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Social Contact, Social Attitudes, and Twin Similarity

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The nature of the relationship between social contact and attitude similarity between twins was investigated using longitudinal data from a sample of Australian twins. Earlier research has suggested that social attitudes are not explained solely by shared environment; rather there are both genetic and environmental components that explain variance in social attitudes. Using three types of analyses we investigated the magnitude of the relationship and the direction of causation between attitude similarity and social contact. Longitudinal analysis of within-pair variance by level of contact suggests that attitude similarity leads to contact among the females and that similarity is both genetically and environmentally based. Analyses using a crosslag regression model suggest that similarity causes contact among MZ females. Biometrical analyses indicate differences in direction of causation for males and females. Among females, both genetic and shared environmental parameter estimates could be equated across contact groups, suggesting little relationship between contact and similarity. Among males, findings of smaller estimated heritability in the high-contact group suggest that similarity causes contact. However, an increased estimate of the contribution of shared environmental variance in the high-contact males could additionally suggest that contact leads to similarity.

KEY WORDS: Attitudes; contact; twin similarity.

INTRODUCTION

Research has suggested that there are both genetic and environmental components of variance in social attitudes (Martin *et al.*, 1986; Truett *et al.*, 1992), however, the nature of the relationship between attitude similarity and shared environment has not been adequately investigated. Using genetically informative data and a measure of frequency of contact between relatives, hypotheses about the magnitude and direction of this relationship can be explored. If shared environment (as mediated by social contact) causes attitude similarity, the degree of social contact between relatives should relate to their attitude similarity. To the extent that monozygotic twins are in greater contact than dizygotic twins, this would lead to a violation of the equal environments assumption in twin methodology. Although some relationship between social contact and attitude similarity has been found (Martin *et al.*, 1986), it has not been unequivocally established that attitude similarity is a *consequence* of social contact. That is, to the extent that attitude similarity between relatives causally influences their degree of contact, the importance of shared environment in explaining attitude similarity would be weakened, because attitude similarity rather than social contact would be the causal factor. The purpose of the present study is to examine the roles of shared environment and social contact between twins on their attitude similarity. Of particular in-

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terest is the determination of the direction of causation between attitude similarity and degree of social contact, using longitudinal twin data.

Twin similarity in social attitudes has been studied to understand what, if any, influence genes and shared environment have on the transmission of social attitudes. This research has shown that transmission of social attitudes does not occur solely through environmental channels but that there is some genetic component involved. In one large-scale study of Australian twins, responses to the Wilson–Patterson Conservatism Scale were analyzed on an item-by-item basis (Martin *et al.*, 1986). The relationships among church attendance, educational level, and six factors of social attitudes derived from the Wilson–Patterson items were also examined in the Australian sample (Truett *et al.*, 1992). In both studies results suggested that both genetic and environmental factors were present in the individual items and a composite ''conservatism'' score. A sex-limitation model was also found to fit the data best, allowing differences in genetic and environmental parameter estimates between men and women in the six ''conservatism scales,'' although there was no consistent direction of sex differences across these six scales (Truett *et al.*, 1992). Genetic and shared environmental effects almost entirely explained the covariation between the ''conservatism'' scales, church attendance and education.

Analyses by both Martin *et al.* (1986) and Truett *et al.* (1992) suggest the presence of some kind of shared environment in addition to that of genetic factors on social attitude similarity among twins, giving some support to the hypothesis that shared environment may causally affect attitude similarity. However, the occurrence of assortative mating for social attitudes would lead to overestimates of the influence of shared environment in these studies (Heath and Eaves, 1985). That is, spouses selecting one another according to their social attitudes, which are possibly genetically influenced (phenotypic assortative mating), would increase attitude resemblance of DZ twins relative to MZ twins. This would effectively lead to underestimated heritable effects and overestimated shared environmental effects in a classical twin analysis (Falconer, 1989). Thus, further investigation into the role of shared environment in social attitudes is clearly warranted.

One approach to resolving the effects of shared environment and assortative mating on twin similarity may be to include measures of shared environment, such as frequency of contact, in the analysis of genetic and environmental variance in attitudes. To the extent that shared environment plays a role in social attitudes, there should be increased twin similarity for those pairs in greatest social contact.

As discussed earlier, however, it is of critical importance to establish the causal direction of effects between attitude similarity and social contact between twins. Some researchers have suggested that shared environment or increased contact causes twin similarity on a given trait (Rose *et al.*, 1990). Support for this explanation has been observed in different domains such as alcohol consumption and neuroticism, where greater contact between cotwins precedes increased twin similarity. However, this explanation has been criticized by others, who have suggested an opposing explanation, that similarity in traits causes increased personal contact among twins (Lykken *et al.*, 1990). Another study suggested that, based on intrapair differences in social attitudes scores, greater personal contact has only a trivial influence on twin similarity at best (Martin *et al.*, 1986). Although never discussed by either Rose *et al.* or Lykken *et al.*, it is entirely possible that both directions of effects could occur simultaneously. To resolve these questions clearly requires longitudinal data. One goal of the present study is to examine the joint effects of similarity causing contact ($S \rightarrow C$) and contact causing similarity ($C \rightarrow S$).

