Effects of the Chorion Type on Prosocial Behavior in Young South Korean Twins

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The present study examined the possible effects of chorionicity of twins on variation of prosocial behavior in the classical twin design. Mothers of 56 pairs of monochorionic monozygotic (MCMZ) twins, 34 pairs of dichorionic monozygotic (DCMZ) twins, and 316 pairs of dizygotic (DZ) twins rated their children's prosocial behavior. The MCMZ correlation for prosocial behavior was similar to the DCMZ correlation (.63 vs. 61), but both correlations were higher than the DZ correlation (.33). Models incorporating the chorion effects were fit to the data. Genetic, shared and nonshared environmental, and chorion effects in the full model were, respectively, 53% (95% CI: 1–70%), 7% (95% CI: 0–37%) , 40% (95% CI: 29–54%), and 0% (95% CI: 0–27%), with the effects of chorion and shared environment being nonsignificant. These findings indicate that genetic and environmental factors in prosocial behavior estimated from twin studies are not significantly influenced by the chorion type of MZ twins.

Prosocial behavior is defined as a cluster of behaviors intended to benefit others, such as helping, sharing, cooperating, kindness, and having a caring attitude (Fehr & Fischbacher, 2003; Jackson & Tisak, 2001). Several studies have examined genetic and environmental influences on prosocial behavior. Depending on the age of the twins and the measures used, approximately 30% to 78% of the variance of prosocial behavior was attributable to genetic factors, and about 0% to 50% was due to common family environmental factors (Knafo & Plomin, 2006; Rushton, 2004; Scourfield et al., 2004; Zahn-Waxler et al., 2001). In general, genetic influences on prosocial behavior tended to increase with age, whereas common family environmental influences decreased. While most twin studies of prosocial behavior have been on the basis of Caucasian samples, genetic and environmental influences on prosocial behavior were recently analyzed in a sample of young South Korean twins (Hur & Rushton, 2007).[1] The results of the South Korean twin study were similar to the findings from Western twin samples, supporting cross-cultural generality of genetic and environmental influences on prosocial behavior.

The classical twin method relies on the comparison of similarities between monozygotic (MZ) and dizygotic (DZ) twins. One of the crucial assumptions of the classical twin method is that MZ and DZ twins experience similar degrees of prenatal environment. However, it is well known that due to differences in placental anatomy, MZ and DZ twins experience different environments during the prenatal period. To the extent that these prenatal environmental differences exert influences on the trait under study, the classical twin study will yield biased estimates of genetic and environmental factors.

Because the zygotes of DZ twins implant individually in the uterus, each embryo develops its own placenta and chorion. Unlike DZ twins, MZ twins vary in their placentation, according to the timing of division of the inner cell mass. If MZ twins are divided at, or before, the morula stage, then each twin will develop individual chorion and amnion like DZ twins — these twins are known as dichorionic MZ (DCMZ) twins. Later division will result in MZ twins with one chorion — known as monochorionic MZ (MCMZ) twins. Approximately a third of MZ twins are DCMZ, and two thirds, MCMZ twins (Bulmer, 1970). The sharing of a chorion and a placenta, and the presence of vascular anastomoses between the circulations of the two fetuses allows exchange of blood, hormones, oxygen and other material between both members of the twin pair (Machin et al., 1996). For this reason, MCMZ twins can be more similar than DCMZ twins in postnatal development. Indeed, prior studies have shown that MCMZ twins resemble each other more than DCMZ twins in behavioral characteristics like cognitive abilities (Jacobs et al., 2001; Melnick et al., 1978) and personality traits (Reed et al., 1991; Sokol et al., 1995). Critics of twin studies argue that MCMZ twins should be removed from twin analyses to minimize biases in estimation of heritability (Phillips, 1993).

To date, little is known about the impact of chorionicity on the postnatal development of prosocial

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behavior. However, prosociality has been shown to be significantly negatively related to testosterone (Baucom et al., 1985; Harris et al., 1996). If, as a consequence of a shared vascular system during the prenatal period, exchange of hormones occurs between the two members of a pair, then MCMZ twins can be more similar than DCMZ twins in prosocial behavior, and subsequently, estimates of genetic influences on prosocial behavior in the classical twin design will be inaccurate. The major goal of the present study, therefore, is to explore the influence of chorion on the estimates of genetic and environmental factors in prosocial behavior, using young South Korean twins. This is the first report of the effects of chorion on the variation of prosocial behavior in twin studies.

