The Heritability of Attitudes: A Study of Twins

James M. Olson, Philip A. Vernon, and Julie Aitken Harris
University of Western Ontario

Kerry L. Jang
University of British Columbia

The genetic basis of individual differences in attitudes was examined in a survey of 195 pairs of monozygotic twins and 141 pairs of same-sex dizygotic twins. A principal components analysis of the 30 attitude items in the survey identified 9 attitude factors, of which 6 yielded significant heritability coefficients. Nonshared environmental factors accounted for the most variance in the attitude factors. Possible mediators of attitude heritability were also assessed, including personality traits, physical characteristics, and academic achievement. Analyses showed that several of these possible mediators correlated at a genetic level with the heritable attitude factors, suggesting that the heritability of the mediator variables might account for part of the heritable components of some attitudes. There was also some evidence that highly heritable attitudes were psychologically "stronger" than less heritable attitudes.

A truism in the social psychological literature on attitudes is that attitudes are learned (e.g., see Eagly & Chaiken, 1993; Olson & Zanna, 1993; Oskamp, 1991). That is, evaluations of objects develop through experience. For example, it is generally agreed that humans are born without predetermined attitudes toward targets, except perhaps a few stimuli closely related to survival (e.g., aversions to pain and cold, attractions to breast milk and the human face). Instead, evaluations of the multitude of stimuli in our environments are formed over the years, on the basis of both personal experiences and information from others.

A common corollary of the hypothesis that attitudes are learned is the idea that attitudes are environmentally caused. That is, if attitudes develop through experience, then it seems to follow that attitudes are determined by environmental factors (i.e., life experiences).

To be sure, the environment is necessary for the development of attitudes. But the hypothesis that attitudes are learned is not incompatible with the notion that biological and genetic factors also influence attitudes. That is, there is a second necessary component to the development of attitudes: the biological organism within which events are subjectively experienced and mnemonically recorded. Biological factors presumably mediate and moderate the impact of personal experiences, in that events are experienced through our sensory structures, and memories and evaluations are stored in our brains.

Yet the role of biological factors, particularly genetic variables, in attitude formation and change has received little attention from social psychologists (although some behavioral geneticists have investigated attitudes; e.g., Eaves, Eysenck, & Martin, 1989; Loehlin & Nichols, 1976). Social psychologists have examined a few biological factors, such as the physiological concomitants of attitudes (e.g., Cacioppo & Petty, 1987), the impact of certain drugs on attitudes and persuasion (e.g., Bostrom & White, 1979), and the role of arousal in specific attitudinal phenomena such as dissonance-motivated persuasion (e.g., Zanna & Cooper, 1974). But benign neglect probably best characterizes the state of research in social psychology on biological factors in attitudes. For example, in the most comprehensive exisiting review of the attitudes literature (Eagly & Chaiken, 1993), there was little discussion of biological processes.

The Possible Role of Genetic Factors in Attitudes

In this article, we present data investigating the issue of genetic determination of the differences between individuals in their expressed attitudes. Given the relative unfamiliarity of a genetic perspective in social psychology, it might be useful, before reviewing relevant studies, to address why a genetic perspective is sensible and how genes could possibly influence evaluations.

Heredity and environment are so intertwined that it is impossible to disentangle them completely. Genetic factors exert their influence on an organism that is in a particular environment, so the final product is inevitably a combination of biological and experiential factors. Asking how much a particular individual's atti-

James M. Olson, Philip A. Vernon, and Julie Aitken Harris, Department of Psychology, University of Western Ontario, London, Ontario, Canada; Kerry L. Jang, Department of Psychiatry, University of British Columbia, Vancouver, British Columbia, Canada.

We thank John DeFries, Charles Judd, and Abraham Tesser for their comments on versions of this article.

Correspondence concerning this article should be addressed to James M. Olson, Department of Psychology, University of Western Ontario, London, Ontario N6A 5C2, Canada. Electronic mail may be sent to jolson@julian.uwo.ca.

Journal of Personality and Social Psychology, 2001, Vol. 80, No. 6, 845–860
 0022-3514/01/$5.00 DOI: 10.1037//0022-3514.80.6.845

tudes or traits are due to heredity versus the environment is nonsensical, just like asking whether a leaky basement is caused more by the crack in the foundation or the water outside. In a very real sense, genetic effects are also environmental because they emerge in an environment, and environmental effects are also genetic because they are mediated by biological processes.

Notwithstanding the intertwining of heredity and environment, it is possible to estimate the extent to which differences between individuals on an attitude or trait can be attributed to genetic versus environmental factors. That is, within a particular range of environmental and genetic "values" or "scores" (namely, the range in the sample), it is possible to estimate whether interindividual differences reflect variation in the environmental scores and/or the genetic scores. Estimates of genetic influence are labeled *heritability coefficients*.

Note that heritability coefficients do not indicate the extent to which characteristics are genetically caused (which, as mentioned earlier, is impossible to determine). Rather, they indicate the extent to which variation on the characteristic in the sample is attributable to genetic differences. Any genetic or environmental influences that apply uniformly to all members of the sample will not be reflected in this statistic. For example, "two-leggedness in humans is highly genetically determined, but differences in leggedness among humans are mostly due to environmental accident" (Loehlin & Nichols, 1976, p. 1); thus, individual differences in leggedness would generate a low heritability coefficient despite the predominantly genetic basis of two-leggedness.

Heritability coefficients are dependent on the variability of environmental and genetic scores in the sample. If members of a sample were genetically identical, then any variation in phenotype would necessarily be due to environmental factors. If members of a sample had experienced identical environments, then any variation in phenotype would necessarily be due to genetic factors. To the extent that a sample is representative of a larger population in terms of the heterogeneity of genes and environments, heritability coefficients reflect the percentage of the variation in a characteristic among members of the population that is attributable to genetic factors.

Genetic influences also do not imply that the characteristic is unchangeable. To take a simple example, hair color is genetically determined but is completely malleable. Thus, learning that attitudes or traits have significant heritabilities does not mean they are inevitable or impossible to alter (although Tesser, 1993, has speculated that heritable attitudes may have a biological substrate that makes attitude change more difficult). For instance, if members of a population have been exposed to very similar environments with regard to a particular characteristic (e.g., they have all been exposed to extensive propaganda regarding a particular belief), the characteristic (belief) will yield a high heritability coefficient in that sample even though a different environment would have produced very different scores (beliefs).

Turning to a more specific issue, how could genes produce particular evaluations of objects by individuals? First, it is extremely unlikely that there are direct, one-to-one connections between genes and attitudes (e.g., a gene that causes attitudes toward capital punishment) or even many-to-one connections (e.g., a set of genes that, together, cause attitudes toward capital punishment). Rather, genes probably establish general predispositions or natural inclinations, which then shape environmental experiences in ways that increase the likelihood of the individual developing specific traits and attitudes. For example, children who are naturally small for their age might be picked on by other children more than their larger peers. As a result, these children might develop anxieties about social interaction, with consequences for their personality (e.g., introversion) and their attitudes (e.g., dislike for parties).

What are some specific genetically influenced characteristics that might systematically bias environmental experiences so as to induce particular attitudes? Tesser (1993) identified several possibilities, including intelligence, sensory structures, and temperament. Intelligence is widely—though not universally—viewed as having a heritable component (e.g., DeFries, Plomin, & LaBuda, 1987; Snyderman & Rothman, 1987). Intelligence could plausibly be linked to many attitudes, ranging from enjoyment of specific intellectual activities like reading and chess to attitudes toward more global targets like education and the role of computers in our lives. In addition, if attitudes toward controversial issues are influenced systematically by cognitive reasoning, then intelligence might also contribute to a genetic component in those attitudes. Sensory structures are inarguably genetically based, at least in part, and could influence preferences for various types of sensory experiences. For example, taste differences could affect attitudes toward chocolate, hearing sensitivity could affect attitudes toward loud music, and differences in inner-ear structures that maintain balance could affect attitudes toward roller coaster rides. Personality and temperament characteristics have been a central focus of behavioral genetics research. Evidence exists to support genetic and biochemical components of several personality traits, including sociability, neuroticism, and sensation seeking (e.g., Bouchard & McGue, 1990; Loehlin, 1989; Loehlin & Nichols, 1976; Tellegen et al., 1988; Zuckerman, 1995). These broad traits could influence a wide range of attitudes, with some obvious examples being sociability affecting attitudes toward meeting new people, neuroticism affecting attitudes toward alcohol, and sensation seeking affecting attitudes toward skydiving. In a nonattitudinal domain, Jockin, McGue, and Lykken (1996) found that genetic factors affecting personality accounted for a substantial portion of the heritability of a different construct, divorce risk. That is, the heritability of divorce risk was shown to be related to genetically based differences in personality.

Thus, there are many characteristics, themselves having a genetic component, that could affect individuals' attitudes. These variables constitute potential mediators of the genes–attitudes relation. In other words, these variables might be mediating mechanisms that underlie connections between genes and attitudes.

Past Research on Attitude Heritability

As mentioned above, researchers have shown that individual differences on a variety of broad personality factors are partly attributable to genetic differences (e.g., Loehlin & Nichols, 1976; Tellegen et al., 1988). These factors, such as sociability, dominance, and self-acceptance, are generally presumed to encompass many specific attitudes. There have also been demonstrations that specific behaviors (which may imply specific attitudes) have significant heritabilities, including alcohol consumption (Partanen, Bruun, & Markkanen, 1966) and television viewing (Plomin, Corley, DeFries, & Fulker, 1990).

But what about the heritability of specific attitudes themselves? A small number of researchers have examined directly whether evaluations of individual targets (objects, behaviors, issues, etc.) contain a heritable component.

For example, Perry (1973) examined a sample of 84 pairs of twins (approximately half identical and half fraternal), who completed Likert-type items assessing attitudes toward alcohol, cigarettes, and coffee. Previous researchers had found that behavioral variability in each of these domains (e.g., amount consumed) was partly attributable to genetic influences, so Perry wanted to see whether the heritability of attitudes paralleled the behavioral findings. In fact, attitudes toward alcohol manifested a significant heritability coefficient, with genetic factors accounting for 51% of the variance in alcohol attitudes, whereas attitudes toward cigarettes and coffee did not yield significant heritability estimates.

Scarr and Weinberg (1981) administered the Authoritarianism scale (California *F*-Scale; Adorno, Frenkel-Brunswik, Levinson, & Sanford, 1950) to the members of 120 biological and 112 adoptive families, involving approximately 450 children. This scale consisted of 20 sociopolitical statements, to which respondents indicated their agreement or disagreement. The results showed generally nonsignificant correlations between the total authoritarianism scores of members of adoptive families (except husband–wife) but consistently significant correlations between the total scores of members of biological families. On the basis of some further analyses involving IQ scores, the authors hypothesized that the genetic transmission of verbal ability partly accounted for the biological component of authoritarianism.