Different hypotheses about direction of causation can have an important impact on basic twin methodology. Monozygotic (MZ) twins are known to be in greater contact than dizygotic (DZ) twins (Rose *et al.*, 1990). If contact does in fact cause twin similarity for a given trait, then the equal environments assumption may be violated in twin analyses of that trait, resulting in biased estimates of genetic and environmental parameters. Specifically, heritability may be overestimated. However, if trait similarity causes social contact between twins, the equal environments assumption would remain valid, and population estimates of relative genetic and environmental variance (based on combined samples of high and low contact twin pairs) would be unaffected.

There are different expectations for the relative contributions of genetic and environmental variance to phenotypic variance among twin pairs in high and low contact, depending on the direction of causation. For example, if C → S, then greater effects of common environment (c^2) should be found in groups of twins in greatest contact, while relative genetic variance (h^2) should remain equivalent across contact groups. In the case where S → C, however, variation of c^2 and h^2 by contact would depend on whether trait similarity is genetically based or not. To understand this, consider that twin pairs self-select into groups of high and low contact on the basis of their attitude similarity, which may, in part, be genetically influenced. In this case, DZ pairs in more contact would be more genetically similar than DZ pairs in less contact as indicated by more similar within-pair correlations among MZ and DZ twins in high contact. (Of course the genetic similarity of MZ pairs cannot vary across level of contact.) Thus, the difference in attitude similarity between low-contact MZ and low-contact DZ twin pairs should be greater than among twins in high contact. This would effectively lead to higher estimates of heritability in low-contact twin pairs, compared to those in greater contact, indicating that S → C. If S → C and similarity is based purely on environmental factors, then greater estimates of c^2 would be expected in high-contact pairs—a finding which would be indistinguishable from that obtained when C → S, as described above. In the case where estimates of h^2 are greater among those in low contact and estimates of c^2 are greater among those in high contact, either S → C is suggested where similarity is both genetically and environmentally influenced or both S → C and C → S are occurring simultaneously.

In the present study, we attempt to understand the role of environmental factors in social attitudes by examining the relationship between twins' degree of social contact and their attitude similarity. Based on longitudinal data from a large-scale study of Australian twins (see Martin *et al.*, 1986; Heath *et al.*, 1994), we investigate two primary (and interrelated) questions concerning (1) the nature of the relationship between twins' attitude similarity and their social contact and (2) the effect of frequency of contact on parameter estimates of genetic and environmental variation in social attitudes.

Determination of the direction of causation is first studied using a crosslag regression model, where twins' attitude similarity and frequency of contact in 1981 are used to predict similarity and contact 9 years later. Biometrical models are then used to explore further the direction of causation by estimating genetic and environmental components of variance for twins in high and low contact. To summarize, expectations for parameter estimates in the direction of causation question would be as follows.

1. If C → S, h^2 should not vary across contact, but c^2 should be greater in high-contact pairs. If found, this would imply that in population samples, where MZ twins are in greater contact, the equal environments assumption would be violated and h^2 would be overestimated.
2. If S → C, h^2 should be lower in the high-contact group, with c^2 being equal across contact groups, providing that similarity is primarily genetically based. [If, however, c^2 is greater and h^2 is lower in the high-contact group, then similarity is either genetically and environmentally based or both S → C and C → S are occurring.]

Thus, based only on examination of c^2 no distinction between similarity causing contact and contact causing similarity can be made. Differences in estimates of h^2 in high- and low-contact groups are required for the determination of direction of causation.

METHODS

Subjects

The sample for the present study is based on 3808 pairs of Australian twins who participated in a mail survey in 1981 and those who also participated in a follow-up mail survey in 1989. Of the 3808 twin pairs who responded in 1981, 1802 (47.3%) were identified as being monozygotic (31.5% male), 1096 (28.8%) dizygotic same-sex pairs (31.9% male), and 910 (23.9%) dizygotic opposite-sex twins. The mean age for respondents in 1981 was 34.46 (14.18), with a range from 17 to 88 years of age. A subset of 2802 respondents also responded to a follow-up survey in 1989, for a 73.6% response rate based on at least one twin reporting level of contact. Of the 2802 twin pairs who responded in 1989, 1353 (48.3%) were identified as being monozygotic (32.6% male), 797 (28.4%)

as dizygotic same-sex pairs (32.0% male), and 652 (23.3%) as dizygotic opposite-sex twins. The mean age for respondents in 1989 was 40.63 (12.52), with a range from 25 to 87 years of age.

