$); moderate for TV Viewing ($c^2 = 25\%$), Hunting and Outdoor Activities ($c^2 = 28\%$), and Dating & Social Activities ($c^2 = 30\%$); and substantial for Religious Activities ($c^2 = 59\%$). Nonshared environmental effects were statistically significant and substantial for all nine LTI scales, ranging from 32% for Sports to 79% for Foreign Travel. It must be noted, however, that the estimate of nonshared environmental factors also includes all variance attributable to measurement error.

In summary, both correlational and biometrical analyses suggest that: (1) genetic and shared environmental factors contribute to individual differences in adolescent leisure-time interests, (2) unlike what has been found in adult samples, the proportion of leisure-time interests variance attributable to genetic and shared environmental factors varies markedly across scales, and (3) approximately half of the variance in adolescent leisure-time interests is associated with nonshared environmental influences.

DISCUSSION

The major finding from the present study is that, in adolescence, the relative importance of genetic and environmental factors differ markedly for various leisure-time interests. This finding contrasts with that reported by Waller *et al.* (in press) for a similar interest measure in a middle-aged twin sample. Both the correlational and model-fitting analyses of data from our adolescent twin sample indicated that the magnitude of genetic influences on interests in Intellectual Activities, Sports, Music and Artistic Activities, Handicrafts, and Hunting and Outdoor Activities were substantial, consistent with what Waller *et al.* found in their middle-aged twin sample. For individual differences in adolescent interests in TV viewing, Dating and Social Activities, and Religious Activities, however, the magnitude of genetic influences was minimal, whereas the magnitude of shared environmental influences was substantial, unlike earlier findings in adult twins. Interestingly, the magnitude of genetic influences on interest in Foreign Travel estimated from our adolescent sample was low (21%), as was the estimate (27%) from the Waller *et al.* adult sample. Waller *et al.* argued that the low heritability of the Foreign Travel scale is largely due to the fact that interest in foreign travel is less stable than interest in other domains. Indeed, they reported a low test–retest stability coefficient (0.57) for the Foreign Travel scale in their adult sample. Although stability coefficients are not available for our adolescent sample, we can assume that many of these U.S. adolescents have not yet experienced foreign travel, and therefore would not be expected to form strong opinions about the attractiveness of travel to foreign countries.

It seems likely that interest in aptitude-based leisure-time activities like sports, music and artistic activities, reading, handicrafts, hunting and drawing are affected by individual talents and abilities. Ability-based activities require certainly a minimal, but perhaps also a high level of competency. For example, it seems likely that children who are dexterous will show stronger interests in activities that require working with their hands than children who are clumsy with their hands. Given that research has shown abilities and talents to be influenced substantially by genetic factors (Plomin, 1986; Bouchard, Lykken, McGue, Segal & Tellegen, 1990; McGue, Hirsch & Lykken, 1993), it is reasonable to expect large genetic effects on leisure-time interests that demand specific skills, aptitudes or talents. As activities such as television watching, dating and attending religious services appear not to be constrained by ability, but rather to be influenced by social context, a finding of strong shared environmental influence on interests in these activities among adolescent twins who are living together is not unexpected. Whereas parental encouragement and discouragement of specific leisure activities may be major sources of shared environmental influence on adolescent interests in TV Viewing, Dating and Social Activities, and Religious Activities, other environmental factors shared by twins, including peer group characteristics as well as the mutual reinforcing effect the twins can have on each other, may also contribute to twin similarity in these interests.