Arvey, Bouchard, Segal, and Abraham (1989) studied 34 pairs of identical twins who were reared apart. These participants completed a 20-item job satisfaction questionnaire. Results showed that total job satisfaction scores yielded a significant heritability estimate, with approximately 30% of the variance in job satisfaction being attributable to genetic factors.

In a related study from the same laboratory, Keller, Bouchard, Arvey, Segal, and Dawis (1992) administered a work values inventory to 43 pairs of twins who were reared apart (23 identical and 20 fraternal). Six composite scores for work values were computed from respondents' expressed preferences for 20 individual job outcomes (e.g., a composite score for the value attached to "achievement outcomes"), and all six yielded significant heritability coefficients, with the proportions of variance accounted for ranging from 18% to 56% ($M = 38\%$).

Waller, Kojetin, Bouchard, Lykken, and Tellegen (1990) surveyed 84 pairs of twins who were raised apart (53 identical and 31 fraternal) and more than 800 pairs of twins who were reared together (approximately 450 identical and 350 fraternal). Five questionnaires measuring religious attitudes and interests were completed by at least some participants: interest in choosing a religious occupation, involvement in religious activities during leisure time, religious fundamentalism, religious interests, and religious values. All five measures yielded significant heritability coefficients, accounting for between 41% and 52% of the interindividual variance.

In the largest studies of genetic variability in specific attitudes, Eaves et al. (1989) reported the results of two surveys, one involving almost 3,000 pairs of same-sex twins in Australia (approximately 2,000 identical and 1,000 fraternal) and the other involving approximately 700 same-sex twins in Great Britain (approximately 450 identical and 250 fraternal). Australian respondents completed a 50-item measure of conservatism (Wilson & Patterson, 1968), which consisted of one- or two-word items (e.g., "death penalty," "hippies," "white superiority," "jazz," and "bible truth") to which people answered "yes," "?," or "no." Thirty-three of the 50 items yielded significant heritability estimates, which ranged from 21% to 51% (see Martin et al., 1986). British respondents completed a 60-item public opinion inventory (Eysenck, 1951), which consisted of attitude statements on a variety of issues, including crime, religion, and race (e.g., "Crimes of violence should be punished by flogging," "A person should be free to take his own life, if he wishes to do so, without any interference from society," "The average man can live a good enough life without religion," and "The practical man is of more use to society than the thinker"); respondents indicated the extent of their agreement or disagreement with each statement on a 5-point scale. Heritability estimates for individual items ranged from 1% to 62%, with a median of 39%.

When the findings across different studies are examined, there appears to have been some stability in the kinds of attitudes that have yielded high heritabilities. Though not perfect, there has been a consistent tendency for attitudes toward the treatment of criminals (e.g., death penalty, flogging) to produce high heritability coefficients. Another domain of attitudes that has appeared heritable is religious attitudes—not specific religious affiliations, but general views about the value of religion (see Eaves et al., 1989). Attitudes toward authority and toward unconventional behavior have also yielded high heritability estimates in more than one study. In contrast, items that have yielded little evidence of heritability have included attitudes toward political ideologies (e.g., socialism, capitalism) and attitudes toward behaviors by young people (e.g., teenage drivers, pajama parties).

The Present Study

In the present study, we examined the genetic basis of individual differences in attitudes by collecting data from a large number of monozygotic (identical) and dizygotic (fraternal) twins. We assessed a wide range of attitude topics, including specific objects (e.g., sweets, roller coaster rides), social issues (e.g., capitalism, abortion on demand), and behaviors (e.g., playing chess, exercising). Many of these attitudes had never before been measured in twin research. By comparing the correlations within identical and fraternal twins, we could estimate the amounts of variance between individuals in attitudinal responses that were attributable to genetic factors. We also calculated estimates of environmental influences on the attitudes.

We had several goals in this research. One goal was to test the replicability of past findings on the heritability of attitudes. If individual differences in some attitudes really are strongly genetically determined, then they should yield high heritability coefficients across studies (although, of course, sampling variability and measurement error can produce fluctuating results). As mentioned earlier, it is possible to identify attitude domains that have produced either high or low heritabilities; we wanted to confirm these findings in another large-sample study.

A second (and more interesting) goal was to explore possible mediators of genetic effects on attitudes. We hoped to identify variables that might underlie gene–attitude relations. This issue is

complex, so we wanted to begin exploring it by simply obtaining some preliminary evidence. We measured several possible mediators directly through self-report assessments of physical characteristics (athleticism, appearance), academic achievement (as a proxy for intellectual abilities), and personality factors. We tested whether these factors were themselves heritable and, if so, whether they shared genetic variance with heritable attitudes. That is, we examined whether attitudes and potential mediators were correlated at the genetic level. Significant genetic correlations are consistent with (though not definitive about) the hypothesis that one variable's heritability is attributable to the heritability of the other variable. For example, if attitudes toward reading proved to be heritable and also correlated at the genetic level with a measure of intelligence that was itself heritable, one interpretation could be that attitudes toward reading were to some extent heritable because intelligence was heritable. For any attitude–mediator pairings that shared genetic variance, we also examined mediation at the phenotypic level (i.e., whether the phenotypic covariation between the variables was consistent with a causal model going from the mediator to the attitude). Finally, we also conducted analyses that explored whether potential mediators were involved in the heritability of all of the attitudes, not just particular attitudes. Specifically, we tested whether the strength of the correlations between the possible mediators and attitude scores predicted the heritabilities of the attitudes. If attitudes that correlate highly with a mediator variable yield higher heritabilities than do attitudes that do not correlate with the mediator variable, then the mediator might be a mechanism through which genes affect the set of attitudes. For example, if the heritability coefficients of a set of attitudes correlated with the correlations between the attitudes and the personality trait of sociability, and if sociability were itself heritable, then sociability would be implicated as a possible explanation of why or how the attitudes yielded significant heritabilities.

A third goal of our research was to gather data relevant to an idea put forward by Tesser (1993). Tesser hypothesized that attitudes that are highly heritable might have a biological basis that makes attitude change difficult. Because people find it difficult or uncomfortable to change these attitudes (and therefore do not like to do so), they may develop psychological defenses to "protect" them. As a result, these attitudes may become "stronger" in a psychological sense. For example, "niche-building" might occur (see Plomin, DeFries, & Loehlin, 1977; Scarr & McCartney, 1983), such that individuals seek out environments that are compatible with their highly heritable attitudes or even construct their own environments to protect these attitudes.

Tesser (1993; Crelia & Tesser, 1996; Tesser & Crelia, 1994) has tested this idea in several ingenious ways. In all of his studies, attitudes were selected for use that had been shown by Eaves et al. (1989) to have either high or low heritability coefficients. In one study, respondents were shown to provide their answers more quickly for high than for low heritability attitudes. In another study, individuals were found to be less affected by conformity pressure when reporting high than when reporting low heritability attitudes. In a third study, interpersonal similarity on high heritability attitudes was shown to affect liking more than similarity on low heritability items. Finally, in two studies, people found agreement feedback more reinforcing when it was based on highly heritable attitudes than when it was based on less heritable attitudes. All of these results suggest that attitude strength is related to attitude heritability.

We examined this issue in a different way: We measured self-reported attitude strength for every item. We expected that attitudes that yielded high heritability coefficients would also yield high average strength ratings.

Method

Participants

Pairs of adult twins were recruited through advertisements in local newspapers asking for twins to participate in psychological research in return for monetary payment (the specific amount paid to participants depended on the set of questionnaires they were asked to complete). Two samples of twins were collected, one in London, Ontario, Canada, and one in Vancouver, British Columbia, Canada. Participants were involved in either the Western Ontario Twin Project or the University of British Columbia Twin Project, which are ongoing behavioral genetic studies of personality and mental ability.

The full set of dependent measures reported in this article was completed by a total of 672 participants, consisting of 195 pairs of monozygotic (MZ) twins (128 female pairs and 67 male pairs) and 141 pairs of same-sex dizygotic (DZ) twins (97 female pairs and 44 male pairs). Zygosity was determined through a questionnaire designed by Nichols and Bilbro (1966), which has a reported accuracy of 93%, as compared with the results of blood typing (Kasriel & Eaves, 1976). The mean age of the participants was 30.40 years (29.96 for the identical twins, and 31.02 for the fraternal twins).

Dependent Measures

Along with other questionnaires unrelated to the present article, participants completed an attitude survey at home and returned it by mail. The survey assessed participants' favorability toward 30 targets (including controversial issues, personal activities, and social settings). The full set of attitude targets is presented in Table 1. Each item was phrased, "My overall attitude toward [name of issue] is: ____", with possible answers ranging from −3 (*extremely unfavorable*) through 0 (*neutral*) to 3 (*extremely favorable*). Immediately after indicating their favorability toward the target, participants answered two questions that assessed the strength of their attitude: "How important is this attitude to you?" with possible answers ranging from 0 (*not at all important*) to 6 (*extremely important*), and "How strongly do you hold this attitude?" with possible answers ranging from 0 (*not at all strongly*) to 6 (*extremely strongly*).

Participants also provided ratings of themselves on 20 personality traits, each of which represented a subscale of the Personality Research Form (Jackson, 1984). Three adjectives described each trait (e.g., "humble, self-blaming, puts self down," "ambitious, competitive, achieving"), and participants rated the self-descriptiveness of the trait on a scale from 0 (*not at all*) to 6 (*very much*). The full set of traits (as reflected by one of the three adjectives) is presented in Table 2.

Participants also rated themselves on four additional items, two of which assessed their physical capabilities: "How athletic (naturally good at physical activities) are you?" with possible answers ranging from 0 (*not at all athletic*) to 6 (*extremely athletic*), and "How physically strong are you?" with possible answers ranging from 0 (*not at all strong*) to 6 (*extremely strong*). The next two items assessed participants' physical attractiveness: "How would you rate your own physical attractiveness?" with possible answers ranging from 0 (*not at all attractive*) to 6 (*extremely attractive*), and "Do other people consider you to be good looking?" with possible answers ranging from 0 (*not at all good looking*) to 6 (*extremely good looking*).