Zygosity was determined from two self-report items included in the 1981 survey. These items have shown to have at least 95% agreement rate with blood typing (Cederlof *et al.*, 1961; Kasriel and Eaves, 1976; Magnus *et al.*, 1983; Martin and Martin, 1975; Ooki *et al.*, 1990). In cases where zygosity was questionable or inconsistent on the basis of the self-report items, cotwins were contacted for further information to determine zygosity. Often cotwins supplied photographs to help determine zygosity.

Measures

The social attitude scale was constructed from 27 items common to two 50-item attitude checklists mailed to twin pairs in 1981 and 1989. The original 50-item checklist used in 1981 was based on the Wilson–Patterson (1968) Conservatism Scale. The instrument was revised for use in the 1989 survey to include more contemporary social issues of the time (e.g., abortion and gay rights). Respondents indicated if they agreed, disagreed, or were uncertain about their attitudes toward these different issues. The 27 items were summed at each time of survey, and total scores were used, where ''Liberal'' items were reversed before scoring so that a high score indicated a more conservative viewpoint. The Wilson–Patterson scale was originally designed to measure a single conservatism factor. A principal-components analysis of the present data further suggested a single-factor solution as being the most economical.

Respondents also reported how often they were in contact with their cotwin in both 1981 and 1989. In 1981 all cotwins indicated how often they both ''saw'' and ''contacted'' their cotwin on a 6-point scale (1 = live together, 2 = almost every day, 3 = at least once a week, 4 = once or twice a month, 5 = a few times a year, and 6 = less often). In 1989 respondents reported how often they both ''saw'' and ''contacted'' their cotwin on a 7-point scale (1 = live together, 2 = almost every day, 3 = at least once a week, 4 = once or twice a month, 5 = a few times a year, 6 = less often, and 7 = not at all). In order to make the scales of contact comparable for both time points, the last two categories in 1989 (''less often'' and ''not at all'') were collapsed into one category. How often the cotwins were in ''contact'' was used as the primary indicator of their level of contact. If the respondents did not report how often they were in ''contact'' with their cotwin but did report how often they ''saw'' their cotwin, then this information was used. In order to maximize the number of twin pairs included in the analyses, the mean level of contact was used if both twins responded to the frequency of contact items. If only one of the cotwins responded, then that information was used to determine level of contact.

Frequency of contact was further classified into two categories of high and low contact. Twins in ''high contact'' were in contact at least once a week. Those in ''low contact'' saw or contacted their cotwin once or twice a month or less. This division into and high and low contact was used to maintain adequate number of respondents by contact groups for each zygosity and sex. In 1981, 2111 (55.5%) of the respondents reported being in high contact. The proportion of MZ twin pairs in high contact (68% MZ females, 60% MZ males) was larger than that of DZ twin pairs (56% DZ females, 45% DZ males, and 39% DZ opposite-sex twin pairs). In 1989, 1249 (44.9%) respondents reported being in high contact with their cotwin. The proportion of twin pairs in high contact in 1989 are generally lower and more consistent across zygosity groups (MZ females, 70%; MZ males, 41%; DZ females, 46%; DZ males, 30%; and opposite-sex twin pairs, 19%).

Analyses

In the current study several methods of analysis were used to investigate two aspects of the data: (1) the determination of the direction of causation between twin similarity and their social contact and (2) the possible effects of contact on estimates of relative genetic and environmental variance. Direction of causation was investigated using two types of analyses, including examination of within-pair variance using a variance ratio test and a cross-lag regression model. Traditional structural equation model-fitting was performed to establish the effect of frequency of contact (high versus low) on estimates of genetic and environmental variances.

First, the within-pair variance (i.e., average squared difference between cotwins) in 1981 on the social attitude scale was compared as a function of their subsequent level of contact (in 1989) using a variance ratio test. This analysis was first done for those twins who were under 25 years of age in 1981 and who both reported living together in 1981. Selection of this subsample was done for two reasons: (a) to control for the amount of time they had lived together and (b) to select a homogeneous sample of those living together with respect to age. Taking all twins who lived together regardless of age would select a sample that was living together for varied reasons. As a comparison, however, the analysis was expanded to include all twins who reported being in "high contact" in 1981. We hypothesized that if attitude similarity causes frequency of contact, then larger within-pair variance in 1981 (i.e., more twin dissimilarity) should occur for those cotwins in less contact later in 1989. Furthermore, if self-selection into high or low contact is affected primarily by genetic similarity, there should be no difference in within-pair variance for MZ twins across levels of contact, but a significant difference between DZ twins in high and low contact should be found. To the extent that attitudes are genetically influenced, then phenotypically similar DZ pairs (and thus genetically similar) in 1981 should be in the most contact in 1989. Differences among both MZ and DZ within-pair variance by level of contact would suggest that selection into contact group occurs on the basis of environmental factors, perhaps in addition to genetic similarity.