Given the substantial degree of assortative mating observed for religious interests and time spent watching television (Eaves, Martin & Heath, 1990; Plomin, Corley, DeFries & Fulker, 1990; Lykken & Tellegen, 1993), it could be that substantial shared environmental effects we found on some leisure interest scales may be attributable largely to assortative mating for leisure interests in the parents of the twins. As mentioned earlier, assortative mating adds to the correlation for DZ twins and thereby tends to inflate the estimate of shared environmental influence. To examine the possible effect of assortative mating on our variance estimates, we weighed the additive genetic expectation for DZ twins in our model by the spouse correlations obtained from parents of twins who participated in the MTFS [i.e. $r_a = 0.5(1+m)$, where r_a is the additive genetic correlation, and m is the spouse correlation; see Chipuer, Rovine & Plomin (1990) for justification of this procedure], and compared the resulting variance estimates to our estimates in Table 3. Table A2 in the Appendix gives the spouse correlations on the nine LTI scales, the variance estimates incorporating those spouse correlations, and changes in estimates, as compared to those in Table 3. As indicated in the table, assortative mating was relatively modest except for Religious Activities. Changes in the variance estimate suggest that, assuming mating is based on phenotypic resemblance, the maximum contribution of assortative mating to the estimate of shared environmental influence was only about 0.16. In most of the LTI scales, especially in the Religious Activities scale, the contribution was near zero. From these results, we conclude that the shared environmental effects we found on some leisure interest scales are likely to be real, at least, in adolescence.

Consistent with the general finding in the behavioral genetic literature that experiences not shared by individuals growing up in the same family exert a significant influence on individual differences in most psychological traits (Plomin & Daniels, 1987), nonshared environmental influences were substantial for all nine LTI scales. Unlike previous research that has demonstrated that the shared experiences of siblings growing up in the same home have little impact on their psychological similarity, however, we found evidence of statistically significant shared environmental influences on several of the interest scales. The shared environmental influence we found in our adolescent sample might not have enduring effects. As mentioned earlier, Waller *et al.* reported that adult twins reared together were no more similar than adult twins reared apart on the Socializing scale (0.50 for MZT and 0.42 for MZA) and on the Religion scale (0.52 for MZT and 0.57 for MZA), indicating minimal effects of common rearing on interests in these activities.

The transition from adolescence to adulthood accompanies a variety of life changes, including leaving home, and the release from parental constraint can permit the expression of previously unexpressed genetic effects (Eaves *et al.* 1990). Moreover, exposure to a wide range of opportunities and extrafamilial influences can also facilitate the expression of individuality. For example, among adolescents who view a large amount of television, some may show a decline in interest in TV Viewing as they are exposed to new experiences, whereas others may remain heavy viewers due to a relatively low enthusiasm for seeking out novelty outside their homes. We speculate that the changes in individual opportunity that accompany the attainment of adulthood contribute to the higher heritability estimates and the lower shared environmental estimates for leisure-time interests found in adult twin samples than found in our adolescent twin sample. Unequivocal conclusions about the developmental changes in the heritability of leisure-time interests would require, however, longitudinal designs. We expect to be able to explore this issue as we follow these twins into adulthood.

There are several limitations of the present study that need to be addressed. First, the LTI might not be a comprehensive measure of adolescent leisure-time interests. It would be interesting in future research to investigate interest in leisure activities like family outings and gambling. Second, the conclusions drawn from this sample are necessarily limited to male adolescents: gender differences could exist in leisure-time interests and these gender differences may be associated with differences in heritability. Although Waller *et al.* did not find evidence of significant gender differences in heritability of leisure-time interests in their adult sample, our study indicates that findings with adults need not apply to adolescents. We are currently collecting data on female twins to examine this question. Finally, our interpretation of the pattern of differential heritabilities across leisure interests was based largely on the assumption that the expressed leisure-time interests of adolescents are affected by their current leisure-time behavior. It seems unlikely, although not impossible, that adolescents will express strong interests in activities which they have never experienced, poorly understand or are incompetent to undertake (cf. Lykken *et al.*, 1993).