Table 1
Genetic Analyses of Individual Attitude Items

Attitude	Correlations		Best fitting model		Estimates			
	MZ	DZ	Model	Fit	a^2	c^2	e^2	d^2
Doing crossword puzzles	.46	.11	ADE	$\chi^2(3) = 1.47$, *ns*	.02		.55	.43
Death penalty for murder	.45	.33	AE	$\chi^2(4) = 5.61$, *ns*	.50	.00	.50	
Sweets	.36	.23	ACE	$\chi^2(3) = 1.41$, *ns*	.22	.12	.65	
Open-door immigration	.47	.20	AE	$\chi^2(4) = 2.18$, *ns*	.46		.54	.00
Doing athletic activities	.41	.26	AE	$\chi^2(4) = 2.18$, *ns*	.44	.00	.56	
Voluntary euthanasia	.45	.21	AE	$\chi^2(4) = 2.29$, *ns*	.44		.56	.00
Smoking	.49	.38	ACE	$\chi^2(3) = 2.51$, *ns*	.31	.21	.48	
Being the center of attention	.31	.14	AE	$\chi^2(4) = 5.52$, *ns*	.28		.71	.00
Separate roles for men and women	.27	.26	CE	$\chi^2(4) = 2.54$, *ns*	.00	.26	.74	
Education	.30	.14	AE	$\chi^2(4) = 11.64$, $p < .02$	.32		.68	.00
Making racial discrimination illegal	.37	−.01	ADE	$\chi^2(3) = 4.71$, *ns*	.00		.66	.34
Loud music	.53	.49	ACE	$\chi^2(3) = 1.15$, *ns*	.11	.43	.46	
Getting along well with other people	.20	.19	AE	$\chi^2(4) = 19.61$, $p < .001$	.28	.00	.72	
Capitalism	.41	.19	AE	$\chi^2(4) = 4.67$, *ns*	.39		.61	.00
Playing organized sports	.52	.10	ADE	$\chi^2(3) = 0.46$, *ns*	.00		.48	.52
Big parties	.44	.30	ACE	$\chi^2(3) = 2.14$, *ns*	.32	.13	.54	
Playing chess	.38	.22	AE	$\chi^2(4) = 2.76$, *ns*	.38	.00	.62	
Looking my best at all times	.42	.14	ADE	$\chi^2(3) = 3.13$, *ns*	.10		.55	.35
Abortion on demand	.53	.28	AE	$\chi^2(4) = 1.00$, *ns*	.54	.00	.46	
Public speaking	.34	.26	ACE	$\chi^2(3) = 1.91$, *ns*	.20	.15	.65	
Playing bingo	.37	.33	CE	$\chi^2(4) = 7.07$, *ns*	.00	.33	.65	
Wearing clothes that draw attention	.38	.28	ACE	$\chi^2(3) = 2.39$, *ns*	.24	.15	.61	
Easy access to birth control	.24	.27	CE	$\chi^2(4) = 5.35$, *ns*	.00	.25	.75	
Exercising	.35	.17	AE	$\chi^2(4) = 2.77$, *ns*	.36		.64	.00
Organized religion	.43	.21	AE	$\chi^2(4) = 3.17$, *ns*	.45		.55	.00
Being the leader of groups	.40	.08	ADE	$\chi^2(3) = 2.13$, *ns*	.00		.59	.41
Reading books	.55	.24	ADE	$\chi^2(3) = 4.31$, *ns*	.37		.43	.20
Castration as punishment for sex crimes	.39	.29	ACE	$\chi^2(3) = 0.48$, *ns*	.17	.21	.62	
Being assertive	.28	.27	CE	$\chi^2(4) = 4.00$, *ns*	.00	.28	.72	
Roller coaster rides	.50	.31	AE	$\chi^2(4) = 2.82$, *ns*	.52	.00	.48	

Note. Estimates of .00 mean that the component was tested but did not account for a significant amount of variance. MZ = monozygotic twins; DZ = dizygotic twins; A (a^2) = additive genetic variance; E (e^2) = nonshared environmental variance; D (d^2) = nonadditive genetic variance; C (c^2) = shared environmental variance.

Finally, participants were asked to report their grade point average (GPA) in their final year of high school (as a percentage) and the highest level of education they had completed. These academic achievement measures were taken as gross indicants of intellectual ability.

Heritability Analyses

Analyses were performed to estimate the amounts of variance in attitude responses (and in other dependent measures) within our sample that were attributable to genetic and environmental factors. We conducted these analyses on each individual item in the questionnaire (attitudes, personality, athleticism, attractiveness, and grades), as well as on composite variables formed on the basis of factor analyses (reported below).

For each dependent measure, covariance matrices were computed between each pair of twins for MZ and DZ pairs separately, with the computer program PRELIS (Jöreskog & Sörbom, 1989b). A model-fitting approach, by means of the computer program LISREL VII (Jöreskog & Sörbom, 1989a), was applied to these covariance matrices to estimate the proportion of the variance attributable to additive genetic (a), shared environmental (c), and nonshared environmental (e) factors (ACE model). The obtained maximum-likelihood parameter estimates of these components were squared to form a^2 (percentage of variance attributable to additive genetic factors—i.e., genetic "main effects" from the two parents), c^2 (percentage of variance attributable to environmental factors that were shared by the twins), and e^2 (percentage of variance attributable to environmental factors that were unique to one of the twins). For those dependent measures in which the ratio of the MZ correlation to the DZ correlation was greater than 2, it was possible to test for nonadditive genetic effects (d)—that is, genetic influences resulting from an interaction of the two parents' contributions. For these measures, a model specifying additive genetic variance, nonadditive genetic variance, and nonshared environmental variance was tested (ADE model). The obtained maximum-likelihood parameter estimates of these components were squared to form estimates of a^2, d^2 (percentage of variance attributable to nonadditive genetic factors), and e^2.

Three reduced models for each measure were also tested that systematically removed one component of variance. The first removed additive genetic effects, the second removed shared environmental effects (or nonadditive genetic effects), and the third removed both types of effects. A significant change in the chi-square analysis from the full model to the chi-square analysis from a reduced model indicated that the remaining parameters could not independently account for the variance. The goodness of fit of all models was determined by means of Akaike's (1987) information criterion = $\chi^2 - 2$ (*df*), which gives a superior indication of fit in models with a small number of parameters (Bollen, 1989), and by the chi square itself. Because a model that has nonadditive genetic variance without additive genetic variance is biologically implausible (see Neale & Cardon, 1992), the DE model was never tested.

Table 2
Genetic Analyses of Individual Nonattitude Items

Category and item	Correlations		Best fitting model		Estimates			
	MZ	DZ	Model	Fit	a^2	c^2	e^2	d^2
Personality								
Humble	.60	.27	AE	$\chi^2(4) = 3.47$, *ns*	.58		.42	.00
Ambitious	.46	.24	AE	$\chi^2(4) = 0.18$, *ns*	.46	.00	.54	
Friendly	.35	.25	AE	$\chi^2(4) = 14.72$, $p < .05$	.42	.00	.58	
Aggressive	.27	.09	ADE	$\chi^2(3) = 0.65$, *ns*	.06		.72	.22
Independent	.27	.09	ADE	$\chi^2(3) = 1.38$, *ns*	.11		.74	.15
Inconsistent	.16	.07	AE	$\chi^2(4) = 1.42$, *ns*	.16		.84	.00
Precise	.31	.20	AE	$\chi^2(4) = 2.00$, *ns*	.33	.00	.67	
Defensive	.35	.25	AE	$\chi^2(4) = 4.06$, *ns*	.38	.00	.62	
Dominant	.24	.12	AE	$\chi^2(4) = 0.68$, *ns*	.23	.00	.77	
Persistent	.36	.10	ADE	$\chi^2(3) = 0.81$, *ns*	.00		.63	.37
Exhibitionistic	.44	.23	AE	$\chi^2(4) = 4.25$, *ns*	.43	.00	.57	
Fearful	.26	.01	ADE	$\chi^2(3) = 2.07$, *ns*	.00		.76	.24
Impulsive	.26	.03	AE	$\chi^2(4) = 1.98$, *ns*	.23		.77	.00
Sympathetic	.35	.25	AE	$\chi^2(4) = 2.57$, *ns*	.39	.00	.61	
Neat	.25	.22	CE	$\chi^2(4) = 5.34$, *ns*	.00	.23	.77	
Playful	.29	.14	AE	$\chi^2(4) = 1.21$, *ns*	.30		.70	.00
Aesthetic	.37	.13	ADE	$\chi^2(3) = 9.30$, $p < .05$	.04		.57	.39
Obliging	.11	.18	CE	$\chi^2(4) = 9.29$, $p < .05$	.00	.14	.86	
Dependent	.26	.02	ADE	$\chi^2(3) = 5.43$, *ns*	.00		.75	.25
Inquiring	.22	.13	AE	$\chi^2(4) = 5.05$, *ns*	.25	.00	.75	
Athleticism								
Athletic	.60	.27	AE	$\chi^2(4) = 3.47$, *ns*	.58		.42	.00
Strong	.52	.21	AE	$\chi^2(4) = 12.87$, $p < .05$	.51		.49	.00
Attractiveness								
Physical attractiveness	.37	.25	AE	$\chi^2(4) = 10.74$, $p < .05$	.42	.00	.58	
Good looking to other people	.47	.28	AE	$\chi^2(4) = 11.95$, $p < .05$	.53	.00	.47	
Academic								
GPA in final year of high school	.61	.25	ADE	$\chi^2(3) = 0.15$, *ns*	.41		.40	.19
Level of completed education	.82	.57	ACE	$\chi^2(3) = 0.23$, *ns*	.49	.33	.18	

Note. Estimates of .00 mean that the component was tested but did not account for a significant amount of variance. MZ = monozygotic twins; DZ = dizygotic twins; A (a^2) = additive genetic variance; E (e^2) = nonshared environmental variance; D (d^2) = nonadditive genetic variance; C (c^2) = shared environmental variance; GPA = grade point average.

Results

Genetic Analyses of Individual Items

Table 1 summarizes the genetic analyses of the individual attitude items: the intra-twin correlations for MZ pairs and for DZ pairs, the best fitting model (the full model or one of the three reduced models) with its associated chi square, and the estimates for each of the elements in the best fitting model (a^2, e^2, and c^2 or d^2). Because only one of the ACE or ADE models could be tested for each measure, either c^2 or d^2 could not be estimated; the estimates that were not tested are left blank in the table. Table 2 presents the same statistics for the individual nonattitude items (personality, athleticism, attractiveness, and academic achievement).

As can be seen in Table 1, 26 of the 30 attitude items yielded significant genetic effects, because of either additive or nonadditive factors (or both). We summed the additive and nonadditive genetic effects to form h^2, or heritability coefficients. The estimates for h^2 ranged from 0 to .57, with a median of .35. The five items with the largest genetic components (greater than or equal to .50) were attitudes toward reading books, abortion on demand, playing organized sports, roller coaster rides, and the death penalty for murder. The four items with the smallest genetic components (no genetic effect) were attitudes toward separate roles for men and women, playing bingo, easy access to birth control, and being assertive.

As can be seen in Table 2, 18 of the 20 personality items yielded significant additive and/or nonadditive genetic effects. The estimates for h^2 ranged from 0 to .58, with a median of .29. The five items with the largest genetic components (greater than .40) were humble, ambitious, exhibitionistic, aesthetic, and friendly. The three items with the smallest genetic components (less than .20) were neat, obliging, and inconsistent.

Table 2 also shows that both athleticism items yielded large heritability coefficients (greater than .50), as did both attractiveness items (greater than .40). Finally, both measures of academic achievement also yielded high heritability coefficients (greater than .40).

It is also worth noting that nonshared environmental factors (i.e., unique experiences of each member of a twin pair) were the most powerful contributors to variability in both sets of items. For the attitude items, e^2 ranged from .43 to .75, with a median value of .60. For the personality items, e^2 ranged from .42 to .86, with a median value of .71. The other nonattitude items (athleticism, attractiveness, academic achievement) also yielded high e^2, with the exception of level of completed

education, where e^2 fell to .18 (though this was still significantly greater than 0).