The second method of determining direction of causation involved a cross-lag regression model, which is an extension of the regression model suggested by Rose *et al.* (1990). Their model would determine the direction of causation through the partial correlations of frequency of contact and twin similarity in 1989 with cotwin similarity in 1981. The logic is that if the correlation between attitude similarity and contact at a later time goes to zero when initial similarity is partialed out, then attitude similarity causes frequency of contact. If, however, the correlation at a later time of observation is unaffected by initial similarity, then frequency of contact causes attitude similarity. Using the cross-lag regression model to evaluate both competing hypotheses simultaneously, we can test if early frequency of contact causes later attitude similarity and/or if early attitude similarity causes later frequency of contact (see Fig. 1). It is possible that both directions of causation can occur simultaneously.

Next, structural equation modeling was used to estimate the genetic, shared environment, and nonshared environmental influences on social attitudes in the high- and low-contact groups. These analyses were also used to explore further the direction of causation. All models were fit at both times of measurement to variance–covariance matrices and evaluated for goodness of fit using MX (Neale, 1991). This approach to the estimation of heritability and environmentality is widely used and these data have been analyzed previously in this manner (Martin *et al.*, 1986; Truett *et al.*, 1992), whereby it was suggested that there were both genetic and environmental components to social attitudes.

Several models were fit to the data to test the possibility of different genetic and environmental components in men and women and/or contact groups. The basic model fit to the data was an *ACE* model where additive genetic (*A*), shared environment (*C*), and nonshared environmental (*E*) contributions to variability were estimated. Submodels were tested where parameters were constrained across contact group and/or gender to determine the most economical model that provided an adequate fit to the data. The fit of these nested models was evaluated using chi-square difference test and Akaike's (1970) information criterion (AIC). Age was included in the model as a covariate to control any relationship between age and twin similarity for social attitudes.

RESULTS

Direction of Causation

To determine the magnitude of the relationship between attitude similarity and frequency of contact, we first computed polyserial correlations between frequency of contact and absolute within-pair difference scores on the social attitude scales. Correlations were computed separately for each gender and zygosity for both 1981 and 1989 and are presented in Table I. As shown, these correlations are only moderate at best, ranging from .08 to .28. Moreover, there is no consistent pattern of differences across zygosity or gender. Direction of causation between attitude similarity and frequency

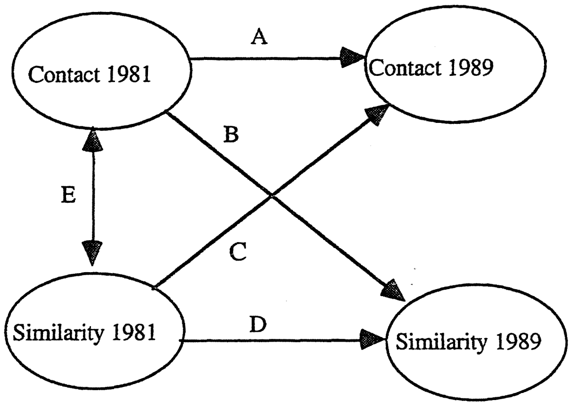

Fig. 1. Standardized cross-lag regression model with path coefficients (SE) for attitude similarity causing frequency of contact and frequency of contact causing attitude similarity.

Table I. Polyserial Correlations Between Within-Pair Variance for Attitude Similarity and Frequency of Contact

	1981	1989
All	.17	.14
MZ females	.15	.10
DZ females	.19	.11
MZ males	.14	.09
DZ males	.28	.11
DZ opposite sex	.08	.09

Table II. Within-Pair Variance of 1981 Social Attitudes for Twins Who Are Under Age 25 and Cohabiting in 1981, by 1989 Contact Status and Zygosity

	N	Mean squared cotwin difference	*F* ratio
All respondents			
High contact (1989)	297	29.46	1.66**
Low contact (1989)	209	49.02	
MZ			
High contact (1989)	172	22.47	1.41*
Low contact (1989)	56	31.78	
DZ same sex			
High contact (1989)	79	33.39	1.50*
Low contact (1989)	61	50.03	
DZ opposite sex			
High contact (1989)	46	48.89	1.21
Low contact (1989)	92	58.98	
Females			
High contact (1989)	169	22.26	2.10**
Low contact (1989)	53	46.75	
Males			
High contact (1989)	82	33.41	1.10
Low contact (1989)	64	36.76	

*$p < .05$.
**$p < .01$.

of contact was next tested in the comparison of within-pair variance (i.e., average squared differences between cotwins) of social attitudes in 1981, based on their level of contact in 1989. Only those cotwins who were under 25 years of age, who both reported that they were living together in 1981, were included in the initial within-pair variance analysis. Variance ratio tests were conducted classifying the sample of same sex twins in three ways: first, across level of contact for the whole sample; next, among MZ and DZ twins; and finally, by gender (for same-sex twins only).