Methods

Sample

The present sample was drawn from the South Korean Twin Registry (SKTR), a nationwide volunteer twin registry that includes twins from infants to adults (Hur et al., 2006). As part of a SKTR telephone interview conducted in 2006, a Korean version of the Prosocial Scale (PS) of the Strengths and Difficulties Questionnaire (SDQ: Goodman, 1997) was given to the mothers of twins born in a large maternity hospital in Seoul between 1998 and 2004. The pathology laboratory of the maternity hospital routinely examines the placentas of twins at delivery, and analyzes the chorionicity using standard methods. Approximately 71% of the mothers of the twins who were approached responded to our telephone interview (Due to high mobility in Seoul, many of the telephone numbers of the twins' parents had changed at the time of contact).

Zygosity was determined from mothers' responses to a questionnaire about physical similarities and frequency of confusion by family members. This questionnaire method has previously been demonstrated to be over 90% accurate in determining zygosity, compared to results from DNA analyses (Ooki et al., 1993). However, in order to minimize misclassification of zygosity in the present sample, 13 pairs were excluded from data analyses because their zygosity was ambiguous. The final sample comprised 56 pairs of MCMZ twins (36 male and 18 female pairs)[2], 34 pairs of DCMZ twins (17 male and 17 female pairs), and 316 pairs of DZ twins (77 male, 80 female, and 159 opposite-sex pairs). The twins ranged in age from 1.9 to 9.1 years, with a mean of 4.0 years, and a SD of 2.0 years. The higher number of DZ than MZ pairs in the present sample is due to the number of assisted pregnancies (Hur & Kwon, 2005).

Measures

The Korean version of the PS has been shown to be reliable and valid (Ahn et al., 2003). The Korean version included five prosocial items regarding children's sharing, helping, and being kind and considerate of others. Mothers of the twins were asked to rate each item on a 3-point Likert scale ('not true' to 'certainly true'). Answers for the five prosocial items were summed. Internal consistency reliability of the scale was .65 in the present twin sample.

Statistical Analyses

To fulfill the goals of the present study, maximum likelihood correlations for MCMZ, DCMZ, and DZ twins were computed, and a structural equation model incorporating chorion effects (Fig 1) was applied to the twin data. The raw data option in Mx (Neale et al., 2003) was used to conduct correlational and model-fitting analyses. Prior to correlational and model-fitting analyses, means and variances for the PS were compared across zygosity and chorion type using Mx. The main effects of sex and age were also examined.

The model used in the present study includes additive genetic (A), shared environmental (C), and nonshared environmental (E) factors, and a chorion effect. Measurement error is confounded with the E factors. The A factors, the sum of the average effect of all genes that influence a trait, correlate at 1.0 for both types of MZ twins, and at .5 for DZ twins. The C factors correlate at 1.0 for both MZ and DZ twins, because the twins in the present sample are raised together in the same home. The chorion effect correlates at 1.0 for MC twins, and at 0 for DC twins. Finally, the E factors, environmental factors that are unique to each member of a twin pair, and measurement error, do not contribute to the twin similarity, and are therefore depicted in the path diagram as residual arrows for each twin. The parameterization of this model is explained in detail in Prescott et al. (1999).

The raw data option in Mx calculates twice the negative log-likelihood (–2LL) of the data. If the models are nested, the difference in –2LL between the nested models is chi-square distributed, which permits evaluation of alternative models. To select the best-fitting model, the fit of the full model in Figure 1 was first compared to that of a saturated model, where variances and means of the first- and the second-born MCMZ, DCMZ and DZ twins were allowed to vary. Next, the fit of the full model was compared to the fit of a series of reduced models, where the parameters of the chorion effects, additive genetic factors, and shared environment factors were constrained to be zero. A significant difference in chi-square between the full and reduced model indicates a significant influence from the constrained parameter, indicating that the reduction of the model is not acceptable. However, a nonsignificant change in chi-square between the full and reduced model implies a negligible influence from the constrained parameter, suggesting that the parameter needs to be removed from the full model to achieve parsimony of the model.