In sharp contrast to nonshared environmental factors, shared environmental factors (i.e., experiences common to both members of a twin pair) generally contributed little to the variance in the items. For the attitude items, c^2 was significantly greater than 0 in only 11 of the 17 analyses in which it was tested, with a median value of .15. For the personality items, c^2 was significantly greater than 0 in only 2 of the 10 analyses in which it was tested, with a median value of 0. The same was true for the other nonattitude items, for which c^2 was significant in only one of three analyses.

Factor Analyses of Individual Items

A principal components factor analysis, with varimax rotation, was conducted on the 30 attitude items. This analysis yielded nine factors with eigenvalues greater than 1. Table 3 presents the factor loadings of each item on each of the factors. The factors generally seemed interpretable on the basis of high-loading items. Factor 1 reflected Attitudes Toward Athleticism, with high loadings for attitudes toward doing athletic activities, playing organized sports, and exercising. Factor 2 reflected Attitudes Toward Leadership, with high loadings for attitudes toward being the leader, being the center of attention, public speaking, and being assertive. Factor 3 reflected Attitudes Toward the Preservation of Life, with high loadings for attitudes toward abortion on demand, voluntary euthanasia, easy access to birth control, and organized religion (reversed). Factor 4 reflected Attitudes Toward Sensory Experiences, with high loadings for attitudes toward loud music, smoking, roller coaster rides, and big parties. Factor 5 reflected Attitudes Toward Intellectual Pursuits, with high loadings for attitudes toward reading books, doing crossword puzzles, playing chess, and education; attitudes toward capitalism also loaded highly on this factor. Factor 6 reflected Attitudes Toward Equality, with high loadings for attitudes toward making racial discrimination illegal, separate roles for men and women (reversed), open-door immigration policies, and getting along well with others. Factor 7 reflected Attitudes Toward Outward Appearance, with high loadings for attitudes toward looking my best at all times, wearing attention-grabbing clothing, and getting along well with other people. Factor 8 reflected Attitudes Toward the Treatment of Criminals, with high loadings for attitudes toward castration as a punishment for sex crimes and the death penalty for murder. Finally, Factor 9 was more difficult to interpret; we labeled it Attitudes Toward Sweets and Games, with high loadings for attitudes toward sweets, doing crossword puzzles, and playing bingo.

A principal components factor analysis was also conducted on the 20 personality trait items, again with varimax rotation. This analysis revealed five factors with eigenvalues greater than 1.

Table 3
Factor Analysis of Individual Attitude Items

Attitude	Factor								
	1	2	3	4	5	6	7	8	9
Doing crossword puzzles	−.01	−.11	−.06	.05	**.55**	−.05	−.03	.16	**.44**
Death penalty for murder	.07	−.06	.04	−.01	−.11	−.17	.06	**.74**	.06
Sweets	.11	.01	.09	−.13	−.04	.11	.08	−.08	**.73**
Open-door immigration	−.20	.15	−.16	.03	−.07	**.46**	−.13	−.33	.20
Doing athletic activities	**.85**	.08	.05	.11	.05	−.05	.05	−.03	.03
Voluntary euthanasia	.01	.08	**.71**	−.03	.06	.15	−.06	.21	.11
Smoking	−.35	−.03	.11	**.57**	.09	−.10	−.01	.24	−.09
Being the center of attention	−.01	**.72**	.01	.15	−.12	−.08	.15	−.04	.16
Separate roles for men and women	.03	.05	−.25	−.05	−.03	**−.56**	−.01	.14	.08
Education	.17	−.10	−.07	−.17	**.44**	.37	.30	.05	−.06
Making racial discrimination illegal	−.02	.07	.00	−.01	.05	**.73**	−.02	.04	.08
Loud music	.12	.02	.02	**.78**	−.12	.04	.04	−.10	−.04
Getting along well with other people	.22	.05	.00	−.02	−.05	**.40**	**.44**	.17	.02
Capitalism	.03	.08	−.09	−.01	**.48**	−.29	.29	.06	−.21
Playing organized sports	**.68**	.06	−.06	.21	.13	−.03	−.02	.20	.15
Big parties	.21	.32	.10	**.46**	−.10	.06	.34	−.03	.06
Playing chess	.08	.22	.08	−.06	**.55**	−.06	−.15	−.13	.04
Looking my best at all times	.06	.02	−.03	−.04	−.01	−.08	**.79**	.11	.02
Abortion on demand	.02	.05	**.73**	.08	.13	−.09	.05	−.06	.15
Public speaking	.14	**.58**	−.10	.03	.30	.12	−.10	−.01	−.12
Playing bingo	−.12	−.10	.04	.36	.13	−.04	.06	.29	**.43**
Wearing clothes that draw attention	−.08	.38	.10	.21	−.15	−.05	**.50**	−.12	.26
Easy access to birth control	−.01	−.06	**.62**	.10	.07	.28	.26	−.06	−.07
Exercising	**.79**	.13	.04	−.04	.00	.01	.12	−.04	−.11
Organized religion	−.02	−.01	**−.62**	−.12	.23	.07	.19	.00	.11
Being the leader of groups	.12	**.81**	.02	.00	.09	.00	−.04	.05	−.02
Reading books	−.01	.05	.10	−.12	**.62**	.21	−.09	−.15	−.01
Castration as punishment for sex crimes	.00	.08	.00	−.02	−.03	.06	.05	**.74**	−.03
Being assertive	.09	**.52**	.17	−.13	.10	.11	.19	.03	−.25
Roller coaster rides	.22	.04	.09	**.52**	−.10	.03	−.09	−.05	.02

Note. Loadings greater than .40 are presented in boldface.

Table 4 presents the factor loadings. Again, the factors seemed interpretable. Factor 1 reflected Aggressiveness, with high loadings for the traits dominant, aggressive, exhibitionistic, defensive, and impulsive. Factor 2 reflected Sociability, with high loadings for playful, friendly, aesthetic, and caring. Factor 3 reflected Dependence, with high loadings for dependent, humble, fearful, obliging, and defensive. Factor 4 reflected Persistence, with high loadings for independent, persistent, inquiring, precise, and ambitious. Finally, Factor 5 reflected Obsessiveness, with high loadings for neat, inconsistent (reversed), precise, and impulsive (reversed).

Genetic Analyses of Factors and Composite Measures

Table 5 summarizes the results of the heritability analyses of the nine attitude factors that emerged from the factor analysis. Individuals' scores for each factor were calculated by weighting all 30 items according to the factor loadings presented in Table 3. Table 6 summarizes the same statistics for the heritability analyses of the five personality factors, using the weights of the 20 items presented in Table 4. Table 6 also presents the results of heritability analyses of three supplementary composite measures: the sum of the two athleticism items (which correlated significantly, $r[670] = .60$, $p < .001$), the sum of the two attractiveness items (which correlated significantly, $r[670] = .75$, $p < .001$), and the sum of the standardized values of the GPA and completed level of education variables (which correlated significantly, $r[670] = .36$, $p < .01$).

As can be seen in Table 5, six of the nine attitude factors yielded significant additive and/or nonadditive genetic components, with the estimates for h^2 ranging from 0 to .66; the median h^2 across the nine factors was .41. The three factors yielding the largest genetic components were Attitudes Toward the Preservation of Life, Attitudes Toward Equality, and Attitudes Toward Athleticism. The three factors yielding the smallest genetic components were Attitudes Toward Intellectual Pursuits, Attitudes Toward the Treatment of Criminals, and Attitudes Toward Sweets and Games.

As can be seen in Table 6, three of the five personality factors yielded significant heritability coefficients, with the estimates for h^2 ranging from 0 to .47. The composite Athleticism, Attractiveness, and Academic measures also yielded significant genetic effects, with the estimates for h^2 ranging from .54 to .61.

Paralleling the analyses of the individual items, nonshared environmental factors constituted the most powerful variable for predicting variance in the factors within our sample. For the attitude factors, e^2 ranged from .34 to .63, with a median value of .49. For the personality factors, e^2 ranged from .53 to .74, with a median value of .62. Analyses of the supplementary composite measures also yielded significant estimates for e^2, ranging from .22 to .46.

Shared environmental factors were somewhat more important for predicting the attitude factors than they were for the individual attitude items, with four of the seven analyses in which they were tested yielding a significant estimate for c^2, with a median value across the seven analyses of .26. Two of the three analyses of the personality factors in which c^2 was tested yielded significant estimates, with a median value of .26. Shared experiences contributed reliably to variance in only one of the supplementary composite measures: academic achievement.

Table 4
Factor Analysis of Individual Personality Items

Personality item	Factor 1	2	3	4	5
Humble	−.06	−.21	**.67**	.11	−.27
Ambitious	.36	.28	−.20	**.43**	.27
Friendly	−.09	**.76**	−.04	.01	.13
Aggressive	**.75**	−.12	.11	.09	−.08
Independent	−.03	−.05	−.22	**.71**	−.03
Inconsistent	.25	.12	.18	.10	**−.70**
Precise	.10	−.06	.04	**.44**	**.59**
Defensive	**.54**	−.16	**.43**	.12	−.16
Dominant	**.79**	−.04	−.01	.12	.25
Persistent	.11	.13	−.06	**.65**	.25
Exhibitionistic	**.57**	.39	−.03	.01	−.10
Fearful	.01	−.33	**.61**	−.09	.15
Impulsive	**.53**	.15	.08	−.07	**−.48**
Sympathetic	−.33	**.51**	.37	.18	.11
Neat	−.06	.10	.16	.04	**.72**
Playful	.11	**.78**	−.10	.04	−.12
Aesthetic	.04	**.51**	.00	.36	−.13
Obliging	.13	.20	**.57**	−.08	.16
Dependent	.14	.16	**.68**	−.32	−.06
Inquiring	.14	.31	.18	**.56**	−.15

Note. Loadings greater than .40 are presented in boldface.

Phenotypic Intercorrelations Among Factors and Composite Measures

Tables 7 and 8 present the intercorrelations between the attitude factors, personality factors, and supplementary composite measures for MZ and DZ twins, respectively. Because of the large number of correlations, only those correlations that were significant at $p < .005$ (two tailed) are presented in boldface in the tables. Relatively few correlations were significant in both groups of twins (these correlations are presented in italics in the tables). We mention here just the correlations that were significant in both groups of twins and that involved the attitude factors.