Results from the within-pair variance analyses (Table II) showed significantly greater attitude similarity for high-contact twin pairs, suggesting that similarity causes contact for the entire sample ($F = 1.66, p < .01$). These differences were also apparent within both MZ ($F = 1.41, p < .05$) and DZ ($F = 1.50, p < .05$) same-sex pairs. However, when analyses were conducted with each gender, only females displayed the pattern of greater similarity ($F = 2.10, p < .01$) (i.e., smaller within-pair variance for pairs in high contact). Thus, the effects of similarity on contact were strongest for the females. Among the males and opposite-sex twins, however, there was no significant difference between those in high and those in low contact, suggesting that similarity and contact have little influence on each other. These analyses also showed a greater absolute difference in within-pair variance for the DZ pairs in high and low contact, compared to the difference in MZ pairs, suggesting that selection into high contact may be a function of genetic similarity.

Broadening these analyses to include all young twins (25 or younger) in high contact (at least once a week or more often) in 1981, or to include all high-contact twins regardless of age, produced a similar pattern of results. Twins with the greatest attitude similarity in 1981 were in the greatest contact in 1989, suggesting that attitude similarity causes frequency of contact. The finding of greater contact among most phenotypically similar MZ pairs indicates that twins may self-select their level of contact due to both environmental and genetic similarity. Among MZ twins it is not possible to distinguish between genetic and environmental selection into contact groups.

Table III. Parameter Estimates for the Best-Fitting Cross-Lag Regression Model

Gender/zygosity group	Parameter estimate A	B	C	D	E
MZ females	.56 (.03)**	.08 (.03)*	.05 (.04)	.18 (.01)**	.15
MZ males	.55 (.04)**	.09 (.05)	.01 (.05)	.34 (.01)**	.14
DZ females	.52 (.04)**	.04 (.05)	.06 (.05)	.29 (.01)**	.18
DZ males	.58 (.06)**	.06 (.08)	.01 (.07)	.39 (.02)**	.28
DZ opposite sex	.49 (.04)**	.03 (.05)	.05 (.04)	.35 (.01)**	.08

*$p < .05$.
**$p < .01$.

Table IV. Twin Correlations for Social Attitudes by Zygosity, Frequency of Contact at Each Time of Measurement

	1981		1989	
	High contact	Low contact	High contact	Low contact
MZ female	.71	.62	.66	.64
DZ female	.58	.50	.53	.53
MZ male	.64	.61	.61	.57
DZ male	.68	.50	.48	.48
DZ opposite sex	.56	.44	.61	.42

Further exploration of the causal relationship between twin attitude similarity and social contact was made using a cross-lag regression model (see Fig. 1). In this model regression coefficients were simultaneously estimated for frequency of contact in 1981 predicting the log-transform of within-pair variance in 1989 (i.e., log of squared cotwin differences) and log-transform of within-pair variance in 1981 predicting frequency of contact in 1989. The model also allowed for stability in both the log-transform of within-pair variance of social attitudes and the frequency of contact over time. Parameters in this model were allowed to vary across the five gender and zygosity groups.

Results from the cross-lag regression model show similar patterns to those observed in the within-pair variance analyses, namely, that among MZ females similarity causes contact, and in all other groups of same-sex twins (e.g., MZ males, DZ same sex, and DZ opposite sex) neither does similarity cause contact nor does contact cause similarity. The best-fitting model is presented in Table III, with separate estimates for all four groups [$\chi^2 = 3.27(5)$, $p = .66$]. Models that equated parameters to be equal across zygosity or gender separately provided a poor fit to the data. Clearly the best model requires unique estimates by zygosity and gender.

Effects of Social Contact on Genetic and Environmental Parameter Estimation

We next investigated what effects frequency of contact might have on estimates of genetic and environmental variance. Twin correlations for social attitudes in 1981 and 1989 are presented in Table IV. Within each sex the MZ twin correlation is greater than the DZ twin correlation for social attitudes. Also, twins in higher contact generally show greater cotwin correlations (in absolute value) than cotwins in low contact. Because the DZ twin correlations were more than half the MZ cotwin correlations, a model including shared environment rather than dominance was fit to the data. All models were fit separately to the 1981 and 1989 data.