Results

Descriptive Statistics

Table 1 presents means and variances for the PS for MCMZ, DCMZ, and DZ twins, by birth order.

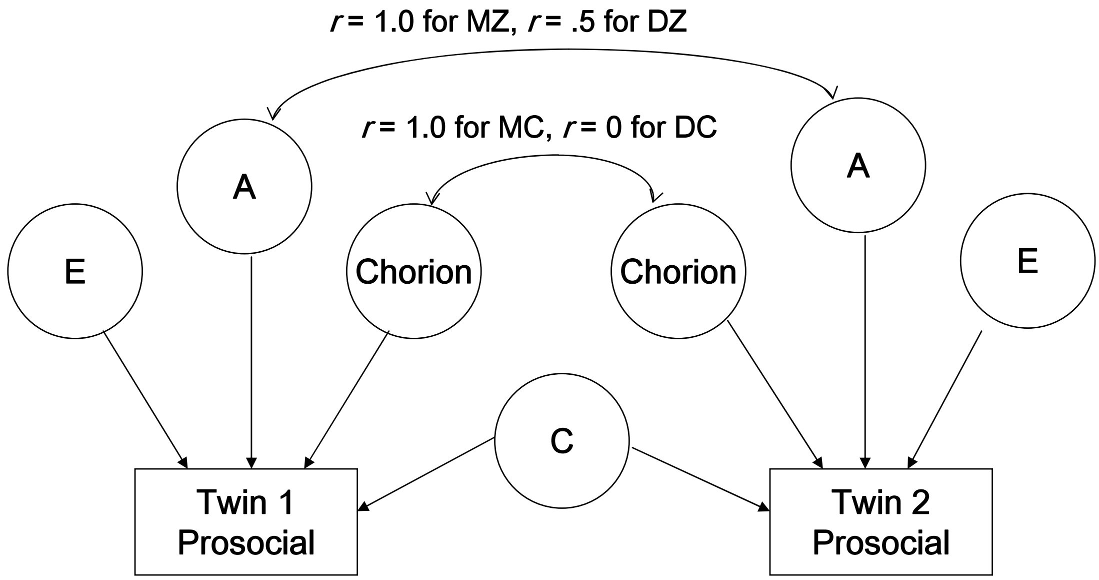

Figure 1

Twin model incorporating chorion effects.

Note: A = additive genetic factors, C = shared environmental factors, E = nonshared environmental factors including measurement error; MZ = monozygotic twins, DZ = dizygotic twins. MC = monochorionic twins, DC = dichorionic twins.

Means or variances were not significantly different across the three twin types. The first-born twins were not significantly different from the second-born twins, indicating no birth order effects on prosocial behavior.

Consistent with literature of prosocial behavior (Stevenson, 1997; Scourfield et al., 2004), females were significantly higher than males on the PS; and the score of the PS increased with age (r = .21) in the present sample. In correlational and model-fitting analyses, therefore, sex and age were treated as covariates to control their main effects.

Twin Correlations

Maximum likelihood correlations for the PS were .63 (95% CI: .44–.73) for MCMZ twins, .61 (95% CI: .38–.76) for DCMZ twins, and .33 (95% CI: .23–.43) for DZ twins. MCMZ and DCMZ twin correlations were not significantly different from each other; however, they were both significantly higher than DZ twin correlations. These results indicate that the effects of chorion may be negligible, while genetic influences on prosociality are substantial.

Model-Fitting

Table 2 summarizes the results of model-fitting analyses. The difference in chi-square between the saturated and full model was not significant, suggesting that the full model incorporating the chorion parameter does not significantly depart from the data.