Attitudes Toward Athleticism correlated only with self-reports of athletic ability, such that more positive attitudes toward athleticism were associated with greater athletic ability. Favorable attitudes toward leadership were associated positively with Aggressiveness, Sociability, and physical attractiveness, but negatively with Dependence. Attitudes Toward the Preservation of Life did not correlate significantly in both groups of twins with any personality or supplementary measures. Attitudes Toward Sensory Experiences, for which high scores reflected favorable attitudes toward intense experiences, correlated positively with Sociability and self-reports of athletic ability but negatively with Obsessiveness and academic achievement. Favorable attitudes toward intellectual pursuits were associated positively with Persistence; surprisingly, such attitudes correlated significantly with academic achievement only within the MZ twins. Attitudes Toward Equality did not correlate significantly in both groups of twins with any personality or supplementary variables. Favorable attitudes toward maintaining an attractive outward appearance were associated positively with Sociability and physical attractiveness. Attitudes Toward the Treatment of Criminals (for which high scores reflected support for severe punishment) correlated positively with Obses-

Table 5
Genetic Analyses of Attitude Factors

Attitudes factor	Correlations MZ	Correlations DZ	Best fitting model Model	Best fitting model Fit	Estimates a^2	Estimates c^2	Estimates e^2	Estimates d^2
Athleticism	.52	.36	AE	$\chi^2(4) = 3.84$, *ns*	.54	.00	.46	
Leadership	.40	.18	AE	$\chi^2(4) = 6.57$, *ns*	.41		.59	.00
Preservation of Life	.64	.32	AE	$\chi^2(4) = 3.60$, *ns*	.66	.00	.34	
Sensory Experiences	.59	.47	ACE	$\chi^2(3) = 4.64$, *ns*	.36	.26	.38	
Intellectual Pursuits	.53	.42	CE	$\chi^2(4) = 2.59$, *ns*	.00	.49	.51	
Equality	.53	.22	ADE	$\chi^2(3) = 2.29$, *ns*	.27		.45	.28
Outward Appearance	.41	.29	AE	$\chi^2(4) = 2.51$, *ns*	.45	.00	.55	
Treatment of Criminals	.52	.51	CE	$\chi^2(4) = 1.33$, *ns*	.00	.51	.49	
Sweets and Games	.38	.37	CE	$\chi^2(4) = 8.59$, *ns*	.00	.37	.63	

Note. Estimates of .00 mean that the component was tested but did not account for a significant amount of variance. MZ = monozygotic twins; DZ = dizygotic twins; A (a^2) = additive genetic variance; E (e^2) = nonshared environmental variance; D (d^2) = nonadditive genetic variance; C (c^2) = shared environmental variance.

siveness, but negatively with academic achievement. Finally, Attitudes Toward Sweets and Games did not correlate significantly in either group of twins with any personality or supplementary measures.

Shared Genetic Variance Between Attitude Factors and Potential Mediators

One way of exploring possible mediators of the heritability of a variable is to calculate the extent to which genetic variation is shared with another variable. If two variables share genetic variance, this means that genetic individual differences in one variable are correlated with genetic individual differences in the other variable. Such a pattern is consistent with the idea that the heritability of one variable mediates or is responsible for some or all of the heritability of the other (although, of course, which variable is doing the mediating is not indicated). That is, the heritability of one variable may be attributable to its genetic overlap with the other variable.

To obtain these statistics, we applied Cholesky or triangular decompositions (see Neale & Cardon, 1992) to the data. Similar to univariate heritability analyses, a Cholesky decomposition assesses whether the phenotypic correlations within MZ twins are higher than within DZ twins. In a Cholesky decomposition, however, cross-correlations within twin pairs (that is, the correlations between one twin's score on one of the variables and the other twin's score on the other variable) are examined to estimate the degree to which phenotypic correlations are due to common genetic and/or environmental factors. If the MZ cross-correlation is larger than the DZ cross-correlation, then a genetic correlation between the two variables is suggested. That is, genetic individual differences on one variable are correlated with genetic individual differences on the other variable.

For each of the six attitude factors that yielded significant heritability coefficients, we calculated the genetic correlation with each of the six potential mediators that also yielded significant heritability coefficients (three personality factors and the three

Table 6
Genetic Analyses of Personality Factors and Supplementary Composite Measures

Factor or measure	Correlations MZ	Correlations DZ	Best fitting model Model	Best fitting model Fit	Estimates a^2	Estimates c^2	Estimates e^2	Estimates d^2
Personality factors								
Aggressiveness	.44	.20	AE	$\chi^2(4) = 2.43$, *ns*	.43		.57	.00
Sociability	.43	.17	ADE	$\chi^2(3) = 5.71$, *ns*	.13		.53	.34
Dependence	.28	.23	CE	$\chi^2(4) = 7.26$, *ns*	.00	.26	.74	
Persistence	.38	.21	AE	$\chi^2(4) = 3.56$, *ns*	.38	.00	.62	
Obsessiveness	.29	.35	CE	$\chi^2(4) = 4.08$, *ns*	.00	.33	.67	
Supplementary composite measure								
Athleticism	.62	.43	AE	$\chi^2(4) = 13.42$, $p < .05$	.61	.00	.39	
Attractiveness	.47	.33	AE	$\chi^2(4) = 16.94$, $p < .05$	.54	.00	.46	
Academic	.79	.48	ACE	$\chi^2(4) = 1.23$, *ns*	.56	.22	.22	

Note. Estimates of .00 mean that the component was tested but did not account for a significant amount of variance. MZ = monozygotic twins; DZ = dizygotic twins; A (a^2) = additive genetic variance; E (e^2) = nonshared environmental variance; D (d^2) = nonadditive genetic variance; C (c^2) = shared environmental variance.

Table 7
Intercorrelations Between Attitude Factors, Personality Factors, and Supplementary Composite Measures: Monozygotic Twins

Factor or measure	Personality factor					Supplementary composite measure		
	Aggressiveness	Sociability	Dependence	Persistence	Obsessiveness	1	2	3
Attitude factors								
Athleticism	.07	**.17**	**−.15**	**.19**	−.03	***.56***	**.18**	**.14**
Leadership	***.40***	***.22***	***−.17***	.13	.09	**.17**	***.28***	.10
Preservation of Life	−.01	.02	**−.18**	.03	−.10	.08	.09	.09
Sensory Experiences	**.26**	***.24***	−.11	−.02	***−.27***	***.29***	.12	***−.16***
Intellectual Pursuits	−.05	−.11	.03	***.29***	.10	−.05	−.05	**.26**
Equality	**−.23**	.13	**.15**	**.19**	.08	−.05	.01	.13
Outward Appearance	.04	***.31***	.06	−.07	**.18**	.02	***.26***	−.07
Treatment of Criminals	.03	−.04	−.06	−.11	***.25***	.01	.04	***−.19***
Sweets and Games	−.01	.00	.04	−.08	.06	−.10	−.06	.08
Supplementary composite measure								
1. Athleticism	**.27**	***.24***	**−.25**	***.23***	−.05	—		
2. Attractiveness	**.20**	***.37***	−.13	**.19**	.02	***.44***	—	
3. Academic	−.06	.01	.03	***.23***	***.18***	.05	**.14**	—

Note. Correlations presented in boldface are significant at $p < .005$ (two tailed). Correlations that are significant in both groups of twins appear in italics.

supplementary composite variables). Cholesky decompositions also provide an estimate of the extent to which relations between variables are attributable to common environmental influences (i.e., to the same nonshared environmental experiences of the twins). Table 9 presents the genetic and environmental correlations for all pairings of the six attitude factors and the six potential mediators; correlations in boldface are significantly greater than 0.

These data provide some interesting ideas about why individual differences in certain attitudes were heritable, which we elaborate in the Discussion section. At this point, we simply summarize the significant genetic correlations. Attitudes Toward Athleticism shared a significant amount of genetic variance with self-reported athletic ability and with Persistence. Attitudes Toward Leadership showed genetic overlap with five of the six possible mediators: physical attractiveness, Sociability, Aggressiveness, Persistence, and academic achievement. Attitudes Toward the Preservation of Life produced significant genetic correlations with physical attractiveness and Sociability. Attitudes Toward Sensory Experiences shared genetic variance with Sociability, Aggressiveness, Persistence, and athleticism. Attitudes Toward Equality yielded significant genetic correlations with Sociability and academic achievement. Finally, Attitudes Toward Outward Appearance showed genetic overlap with Sociability and physical attractiveness.

The attitude factors did not, in general, show much overlap with the potential mediators in terms of being attributable to the same nonshared environmental experiences of the twins. Attitudes Toward Athleticism appeared to be influenced by the same environmental experiences as athletic ability. Attitudes Toward Leadership were associated with similar environmental experiences as Aggressiveness. Attitudes Toward Sensory Experiences were re-

Table 8
Intercorrelations Between Attitude Factors, Personality Factors, and Supplementary Composite Measures: Dizygotic Twins

Factor or measure	Personality factor					Supplementary composite measure		
	Aggressiveness	Sociability	Dependence	Persistence	Obsessiveness	1	2	3
Attitude factors								
Athleticism	−.04	.12	−.07	.10	.01	***.43***	.08	.15
Leadership	***.37***	***.17***	***−.22***	.13	.03	.15	***.25***	.13
Preservation of Life	−.03	.14	−.14	.12	−.16	.05	.11	.08
Sensory Experiences	.14	***.24***	−.03	−.08	***−.36***	***.17***	.10	***−.24***
Intellectual Pursuits	−.05	−.14	−.11	***.25***	−.04	.04	−.04	.12
Equality	−.13	***.27***	.06	.02	.00	−.04	.01	.15
Outward Appearance	.03	***.35***	.10	.01	.04	−.01	***.21***	−.13
Treatment of Criminals	.14	.00	.07	−.13	***.28***	.04	−.03	***−.20***
Sweets and Games	.05	.08	.15	−.10	−.04	−.09	.02	−.02
Supplementary composite measure								
1. Athleticism	.14	***.18***	−.14	***.28***	.06	—		
2. Attractiveness	.15	***.38***	−.10	.10	.11	***.31***	—	
3. Academic	−.02	−.06	−.04	***.29***	***.18***	.05	.01	—

Note. Correlations presented in boldface are significant at $p < .005$ (two tailed). Correlations that are significant in both groups of twins appear in italics.