A full model with genetic (*A*), shared environmental (*C*), and nonshared environmental (*E*) components, estimated separately for each gender and contact group, was fit to the data first (Model 1). Constraining estimates for gender and contact to be equal provided a poor fit to the data [$\chi^2 = 156.22(46), p < .01$]. Given this finding, all further analyses were conducted using separate analyses for gender and contact. The full model was fit both constraining the regression of age to be equal across all groups (gender, zygosity, and contact) and allowing it to be uniquely estimated for each of the gender, zygosity, and contact group. Allowing the age variance component to be estimated for each gender–zygosity–contact group provided the best fit of the full model and this condition was therefore used in all subsequent model fitting. From the data collected in 1981 the results more strongly suggested that individual estimates of age variance were required than from the 1989 data. In the 1981 data for unique age variance components the model fit significantly better [$\chi^2 = 27.10(37)$, $p = .88$] than for equal age variance components between zygosity differing by gender and level of contact [$\chi^2 = 47.25(41)$, $p = .23$]. Results from the data collected in 1989 a unique age variance components for all groups provided a slightly better fit [$\chi^2 = 40.92(37)$, $p = .30$], than when the age variance components were constrained to be equal across zygosity for each gender and level of contact group [$\chi^2 = 47.825(41)$, $p = .22$]. This finding that the age variance is different for all 10 groups (MZ female, MZ male, DZ female, DZ male, and DZ opposite sex for both high and low contact) suggests that there may be some age-specific sample selection for each of these groups. In 1981 models constraining age variance estimates to be equal across gender and zygosity [$\chi^2 = 129.017(45)$, $p < .01$], level of contact and zygosity (with unique estimates for opposite-sex twins) [$\chi^2 = 71.445(43)$, $p < .01$], and a completely constrained age variance model [$\chi^2 = 156.22(46)$, $p < .01$] all provided an inadequate fit to the data, therefore in all further analyses separate estimates for gender, zygosity, and contact groups were calculated.

After determination of the best-fitting full model regarding age variance constraints, models were further fit to determine if any biometrical parameters could be constrained to be equal across contact groups. Models were fit constraining the *A*, *C*, and *E* components to be equal across contact groups within one gender while not putting any constraints on the variance components for the other gender. Using nested comparisons, any nested model (Models 2–11) significantly different from the baseline model (Model 1) would suggest a worsening of fit compared to the full model. Using the Akaike's criterion, the best-fitting model is determined by the smallest value. For 1981 a model where *A* and *C*, but not *E*, were constrained across contact groups for females, with no constraints among males (Model 5), provided the most economical fit to the data based on Akaike's criterion (see Table V). Consistent with this are the nested chi-square comparisons, which indicate only equality of *A* and *C* across contact groups for the females.

Table V. Fit of *ACE* and Sex-Limitation Models for 1981 Social Attitudes[a]

Model	χ^2 (df)	*p*	AIC
1. *ACE*, female ≠ male, high ≠ low	27.10(37)	.88	−46.90
2. Females: $A_L=A_H$	27.11(38)	.91	−48.89
3. Females: $C_L=C_H$	27.14(38)	.91	−48.86
4. Females: $E_L=E_H$	47.77(38)	.13	−28.07
5. Females: $A_L=A_H$; $C_L=C_H$	27.49(39)	.92	−50.51
6. Females: $ACE_L=ACE_H$	56.94(40)	.04	−23.07
7. Males: $A_L=A_H$	32.78(38)	.71	−43.23
8. Males: $C_L=C_H$	31.79(38)	.75	−44.21
9. Males: $E_L=E_H$	38.60(38)	.44	−37.40
10. Males: $A_L=A_H$; $C_L=C_H$	32.80(39)	.75	−45.20
11. Males: $ACE_L=ACE_H$	72.13(40)	.01	−7.87

[a] *A* = additive genetic variance; *C* = common twin environmental variance; *E* = individual specific environmental variance; H = high contact; L = low contact in 1981.

The same set of models was fit to the 1989 data to determine the most economical fit to the data. In females, either *A*, *C*, or *E* could be constrained to be equal across contact groups (Models 2–4). However, equality constraints for all three components simultaneously provided a significant worsening of fit, suggesting some differences across contact groups in the females, but insufficient power to determine the exact source (genetic or environmental) of the difference. Given the ambiguity of the results Akaike's criterion was used to select the best-fitting model (Model 3), where only *C* could be constrained across contact groups for the females (Model 3). In the males, however, all three components of variance could be constrained to be equal across level of contact (Model 11) (see Table VI).