Additive genetic, and shared and nonshared environmental variances, and chorion effects in the full model were, respectively, .53 (.01–.70), .07 (.0–.37), .40 (.29–.54), and .0 (.0–.27). When the additive genetic parameter was removed from the full model, a significant change in chi-square occurred, suggesting that genetic factors are important in the variance of prosocial behavior. The difference in chi-square was not significant when the chorion effects were eliminated from the full model, indicating that chorionicity exerts little influence on the variation of prosocial behavior. Similar results occurred when shared environmental factors were dropped from the full model. From these results, the model that includes additive genetic and nonshared environmental factors was chosen as the best-fitting one. Under this model, addi-

Table 1

Means and Variances for the Prosocial Scale for MCMZ, DCMZ, and DZ Twins by Birth Order

	MCMZ[1]		DCMZ		DZ		Test statistics	
	1st-born	2nd-born	1st-born	2nd-born	1st-born	2nd-born	$\Delta\chi^2$	p
Mean	6.71	6.25	6.88	6.38	6.44	6.24	1.81	.88
Variance	4.13	5.62	4.16	4.79	4.72	4.48	3.49	.63

Note: [1]Includes two pairs of monoamnionic twins; MCMZ = monochorionic monozygotic twins, DCMZ =dichorionic dizygotic twins; DZ = dizygotic twins.

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Table 2
Model-Fitting Resultsa

	Goodness-of-fit indices					Parameter estimates (95% CI)			
Model Description	–2LL	*df*	$\Delta\chi^2$	Δdf	*p*	A	C	E	Chorion
Saturated	3407.5	789							
Full	3409.5	803	2.0	14	.75	.53 (.01–.70)	.07(.00–.37)	.40 (.29–.54)	.00 (.00–.27)
Drop chorion	3409.5	804	0.0	1	.99	.53 (.21–.70)	.07(.00–.29)	.40(.30–.54)	—
Drop A	3413.4	804	3.9	1	.04	—	.36(.26–.45)	.40(.29–.58)	.24(.04–.39)
Drop C	3409.9	804	0.4	1	.55	.61 (.48–.70)	—	.39(.28–.50)	.00(.00–.16)
Drop C & chorion	3409.9	805	0.4	2	.84	.61 (.50–.70)	—	.39 (.30–.50)	—

Note: [a]Sex and age were treated as covariates in the model; A = additive genetic factors, C = shared environmental factors, E = nonshared environmental factors including measurement error. LL = log-likelihood; — = constrained to be zero.

tive genetic and nonshared environmental factors were, respectively, .61 (95% CI: .50–.70) and .39 (95% CI: .30–.50). These estimates are largely in the range of those reported in previous twin studies of prosocial behavior (e.g., Scourfield et al., 2004).

Discussion

The present study demonstrates that chorionicity of twins plays a minimal role in the variation of prosocial behavior, suggesting that genetic and environmental influences on prosocial behavior using the classical twin design may not be significantly influenced by the chorion type of MZ twins. To obtain a clear picture of the impact of the chorion type on the estimates of genetic and environmental factors in the classical twin method, additional model-fitting analyses were carried out, where DZ twins were compared, respectively, to the DCMZ twins only, and to the pooled MZ twin group consisting of MCDZ and DCDZ twins. In both comparisons, the full model produced 54% for heritability, 6% for shared environmental variance, and 40% for nonshared environmental variance including measurement error. These values are extremely close to the corresponding estimates of 53%, 7%, and 40% reported in Table 1, indicating that MZ twins, in spite of differences in chorionicity, can be treated as a homogeneous group in the classical twin design to evaluate genetic and environmental influences on prosocial behavior. The similarity in correlations between MCMZ and DCMZ twins (.63 vs. 61) also confirms the lack of an effect of chorionicity in prosocial behavior.

Some limitations of this study should be emphasized. First, the sample sizes of MCMZ and DCMZ twins in the present study were relatively small. To strengthen the present findings, therefore, a replication with a larger sample will be necessary in the future. Another limitation of the present findings is a possible rating bias, that mothers exaggerated the similarity of the MZ twins, and magnified the differences of the DZ twins, thereby producing an overestimation of genetic influence. However, it is unlikely that this rating bias occurred, because the variance within the DZ twin pairs was no different than that within the MZ twin pairs, and because the majority of the mothers were not certain of their twin children's zygosity or chorionicity at the time of interview.

In conclusion, genetic factors in childhood prosocial behavior are relatively high when estimated from the classical twin design, and are not significantly affected by variations of the timing of the blastomere division, or differences in the sharing of vascular systems in MZ twins.

Endnotes

1 The present study was based on a subsample of twins who participated in the Hur and Rushton study.

2 MCMZ twins in the present sample included two pairs of monoamnionic twins.

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