Table 9
Genetic and Environmental Correlations Between Attitudes and Potential Mediators

Attitudes factor and mediator	h^2	Genetic correlation	Environmental correlation
Athleticism	.54		
Aggressiveness	.43	−.03	.06
Sociability	.47	.03	.19
Persistence	.38	**.25**	.11
Athleticism	.61	**.63**	**.30**
Attractiveness	.54	.10	.09
Academic ach.	.56	.17	.04
Leadership	.41		
Aggressiveness	.43	**.41**	**.37**
Sociability	.47	**.43**	.02
Persistence	.38	**.26**	.09
Athleticism	.61	.10	.15
Attractiveness	.54	**.55**	.01
Academic ach.	.56	**.22**	−.03
Preservation of Life	.66		
Aggressiveness	.43	−.13	.10
Sociability	.47	**.21**	−.10
Persistence	.38	.11	.03
Athleticism	.61	.05	.05
Attractiveness	.54	**.22**	−.02
Academic ach.	.56	−.04	.00
Sensory Experiences	.36		
Aggressiveness	.43	**.33**	.08
Sociability	.47	**.41**	.07
Persistence	.38	**−.28**	.14
Athleticism	.61	**.28**	**.20**
Attractiveness	.54	.14	.07
Academic ach.	.56	−.05	−.13
Equality	.55		
Aggressiveness	.43	−.19	−.17
Sociability	.47	**.44**	−.01
Persistence	.38	.17	.04
Athleticism	.61	.00	−.06
Attractiveness	.54	.11	−.08
Academic ach.	.56	**.24**	**−.24**
Outward Appearance	.45		
Aggressiveness	.43	.01	.04
Sociability	.47	**.36**	**.34**
Persistence	.38	−.11	.03
Athleticism	.61	−.09	.08
Attractiveness	.54	**.27**	**.21**
Academic ach.	.56	−.04	.06

Note. Correlations presented in boldface are significant at $p < .005$ (two tailed). h^2 = heritability coefficients; ach. = achievement.

lated to the same environmental experiences as athleticism. Attitudes Toward Equality showed a negative environmental correlation with academic achievement, which means that environmental experiences that were associated with positive attitudes toward equality also tended to be negatively associated with academic achievement. Finally, Attitudes Toward Outward Appearance were related to the same environmental experiences as were Sociability and physical attractiveness.

Testing Phenotypic Mediation of Attitude Factors

Another means of examining mediation relies on phenotypic correlations, testing direction of causality models that go from the phenotype of one variable (e.g., a personality variable) to the phenotype of another variable (e.g., an attitude). Techniques have been developed that allow the testing of simple models of causation using cross-sectional family data (see Carey & DiLalla, 1994; Heath et al., 1993). Like the Cholesky analyses previously described, these techniques use cross-correlations within MZ and DZ twin pairs. For example, if the personality trait of sociability causes positive attitudes toward parties, then the cross-correlation between one twin's Sociability and the other twin's attitude toward parties should be equal to the product of two other correlations: the intraindividual correlation between Sociability and attitudes toward parties and the correlation between one twin's Sociability and the other twin's Sociability. With sufficient sample sizes, the obtained cross-correlation can be tested against the predicted value; a significant difference suggests that the model is invalid.

Because we were interested specifically in the mediation of genetic effects, we conducted these phenotypic analyses only for attitude–mediator pairings that produced a significant genetic correlation in Table 9 (i.e., we used these analyses as another way of exploring whether an attitude might be heritable because it is caused by another variable that is heritable). Of the 17 such pairings, 8 did not produce a significant phenotypic correlation within both sets of twins in Tables 7 and 8; clearly, it made no sense to test phenotypic mediation when there was no phenotypic correlation between the two variables.

Thus, there were nine attitude–mediator pairs that produced both a significant genetic correlation and a significant phenotypic correlation. For these pairs, we tested across all twins (both MZ and DZ to increase power) two contrasting, simple models of causation: the mediator caused the attitude versus the attitude caused the mediator. Unfortunately, six of the nine tests yielded inconclusive results, either because the two models yielded very similar predictions within our sample or because the correlation between the potential mediator and the attitude was small (or both). For these six pairs, neither causal model could be rejected on the basis of our data.

On the other hand, three pairs of variables yielded results that supported one model over the other. First, our data supported the conclusion that athletic abilities cause Attitudes Toward Athletics. The predicted cross-correlation for this model was $r = .29$, which did not differ significantly from the obtained cross-correlation, $r = .34$ (cross-correlations can be computed in two ways, from Twin 1 to Twin 2 or from Twin 2 to Twin 1, so we averaged the two values). In contrast, the predicted cross-correlation for the model assuming that Attitudes Toward Athletics cause athletic abilities was $r = .23$, which differed significantly ($p < .05$) from the obtained value of .34.

Unexpectedly, our data weakly supported the conclusion that Attitudes Toward Sensory Experiences cause the personality variables of Aggressiveness and Sociability. With regard to Aggressiveness, the Aggressiveness causes attitudes model predicted a cross-correlation of $r = .07$, which differed significantly from the obtained cross-correlation of .17; the attitudes cause Aggressiveness model predicted a cross-correlation of .11, which did not differ significantly from .17 (though it was not much larger than the preceding correlation of .07). With regard to Sociability, the Sociability causes attitudes model predicted a value of $r = .07$, which differed significantly from the obtained cross-correlation of .16; the attitudes cause Sociability model predicted a cross-correlation of .13, which did not differ from .16. Thus, for these

two pairings, the phenotypic data were more consistent with the hypothesis that the attitudes caused the hypothesized mediator than with the reverse causal hypothesis.

Predicting the Heritability Coefficients of Attitude Items

As a final way of exploring possible mediators of the heritabilities of attitudes, we examined the correlations between (a) the heritability coefficients of the attitudes and (b) the absolute values of the correlations between the attitudes and other variables (potential mediators). For example, across the 30 attitude items, we calculated the correlation between the heritability coefficients of the 30 items (h^2) and the 30 absolute values of the correlations between the items and the personality factor of Aggressiveness. A positive correlation would indicate that as attitude items correlated more strongly with Aggressiveness (either positively or negatively, because absolute values were computed), they (attitude items) also tended to be more heritable. In other words, a positive correlation would be consistent with the view that differences in the strength of associations with Aggressiveness accounted for some of the variability in the heritabilities of the attitude items; Aggressiveness would be implicated as a possible mediator of the heritability of the attitudes measured in our study. This analysis assumes that all of the measured attitudes have the same underlying determinant or determinants of their heritability; it is quite possible (or even likely) that different attitudes are heritable for different reasons (i.e., have different mediators of their heritability), which would not be revealed by this particular statistical approach.

We computed these correlations for the mediators that were themselves heritable (three personality factors and the three supplementary composite measures). Only one variable yielded a significant result. Specifically, the amount of genetic variance in an attitude item (h^2) was positively correlated with the correlation between the item and the academic achievement composite measure, $r(28) = .33$, $p < .04$. Thus, attitudes that correlated with academic achievement tended to be more heritable. Given that academic achievement was itself highly heritable and correlated at the genetic level with some attitudes in the earlier Cholesky decomposition analyses, this correlation with the heritability of attitudes is provocative.

Relation Between Attitude Heritability and Attitude Strength

Immediately after reporting their attitude toward a target, participants indicated how important this attitude was to them and how strongly they held the attitude. These questions assessed attitude strength, which Tesser (1993) has argued might be related to attitude heritability. To examine this hypothesis, we calculated for each attitude item the mean rating of importance across all participants and the mean rating of strength across all participants; each of these two sets of means was then correlated, across the 30 items, with the heritability coefficients of the items. Mean ratings of importance did not correlate with h^2 across the 30 items, $r(28) = .05$, *ns*. Although the relation was not statistically significant, mean ratings of strength were positively correlated with h^2 across the 30 items, $r(28) = .17$, $p < .19$, as predicted by Tesser (1993).

We also looked at the relation between heritability and strength within the attitude factors. Thus, we computed a weighted importance score and a weighted strength score for each attitude factor by multiplying the mean importance (or strength) rating for each item by the factor loadings in Table 3. In so doing, we generated a single importance (and strength) score for each of the nine factors. We then correlated these nine scores with the heritability coefficients of the attitude factors. More-heritable factors were strongly associated with both higher weighted importance scores, $r(7) = .52$, $p < .08$, and higher weighted strength scores, $r(7) = .51$, $p < .08$, although the correlations were only marginally significant because of the few degrees of freedom. Thus, as predicted by Tesser (1993), heritable attitude factors tended also to be psychologically stronger.

Discussion

This study provided strong evidence that differences between respondents in many of their expressed attitudes were partly determined by genetic factors. Twenty-six of the 30 individual attitude items yielded significant genetic effects, with a median h^2 of .35. Six of the nine attitude factors yielded significant genetic effects, with a median h^2 of .41. These genetic effects emerged across a wide variety of attitude topics and domains, from attitudes as diverse as support for the death penalty to enjoyment of roller coaster rides.

Our results are consistent with past studies of the heritability of social attitudes (e.g., Arvey et al., 1989; Eaves et al., 1989; Keller et al., 1992; Waller et al., 1990), which have also found a genetic component in many evaluations. Our study included many new attitude topics never previously tested in twin research, such as attitudes toward physical activities, intellectual tasks, and leadership behaviors. Differences between respondents in some of these new attitudes proved to be highly heritable (e.g., Attitudes Toward Athleticism and Attitudes Toward Leadership).

What about the specific attitudes that have yielded high or low heritabilities in past studies? As stated in the introduction, one of our goals was to test the replicability of the heritability coefficients for particular attitudes in past research. In general, attitudes that have yielded high heritabilities in past studies also did so in this research. For example, like in Eaves et al. (1989), a substantial genetic component was found in participants' attitudes toward the death penalty for murder and voluntary euthanasia. Like Waller et al. (1990), we found that attitudes toward organized religion were also heritable. One puzzling exception to this pattern was the attitude factor of the treatment of criminals (a domain that has yielded high heritabilities in the past), which was not heritable despite the fact that the two highest loading items, attitudes toward the death penalty and castration for sex crimes, yielded significant heritability coefficients. Perhaps some items with lower loadings that were not heritable (e.g., attitudes toward bingo) or that were heritable but conceptually distinct from Attitudes Toward the Treatment of Criminals (e.g., attitudes toward smoking) masked the heritability of the highest loading items.[1]

[1] These data raise an issue concerning our heritability analyses of the attitude factors. Given that the factor analyses were conducted on the phenotypic covariances, items that loaded heavily on the same factor did

We were less successful at replicating previous findings of low heritabilities. Attitudes toward separate roles for men and women were not heritable, replicating previous findings for similar items dealing with gender roles (Eaves et al., 1989). Several other attitudes that have yielded low heritabilities in past research, however, were more heritable in our sample. For example, heritability coefficients of .54, .46, .39, and .31 were obtained for attitudes toward abortion on demand, open-door immigration, capitalism, and smoking, respectively, which have yielded low or nonsignificant estimates in past studies (Eaves et al., 1989; Perry, 1973). When all of the relevant studies, including the present one, are examined, there are few attitude topics that have consistently yielded null heritability estimates (although, of course, many possible attitude topics have yet to be examined in behavioral genetics research).

We should remind the reader of some of the assumptions underlying the twin methodology adopted in this study. First, we assumed that our zygosity determination was accurate—that is, the questionnaire designed by Nichols and Bilbro (1966) approached the accuracy rate of 93% that has been reported in past studies. Second, we assumed that the degree of environmental similarity was equal for identical and fraternal twins. This assumption has generally been supported by empirical tests (e.g., see Plomin et al., 1997), although it remains contentious for critics of behavioral genetics. Violation of this assumption (with identical twins being exposed to more similar environments) would tend to increase heritability estimates. Third, we assumed that relatively little assortative mating occurred in our sample. Assortative mating is the tendency for genetically similar individuals to mate, which will increase genetic similarity within families and decrease genetic similarity between families. Because such increased intrafamilial genetic similarity will occur for DZ twins but not MZ twins (who are genetically identical irrespective of assortative mating), strong assortative mating would tend to decrease heritability estimates. Finally, given that we want to generalize the findings from our study to the general population, we assumed that the sample of twins was reasonably representative of the larger population. To the extent that the heterogeneity of the genes and/or environments in our sample differed substantially from those in the larger population, our estimates of genetic and environmental influence will not generalize.