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Appendix overleaf

APPENDIX

Table A1. A listing of item content and the internal consistency reliability estimate (α) for the nine Leisure-Time Interests scales

Scale	α	Item
Intellectual Activities	0.87	Reading current novels. Reading history, philosophy, biographies, economics, etc. Reading or re-reading literary classics. Reading books or magazines on science. Reading science fiction. Learning about some subject that interests you like science, history, politics, etc. Spending some time at the library. Reading mystery or detective novels. Keeping on current events, political and other issues of the day, Attending lectures on topics of interest. Watching news and public affairs programs on TV.
Sports	0.85	Playing team sports (softball, football, basketball, etc.). Playing touch or tackle football, practising passing, kicking, etc. Attending sporting events (ballgames, races, hockey, etc.). Playing basketball, pitch and catch, hitting fly balls, etc, Watching TV sports. Being in competitions (races, contests, tournaments, shows, etc.). 'Shooting hoops' or playing basketball with friends. Ice skating or playing ice hockey. 'Pumping iron', muscle-building at a gym. Jogging or running for exercise.
Music & Artistic Activities	0.75	Attending live theater or musicals. Making music (playing an instrument, singing, composing). Participating in amateur theater, music or dance groups. Listening to 'serious' music (records or 'live' performances). Creative art work (sculpting, potting, print-making, etc.). Pretending that you are someone famous, like a rock star. Painting, drawing or sketching.
Handicrafts	0.81	Rebuilding, repairing things (furniture, clothes, cars, machines, etc.). Making things (furniture, clothes, toys, electronic devices, baked goods, etc.). Model building or craft work. Building a workshop, darkroom, green house, etc. Inventing things, a new or improved device, method, idea.
Hunting and Outdoors Activities	0.90	Hunting big game. Hunting ducks or other game birds. Hunting small game, rabbits, squirrels, etc. Target shooting, trap shooting or archery. Working in the woods with friends, making maple syrup or hunting mushrooms, etc. Back-packing, hiking, camping out. Going fishing. Riding trail bikes, snowmobiles or similar off-the-road vehicles. Wild-life study, bird watching, etc. Motorcycle riding with friends.
Foreign Travel	0.88	Visiting foreign cities. Going on a camera safari in Africa, Borneo, the desert or the Amazon basin. Traveling by train or car across Scotland, Europe, Russia, Patagonia or other foreign places. Traveling around the country in a camper or mobile home.
TV Viewing	0.65	Playing video or computer games. Watching a movie on TV. Watching TV adventure or comedy programs. Watching cartoons on TV.
Dating & Social Activities	0.85	Getting acquainted with a pretty girl. Flirting a little. Getting together with friends, partying, etc. Spending time with a special girl. Going out with different girls. Doing something exciting, even slightly dangerous. Cultivating your looks, dress, physical appearance. Making money. Shopping for new clothes, records, furniture or whatever interests you. Having discussions with friends. Joy-riding in a car.
Religious Activities	0.81	Listening to religious music (oratorios, hymns, spirituals, etc.). Activities sponsored by your church or synagogue. Attending religious services. Watching religious programs on TV.

Table A2. Maximum-likelihood variance estimates for the nine Leisure-Time Interests (LTI) scales in the full model with additive genetic effects (A) and shared (C) and nonshared (E) environmental effects. When spouse correlations (m) are included*

Scale	m†	Variance estimates					
		A	Δ†	C	Δ‡	E	Δ‡
Intellectual Activities	0.17**	56%	+1%	0%	−1%	44%	0
Sports	0.28**	68%	+15%	0%	−15%	32%	0
Music & Artistic	0.30**	49%	−2%	0%	0	51%	+2%
Handicrafts	0.14**	44%	+6%	4%	−6%	52%	0
Hunting & Outdoor	0.29**	53%	+16%	12%	−16%	35%	0
Foreign Travel	0.22**	20%	−1%	0%	0	80%	+1%
TV Viewing	0.29**	13%	+4%	21%	−4%	66%	0
Dating & Social	0.24**	10%	+3%	28%	−2%	62%	0
Religious Activities	0.46**	0%	0	59%	0	41%	0

* Parameter estimates assuming assortative mating is based on phenotype.
** $P < 0.01$.
† Spouse correlations on the adult LTI scales were obtained from maximum number of parents of twins participated in the MTFS (N = 591–608); items in the adult LTI scales are not necessarily identical to those in the child LTI scales.
‡ Change in the estimate, as compared to the estimates in Table 3.