To summarize, in 1981 a model constraining the *A* and *C* variance components to be equal across contact groups was found to be provide the best fit to the data for females. In 1989, only the *C* component of variance could clearly be constrained to be equal across contact groups, although the differences in *A* were trivial (see Models 2 and 5 in Table VI). Thus the results for females are fairly consistent between 1981 and 1989. Among males in 1981 the model fit allowed no constraints across level of contact. In contrast, in 1989 *A*, *C*, and *E* could all be constrained to be equal across

Table VI. Fit of ACE and Sex-Limitation Models for 1989 Social Attitudes[a]

Model	χ^2 (df)	p	AIC
1. ACE, female $\neq$ male, high $\neq$ low	40.92(37)	.30	−33.08
2. Females: $A_L=A_H$	41.14(38)	.34	−34.86
3. Females: $C_L=C_H$	40.94(38)	.34	−35.06
4. Females: $E_L=E_H$	43.41(38)	.31	−32.59
5. Females: $A_L=A_H$; $C_L=C_H$	43.23(39)	.37	−34.67
6. Females: $ACE_L=ACE_H$	55.51(40)	.35	−24.49
7. Males: $A_L=A_H$	41.19(38)	.33	−34.81
8. Males: $C_L=C_H$	41.09(38)	.34	−34.91
9. Males: $E_L=E_H$	41.78(38)	.31	−34.23
10. Males: $A_L=A_H$; $C_L=C_H$	41.43(39)	.37	−36.57
11. Males: $ACE_L=ACE_H$	42.80(40)	.35	−37.20

[a] A = additive genetic variance; C = common twin environmental variance; E = individual specific environmental variance; H = high contact; L = low contact in 1989.

Table VII. Parameter Estimates for Best-Fitting Model in 1981 (Females $AC_L=AC_H$; No Constraints for Males)[a]

Year/gender/contact	h^2	c^2	e^2	V_a	V_c	V_e	V_p
1981/female/high	.31	.36	.33	14.77	16.99	15.35	47.13
1981/female/low	.27	.32	.41	14.77	16.99	22.16	53.92
1981/male/high	.02	.61	.37	.98	32.27	19.70	52.95
1981/male/low	.40	.18	.42	27.15	12.23	28.38	67.76

[a] Age variance estimated separately with each gender, contact, and zygosity group.

Table VIII. Parameter Estimates for Best-Fitting Model in 1989 (Females $C_L=C_H$; Males $ACE_L=ACE_H$)[a]

Year/gender/contact	h^2	c^2	e^2	V_a	V_c	V_e	V_p
1989/female/high	.25	.35	.40	11.00	15.03	17.19	43.22
1989/female/low	.32	.28	.40	17.09	15.03	21.73	53.84
1989/male/high	.26	.30	.44	14.94	17.47	25.84	58.25
1989/male/low	.26	.30	.44	14.94	17.47	25.84	58.25

[a] Age variance estimated separately with each gender, contact, and zygosity group.

contact groups among the males. The pattern of results from biometrical analyses are particularly inconsistent across time for males.

Parameter Estimates

Biometrical models provide estimates of both h^2, c^2, and e^2 and variance components (V_A, V_C, V_E). Tables VII and VIII provide estimates for these parameters for the 1981 and 1989 data based on the best-fitting models identified above. In 1981 there was greater phenotypic variance among those cotwins in less contact for both males and females. The phenotypic variance differences between contact groups and the biometrical source of the difference are indications of the relationship between attitude similarity and frequency of contact. Among females in 1981, differences in phenotypic variance are due only to nonshared environmental variance, suggesting that the relationship between attitude similarity and level of contact is due to the cotwins' unique experiences. That is, females in greater contact do *not* have greater shared environmental effects. Rather, females in *least* contact demonstrate greater variation in their unique, nonshared experiences. In 1989, differences in phenotypic variance are still due to nonshared environment. Additionally, there is a smaller proportion of genetic variance. This suggests that similarity causes contact, where in 1981 this pattern was not observed.

Among males in 1981, the relationship between similarity and level of contact is apparently due to both genetic and environmental factors, as indicated by differences in V_A, V_C, and V_E. In 1989 this pattern of variance differences by level of contact no longer holds true among the males, suggesting little or no relationship between similarity and contact. Recall that if there is no relationship between attitude similarity and frequency of contact, we would expect to find no differences in parameter estimates for high- and low-contact groups. In 1981, however, based on our expectations the differences in parameter estimates would suggest that both S → C and C → S are occurring.