Mediators of Attitude Heritability

If the conclusion is accepted that many attitudes are partly heritable, then the question arises, why or how are differences between individuals' attitudes genetically determined? Given that direct gene-to-attitude connections are extremely unlikely, what are the mechanisms that might account for the genetic component of attitudes? This issue has received very little attention from social scientists. We explored it in several ways in the present research.

Most directly, we calculated the extent to which genetic variation was shared between heritable attitude factors and heritable potential mediators (namely, personality factors and supplementary composite variables). Genetic correlations indicate the extent to which genetic individual differences in one variable are related to genetic individual differences in another variable. Causal direction is not revealed by genetic correlations, of course, a point that we illustrate several times by presenting competing possible interpretations of our results. Nevertheless, as described in the following paragraphs, our genetic analyses identified several potential mediators that overlapped considerably with attitudes (as well as some smaller but significant genetic correlations that we do not discuss). All of the mediators yielded significant genetic correlations with at least two of the attitude factors; the personality trait of Sociability was particularly impressive, correlating at the genetic level with five of the six attitude factors. We followed up the genetic correlation analyses with phenotypic mediation analyses testing two simple models: the mediator caused the attitude versus the attitude caused the mediator. These analyses only made sense when the variables were correlated at the phenotypic level and, even then, were usually inconclusive because of relatively weak phenotypic correlations. A few mediator–attitude pairings, however, yielded interesting data that are also discussed below.

Attitudes Toward Athleticism, which were heritable ($h^2 = .54$), showed a high genetic correlation (.63) with self-reported athletic ability, which was itself highly heritable ($h^2 = .61$). One interpretation of this overlap is that inherited physical abilities relevant to athletics influenced attitudes toward athletics (playing organized sports, exercising, etc.). For example, individuals with naturally good coordination and strength might have been more successful at sports than less athletically inclined individuals, with the result that the former individuals developed more favorable attitudes toward sports than did the latter. This causal model was explicitly supported by the phenotypic analyses, for which the model going from athletic abilities to athletic attitudes was consistent with the data, whereas the model going from athletic attitudes to athletic abilities could be rejected. Thus, there were converging pieces of evidence in our study supporting the conclusion that attitudes toward athletics yielded a significant heritability coefficient, at least in part, because they were caused by genetically influenced physical and athletic abilities.

Attitudes Toward Leadership ($h^2 = .41$) showed relatively large genetic correlations with self-reported physical attractiveness (.55), Sociability (.43), and Aggressiveness (.41), all of which were also highly heritable ($h^2 = .54$, .47, and .43, respectively). Thus, it is possible that Attitudes Toward Leadership were heritable, in part, because other inherited characteristics led to particular experiences relevant to leadership. For example, perhaps physically attractive persons were treated deferentially and developed more confidence in their leadership abilities. Similarly, perhaps individuals who were naturally outgoing (sociable) gravitated to positions of leadership and developed positive attitudes. Natural aggressiveness or assertiveness might also have led to greater success in attempts to lead, which induced favorable attitudes toward being a leader. These variables constitute a good example of the ambiguity of genetic correlations, however, in that they can plausibly be interpreted in other ways (phenotypic mediation analyses involving Attitudes Toward Leaders were inconclusive). For example, Attitudes Toward Leadership may have been heritable for reasons other than those we have proposed, and the heritabilities of the hypothesized mediators may themselves have been due

not necessarily show similar patterns of heritabilities themselves. An alternative strategy might have been to conduct a factor analysis of the attitude covariances that derived simply from shared genetic variance.

to the heritability of Attitudes Toward Leadership. For example, perhaps individuals who were favorable toward leadership made more effort to make themselves physically attractive, or became more sociable and aggressive because they wanted to be leaders.

Attitudes Toward Sensory experiences ($h^2 = .36$), with higher scores reflecting more positive attitudes toward intense experiences like loud music, big parties, and roller coaster rides, shared a substantial amount of genetic variance with Sociability ($r = .41$). Perhaps the trait of sociability encompasses a general tendency to approach sources of stimulation (including other people), which resulted in positive attitudes toward various kinds of sensory experiences. This relation might have reflected the opposite causal direction, however. For example, positive attitudes toward intense sensory experiences may have induced the trait of sociability by motivating people to approach social gatherings. Indeed, the phenotypic causal analyses supported this latter interpretation: The data were consistent with the causal model going from sensory attitudes to Sociability, whereas the reverse causal model (which was the one we would have predicted) was disconfirmed by the data.

Attitudes Toward Sensory experiences also yielded a moderately high genetic correlation with Aggressiveness (.33). Perhaps inherited aggressiveness induced relatively intense sensory experiences, which produced more positive attitudes toward such experiences. Once again, though, the phenotypic analyses were more consistent with an opposing view: The causal model going from sensory attitudes to Aggressiveness was supported by the data, whereas the model going from Aggressiveness to attitudes was disconfirmed. Thus, for example, positive attitudes to intense sensory experiences (heritable for whatever reason) may have facilitated the development of an aggressive personality by motivating intense experiences like interpersonal confrontations or highly competitive activities.

Attitudes Toward Equality ($h^2 = .55$) yielded a strong genetic correlation (.44) with Sociability. This overlap is intriguing, because the attitude items included in the equality factor reflected, at least in part, a desire for positive interpersonal relationships (e.g., making racial discrimination illegal, getting along well with other people). Thus, natural inclinations to be sociable might have induced a desire for smooth interactions, which affected attitudes toward issues involving interpersonal relationships. Of course, it is also possible that positive attitudes toward getting along with other people could have facilitated the development of sociability (phenotypic mediational analyses were inconclusive).

The final heritable attitude factor, Attitudes Toward Outward Appearance (e.g., looking my best at all times, wearing attention-grabbing clothes; $h^2 = .45$), yielded a moderately high genetic correlation with Sociability (.36). Natural inclinations toward sociability could plausibly have induced more interest in looking good (to impress or attract others). Alternatively, this relation might have reflected that positive attitudes toward looking good increased Sociability (phenotypic analyses were inconclusive).

We conducted another, very different analysis that explored the extent to which the potential mediators could account for the heritabilities of many attitudes. Specifically, we calculated the correlation between the heritability coefficients of the 30 attitude items and the items' correlations with the mediators. Rather than testing genetic overlap between a specific attitude and possible mediators, this analysis investigated the ability of the mediators to account for differences between the attitudes in heritability. Only one mediator yielded a significant result—the academic achievement measure. The correlations between academic achievement and each of the attitude items were significantly related ($r = .33$) to the heritability coefficients of the attitudes. Thus, attitude items that correlated highly with academic achievement also tended to be highly heritable. (In a similar vein, there is also a positive correlation between the g loadings of IQ subtests and the subtests' heritabilities; see Jensen, 1998.) Our result suggests that academic achievement may have accounted, at least in part, for the heritability of individual differences in many attitudes. That is, academic achievement, which was itself heritable, may have contributed to the heritable component of individual differences in many attitudes. This hypothesis is consistent with the conclusions of Scarr and Weinberg (1981), who argued that the genetic transmission of verbal ability (one probable aspect of academic achievement) partly accounted for the genetic component of individual differences in authoritarian attitudes. We should reemphasize, however, that this analysis rests on the assumption that the same variable underlies the heritability of many attitudes, which arguably is a questionable assumption. Also, academic achievement might have reflected respondents' motivation as much as (if not more than) their intellect, in which case motivational variables might have been the operative variable influencing attitudes across many domains.

Environmental Effects on Attitudes

We have focused to this point on the relevance of our data for understanding the genetic transmission of individual differences in attitudes, but it is important to emphasize that our findings also strongly confirmed the importance of environmental variables in attitude formation. In all of our analyses, the largest percentages of variance in attitudes were attributable to nonshared environmental factors. That is, the most significant predictor of variability in attitude scores (whether at the item or factor level) was variation in experiences that were unique to individual members of twin pairs. Of course, these findings should not be surprising to social psychologists, who subscribe strongly to a belief in environmental causation. Nevertheless, in the context of an article on genes and attitudes, it is worth keeping in mind the fact that environmental factors outweighed genetic ones as predictors of the attitudes in our sample (although we should also note that estimates for nonshared environmental factors were calculated as residuals that include variance due to issues such as item unreliability, which might be considered error rather than environmental influence).

The observation that nonshared environmental factors are important is not new to our research. Indeed, behavioral geneticists have increasingly been noting both the predictive strength of unique experiences and the surprising weakness of shared environmental factors in the domains of personality, attitudes, and aptitudes (see Dunn & Plomin, 1990; Eaves et al., 1989). For example, Plomin and Rende (1991) stated, "One of the most important discoveries in human behavioral genetics involves nurture rather than nature: Environmental factors important to development are experienced differently by children in the same family" (p. 179). An important direction for future research is to explore more thoroughly the specific experiences of siblings that lead to differences in attitudes. Such research may require better measures

of the environment than are currently available (Plomin & Rende, 1991), although in a recent study using multiple environmental measures, the authors had some success identifying nonshared environmental mediators of personality differences (Vernon, Jang, Harris, & McCarthy, 1997).

The Cholesky analyses of our data identified a few attitude–mediator pairs that shared environmental origins. That is, in a few cases, an attitude factor and a potential mediator variable yielded a significant environmental correlation, indicating that similar nonshared experiences influenced both variables. In all of the cases of a significant, positive environmental correlation, the two variables also correlated positively at the phenotypic level. Specifically, similar experiences were implicated in the development of both variables of (a) athletic ability and Attitudes Toward Athleticism, (b) Aggressiveness and Attitudes Toward Leadership, (c) athletic abilities and Attitudes Toward Sensory Experiences, (d) Sociability and Attitudes Toward Outward Appearance, and (e) physical attractiveness and Attitudes Toward Outward Appearance. For example, exposure to a good coach might both improve athletic abilities and foster positive attitudes toward organized sports (the first environmental correlation listed above). Or early experiences of peer ridicule might both produce a shy, nonaggressive style and precipitate negative attitudes toward being a leader (the second environmental correlation). These environmental findings further underscore the importance of studying the specific experiences of siblings that lead to particular psychological characteristics.

Attitude Heritability and Attitude Strength

Tesser (1993) hypothesized that heritable attitudes are psychologically stronger than are attitudes that are not heritable (see also Crelia & Tesser, 1996; Tesser & Crelia, 1994). He showed that attitudes that had yielded high heritabilities in past research were reported more quickly, were less influenced by conformity pressure, affected interpersonal liking more, and yielded stronger agreement–reinforcement effects than did attitudes that had yielded low heritabilities. Tesser speculated that highly heritable attitudes may have a biological basis that makes change difficult or uncomfortable; thus, individuals build up psychological defenses around such attitudes and seek out or construct environments that support and protect them.