DISCUSSION

In the present study the analyses indicate that S → C as well as C → S are occurring, although there is more evidence for S → C than C → S. The presence of S → C weakens any theory suggesting that similarity is determined primarily by shared environment. If attitude similarity were primarily a function of shared environment, we would expect a large relationship between shared environment (as measured by social contact) and trait similarity and large estimates of shared environment in biometrical analyses, however, neither of these expectations is supported by our analyses. The phenotypic variance differences in 1981 suggest that there is some relationship between similarity and contact among both males and females, however, in 1989 this relationship holds only among the females. Because the relationship between frequency of social contact and trait similarity is small, support for the hypothesis that attitude similarity is a function of social contact is weakened. Additionally, we expect only trivial effects on population estimates of genetic and environmental variance in social attitudes, effectively leaving the twin model intact.

The analyses of the within-pair variance suggest that attitude similarity causes frequency of contact among the females. These analyses show that there is an initial within-pair variance difference in attitudes among those females who are in high and low contact 9 years later, however, not for the males. When the analyses are conducted by zygosity the variance difference among MZ twins by contact group is probably an artifact of the difference observed among the females. Again, the variance difference among DZ twins is likely an artifact of the gender differences. Even so, these differences among MZ and DZ twins suggest that there are genetic as well as environmental influences on trait similarity, indicating that similarity is causing contact. The results from the within-pair variance analyses support the hypothesis that similarity causes contact for females, however, there is no identifiable trend for similarity causing contact or contact causing similarity among the males. Unfortunately there is not adequate power to test by gender and zygosity simultaneously. One of the limitations of this method is the large number of twins living together required to investigate completely differences by gender and zygosity.

The phenotypic variance is greater for both females and males in 1989 than in 1981 as shown in the biometrical analyses. This finding suggests that as the twins age, there is a divergence in attitude similarity. Additionally, among males there also may be some age effect on frequency of contact as indicated by the changes in the best-fitting model from 1981 to 1989.

Next, using the cross-lag regression method, a similar pattern of results suggests that attitude similarity does cause contact among MZ females, however, there is no relationship for DZ females, males regardless of zygosity, and opposite-sex twins. This model has the advantage of testing the two competing hypotheses simultaneously, however, is hindered by sample size issues similar to those for the within-pair variance analysis. Among the females, initial attitude similarity is a significant predictor of frequency of contact in 1989, suggesting that cotwins who were initially similar were in higher contact in later times, indicating that S → C. Attitude similarity in 1981 was a significant predictor of attitude similarity in 1989, suggesting that attitude similarity was stable across the 8-year span. Similarly, level of contact in 1981 is also a predictor of level of contact in 1989, suggesting that there is some stability in contact over time also. Both analyses discussed thus far capitalize on the longitudinal information in investigating the relationship between similarity and contact.

In the genetic analyses more evidence is presented about the direction of causation between similarity and contact. If C → S was the primary direction of causation, we would expect to find only an increased estimate of shared environment (c^2) in the high-contact group; estimates of genetic variance (h^2) would be constant across contact groups. Our findings, however, indicate that both genetic and shared environmental variance estimates were different across contact groups, especially for the men in 1981, suggesting that S → C. There may not be adequate power in 1989 to detect differences between the high- and the low-contact groups for both males and females as exemplified by the inconclusive model fitting for the females and the lack of differences between males in high and males in low contact.

As with other analyses of this data (Martin *et al.*, 1986; Truett *et al.*, (1992)), we found that there are genetic, shared environmental, and nonshared environmental variance components to social attitudes. We suggest the need for a sex-limitation model of social attitude similarity as did Truett *et al.* (1992). Evidence for a sex-limitation model comes from all three methods of analyses, which clearly indicate differences among males and females. In both 1981 and 1989, within level of contact there were greater phenotypic variance among male cotwins and similar patterns in the relative magnitude of genetic and shared environmental variance for both males and females. These differences in phenotypic variance and proportions of variance indicate that a sex-limitation model would best fit the model. Additionally, initial analyses suggested that equating parameter estimates for males and females provided a poor fit to the data. To the extent that contact can be viewed as a proxy measure of shared environment, failure to find consistent c^2 differences across contact (not at all in females and only in 1981 for males) suggests that it (c^2) may not really reflect true shared environment but, rather, is an artifact of assortative mating. Partitioning variance of social contact into genetic and environmental components is difficult because there is a single phenotype for the twin pair unlike most phenotypes studied in biometrical analyses.

The relationship between shared environment (as measured by social contact) and social attitude similarity is small. However, the effect of the relationship between frequency of contact and attitude similarity on estimates of genetic and environmental variance has important implications for the equal environments assumption in the twin model. When the sample is divided into high and low contact, estimates of genetic and environmental parameters are biased. This is due primarily to the high DZ correlation among those twins in high contact. This suggests that assortment into high and low contact is occurring at the genetic level, where the more similar DZ twins are in higher contact. To the extent that S → C, population estimates of genetic and environmental variance should not be affected. Additionally, the equal environments assumption is not violated due to the relationship of similarity and contact, leaving the basic twin model intact.

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