No researchers have previously tested this hypothesis by obtaining direct, self-report measures of attitude strength from participants. In the present study, we obtained such measures and examined their relation to attitude heritability. This approach yielded evidence that supported Tesser's (1993) reasoning. Specifically, across the 30 attitude items, there was a weak correlation of .17 (which was statistically nonsignificant) between the heritability of the item and the mean rating across all participants of how strongly they held the attitude: Items that were more heritable also tended to yield somewhat higher mean strength ratings across participants. More impressively, when mean importance and mean strength scores were calculated for each attitude factor (by weighting the importance or strength means for the 30 items by the factor loadings in Table 3), these scores were strongly related to the heritabilities of the factors (correlations of .52 and .51), although the correlations were only marginally significant because of the few degrees of freedom. Twenty-five percent of the variation in the strength or importance scores of the attitude factors could be accounted for by variation in the heritabilities of the factors.

These data provide support for Tesser's (1993) hypothesis that highly heritable attitudes are stronger than are less heritable attitudes. Moreover, our support comes from an entirely different research strategy than those used by Tesser. There are a variety of ways that attitude strength can be operationalized (see Bassili, 1996); our findings, together with those of Tesser (1993; Crelia & Tesser, 1996; Tesser & Crelia, 1994), provide converging evidence from very different operationalizations that highly heritable attitudes are psychologically stronger than less heritable attitudes.

Conclusions

Attitudes are learned. But attitudes also depend on biological factors. In this research, we obtained evidence that variation across individuals on a wide variety of attitudes is partly attributable to genetic factors. The median h^2 across the 30 individual attitude items was .35, meaning that, typically, 35% of the attitudinal variance in our sample was attributable to genetic factors. Nonshared environmental factors were even more important in predicting variation within our sample, producing a median e^2 of .60 across the 30 individual attitude items. Nevertheless, fully 26 of the 30 individual attitudes yielded an estimate of genetic influence that was significantly greater than zero.

Several personality traits and supplementary variables were implicated as possible mediators of attitude heritability. Presumably, these characteristics—themselves highly heritable—predisposed individuals to form particular kinds of attitudes, thereby contributing to the genetic determination of individual differences in those attitudes. Sociability, in particular, was correlated at a genetic level with several attitudes. Athletic ability and physical attractiveness also yielded substantial genetic correlations with relevant attitudes. Finally, academic achievement appeared to be capable of predicting the heritability of the set of attitudes measured in our sample. We think that the primary value of our mediational analyses is to raise interesting questions about the sources of attitude heritability that can be examined in future research.

We hope that attitude researchers will begin to direct more attention to the role of biological processes, including genetic factors, in the formation and change of attitudes. Twin methodologies constitute just one of a variety of approaches that offer the potential to examine the simultaneous effects of nature and nurture. In the long run, we stand to gain the most understanding from perspectives that integrate biology and experience in accounting for individual differences.

References

Adorno, T. W., Frenkel-Brunswik, E., Levinson, P. J., & Sanford, R. N. (1950). *The authoritarian personality.* New York: Harper & Row.

Akaike, H. (1987). Factor analysis and AIC. *Psychometrika, 52,* 317–332.

Arvey, R. D., Bouchard, T. J., Segal, N. L., & Abraham, L. M. (1989). Job satisfaction: Environmental and genetic components. *Journal of Applied Psychology, 74,* 187–192.

Bassili, J. N. (1996). Meta-judgmental versus operative indexes of psychological attributes: The case of measures of attitude strength. *Journal of Personality and Social Psychology, 71,* 637–653.

Bollen, K. A. (1989). *Structural equations with latent variables.* New York: Wiley.

Bostrom, R. N., & White, N. D. (1979). Does drinking weaken resistance? *Journal of Communication, 29*, 73–80.

Bouchard, T. J. Jr., & McGue, M. (1990). Genetic and rearing environmental influences on adult personality: An analysis of adopted twins reared apart. *Journal of Personality, 58*, 263–292.

Cacioppo, J. T., & Petty, R. E. (1987). Stalking rudimentary processes of social influence: A psychophysiological approach. In M. P. Zanna, J. M. Olson, & C. P. Herman (Eds.), *Social influence: The Ontario symposium* (Vol. 5, pp. 41–74). Hillsdale, NJ: Erlbaum.

Carey, G., & DiLalla, D. L. (1994). Personality and psychopathology: Genetic perspectives. *Journal of Abnormal Psychology, 103*, 32–43.

Crelia, R. A., & Tesser, A. (1996). Attitude heritability and attitude reinforcement: A replication. *Personality and Individual Differences, 21*, 803–808.

DeFries, J. C., Plomin, R., & LaBuda, M. C. (1987). Genetic stability of cognitive development from childhood to adulthood. *Developmental Psychology, 23*, 4–12.

Dunn, J., & Plomin, R. (1990). *Separate lives: Why siblings are so different.* New York: Basic Books.

Eagly, A. H., & Chaiken, S. (1993). *The psychology of attitudes.* San Diego, CA: Harcourt Brace Jovanovich.

Eaves, L. J., Eysenck, H. J., & Martin, N. G. (1989). *Genes, culture, and personality: An empirical approach.* London: Academic Press.

Eysenck, H. J. (1951). Primary social attitudes as related to social class and political party. *British Journal of Sociology, 2*, 198–209.

Heath, A. C., Kessler, R. C., Neale, M. C., Hewitt, J. K., Eaves, L. J., & Kendler, K. S. (1993). Testing hypotheses about direction of causation using cross-sectional family data. *Behavior Genetics, 23*, 29–50.

Jackson, D. N. (1984). *Personality Research Form manual* (3rd ed.). Port Huron, MI: Research Psychologists Press.

Jensen, A. R. (1998). *The g factor: The science of mental ability.* Westport, CT: Praeger.

Jockin, V., McGue, M., & Lykken, D. T. (1996). Personality and divorce: A genetic analysis. *Journal of Personality and Social Psychology, 71*, 288–299.

Jöreskog, K. G., & Sörbom, D. (1989a). *LISREL: A guide to program and applications* (2nd ed.). Mooreseville, IN: Scientific Software.

Jöreskog, K. G., & Sörbom, D. (1989b). *PRELIS: A preprocessor for LISREL* (2nd ed.). Mooreseville, IN: Scientific Software.

Kasriel, J., & Eaves, L. (1976). The zygosity of twins: Further evidence on the agreement between diagnosis by blood groups and written questionnaires. *Journal of Biosocial Science, 8*, 263–266.

Keller, L. M., Bouchard, T. J. Jr., Arvey, R. D., Segal, N. L., & Dawis, R. V. (1992). Work values: Genetic and environmental influences. *Journal of Applied Psychology, 77*, 79–88.

Loehlin, J. C. (1989). Environmental and genetic contributions to behavioral development. *American Psychologist, 44*, 1285–1292.

Loehlin, J. C., & Nichols, R. C. (1976). *Heredity, environment, and personality: A study of 850 sets of twins.* Austin: University of Texas Press.

Martin, N. G., Eaves, L. J., Heath, A. C., Jardine, R., Feingold, L. F., & Eysenck, H. J. (1986). Transmission of social attitudes. *Proceedings of the National Academy of Sciences, USA, 83*, 4364–4368.

Neale, M. C., & Cardon, L. R. (1992). *Methodology for genetics studies of twins and families.* Norwell, MA: Kluwer Academic.

Nichols, R. C., & Bilbro, W. C., Jr. (1966). The diagnosis of twin zygosity. *Acta Genetica Medicae et Gemellologiae, 16*, 265–275.

Olson, J. M., & Zanna, M. P. (1993). Attitudes and attitude change. *Annual Review of Psychology, 44*, 117–154.

Oskamp, S. (1991). *Attitudes and opinions* (2nd ed.). Englewood Cliffs, NJ: Prentice Hall.

Partanen, J., Bruun, K., & Markkanen, T. (1966). *Inheritance of drinking behavior.* Helsinki, Finland: The Finnish Foundation for Alcohol Research.

Perry, A. (1973). The effect of heredity on attitudes toward alcohol, cigarettes, and coffee. *Journal of Applied Psychology, 58*, 275–277.

Plomin, R., Corley, R., DeFries, J. C., & Fulker, D. W. (1990). Individual differences in television viewing in early childhood: Nature as well as nurture. *Psychological Science, 1*, 371–377.

Plomin, R., DeFries, J. C., & Loehlin, J. C. (1977). Genotype–environment interaction and correlation in the analysis of human behavior. *Psychological Bulletin, 84*, 309–322.

Plomin, R., & Rende, R. (1991). Human behavioral genetics. *Annual Review of Psychology, 42*, 161–190.

Scarr, S., & McCartney, K. (1983). How people make their own environments: A theory of genotype-to-environment effects. *Child Development, 54*, 424–435.

Scarr, S., & Weinberg, R. A. (1981). The transmission of authoritarianism in families: Genetic resemblance in social-political attitudes? In S. Scarr (Ed.), *Race, social class, and individual differences in I. Q.* (pp. 399–427). Hillsdale, NJ: Erlbaum.

Snyderman, M., & Rothman, S. (1987). Survey of expert opinion on intelligence and aptitude testing. *American Psychologist, 42*, 137–144.

Tellegen, A., Lykken, D. T., Bouchard, T. J. Jr., Wilcox, K. J., Segal, N. L., & Rich, S. (1988). Personality similarity in twins reared apart and together. *Journal of Personality and Social Psychology, 54*, 1031–1039.

Tesser, A. (1993). The importance of heritability in psychological research: The case of attitudes. *Psychological Review, 100*, 129–142.

Tesser, A., & Crelia, R. A. (1994). Attitude heritability and attitude reinforcement: A test of the niche building hypothesis. *Personality and Individual Differences, 16*, 571–577.

Vernon, P. A., Jang, K. L., Harris, J. A., & McCarthy, J. M. (1997). Environmental predictors of personality differences: A twin and sibling study. *Journal of Personality and Social Psychology, 72*, 177–183.

Waller, N. G., Kojetin, B. A., Bouchard, T. J. Jr., Lykken, D. T., & Tellegen, A. (1990). Genetic and environmental influences on religious interests, attitudes, and values: A study of twins reared apart and together. *Psychological Science, 1*, 138–142.

Wilson, G. D., & Patterson, J. R. (1968). A new conservatism scale. *British Journal of Social and Clinical Psychology, 7*, 264–269.

Zanna, M. P., & Cooper, J. (1974). Dissonance and the pill: An attribution approach to studying the arousal properties of dissonance. *Journal of Personality and Social Psychology, 29*, 703–709.

Zuckerman, M. (1995). Good and bad humors: Biochemical bases of personality and its disorders. *Psychological Science, 6*, 325–332.

Received April 2, 1997
Revision received March 1, 1998
Accepted December 15, 1998 ■