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A genetic analysis of individual differences in dissociative behaviors in childhood and adolescence

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Background: Dissociation – a pattern of general disruption in memory and consciousness – has been found to be an important cognitive component of children's and adults' coping with severe trauma. Dissociative experiences include amnesia, identity disturbance, age regression, difficulty with concentration, and trance states. Stable individual differences in dissociative behaviors may represent a dissociative tendency trait that varies in the population independent of the influence of trauma. **Method:** In the current study, we examined genetic and environmental sources of variance in some of these behaviors by comparing 86 pairs of adoptive siblings and 102 pairs of full siblings from the Colorado Adoption Project (parents' and teachers' ratings), and 218 pairs of identical and 173 pairs of same-sex fraternal twins from the British Register for Child Twins (parents' ratings). The study used a dissociation scale comprised of six CBCL items. **Results:** Developmentally, there was no change in mean dissociation scores across middle childhood and adolescence, and individual differences were moderately stable. Both parents' and teachers' ratings showed moderate to substantial amounts of genetic and nonshared environmental variance and negligible shared environmental variance, and most of the parent–teacher agreement in their ratings was accounted for by overlapping genetic variance. **Conclusions:** The results support further research into possible genetic and environmental factors that contribute to dissociative tendencies in children and adolescents. **Keywords:** Behavioral genetics, Child Behavior Check List, dissociation, environmental influences, genetics, individual differences.

Dissociation has been defined as 'a disturbance or alteration in the normally integrative functions of identity, memory, or consciousness' (American Psychiatric Association, 1994). Some empirical research on the widely used Dissociative Experiences Scale (DES; Bernstein & Putnam, 1986) supports a dimensional model in which dissociative experiences are distributed throughout the population, with people with dissociative disorders experiencing more frequent and severe symptoms. However, other work points to a typological model in which most people experience relatively mild symptoms (e.g., absorption), while people with dissociative disorders experience qualitatively different symptoms (e.g., derealization and amnesia; Putnam, 1997; Waller, Putnam & Carlson, 1996).

The etiology of dissociation has most often been considered in relation to environmental influences. Environmental factors, specifically abusive childhood experiences, are associated with both pathological and non-pathological dissociation. Adults (Coons, Bowman, & Milstein, 1988; Putnam, Gurof, Silberman, Barbar, & Post, 1986), adolescents (Dell & Eisenhower, 1990; Bowman, Blix, & Coons, 1985; Hornstein & Putnam, 1992) and children (Coons, 1994; Fagan & McMahon, 1984) with dissociative disorders report high rates of childhood trauma and neglect. Childhood sexual and physical trauma and neglect are positively related to scores on measures of dissociative tendency in adults (DiTomasso & Routh, 1993; Draijer & Langeland, 1999; Irwin, 1996) and children (Ogawa, Sroufe, Weinsfeld, Carlson, & Egeland, 1997; Sanders & Giolas, 1991). Adults who were physically or sexually abused as children have higher scores on measures of dissociation than do non-abused adults (Chu & Dill, 1990). Similarly, abused children score higher on dissociation measures than non-abused children (Atlas & Hiott, 1994; Malinosky-Rummell & Hoier, 1991; Putnam, Helmers, & Trickett, 1993).

Environmental factors may also be involved in bolstering resiliency against pathological and non-pathological dissociation. A factor in Kluft's 4-factor model of the development of dissociative identity disorder is the absence of restorative experiences, often provided by an adult outside of the child's nuclear family (Kluft, 1984, 1996). Supporting this model, Irwin (1996) found that dissociative tendency in adults was positively related to reported childhood trauma, and that this relation was mediated by the amount of perceived emotional support from extended family, other adults and peers.

Some etiological models have also postulated a genetic diathesis. For example, Braun and Sachs (1985) describe a 'natural, inborn capacity to disso-

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ciate.' Kluft (1984, 1996) discusses the 'biological capacity to dissociate.'

Behavioral genetic analysis provides tools to examine empirically genetic and environmental processes in the development of normative and pathological dissociation. The present study is a first step toward understanding of these genetic and environmental processes in the etiology of dissociative behaviors in children and adolescents.

Two recent twin studies investigated environmental and genetic components of dissociation as measured by the DES-T (an eight-item subscale of the DES empirically derived to indicate the most severe dissociation). These findings are summarized in Table 1. Waller and Ross (1997) estimated genetic and environmental components of DES-T scores in a volunteer, adolescent twin sample ($n = 140$ MZ and 74 DZ pairs). Although adults can be assigned to classes (highly dissociative or not) based on Bayesian probabilities, these probabilities have not yet been validated for adolescent samples. For this reason, Waller and Ross (1997) used a taxometric of DES-T scores (based on adult norms), as well as calculating the sum of the eight DES-T items. When using the sum of DES-T items, Waller and Ross (1997) found that 45% of the variance on the DES-T was attributable to shared environment (i.e., environmental influences that lead to sibling similarity in dissociation), and 55% was attributable to non-shared environment (i.e., environmental influences that lead to sibling differentiation, including error variance); there was no genetic variance. Waller and Ross (1997) found similar results for the taxon membership scores.

Jang, Paris, Haille, and Livesley (1998) analyzed similar data in a volunteer, adult twin sample ($n = 177$ MZ and 152 DZ pairs), using taxon membership scores derived in the same manner as Waller and Ross (1997). In contrast to the findings of Waller and Ross (1997), Jang et al. (1998) obtained a non-shared environment estimate of 52%, but the remaining 48% of the variance was accounted for by additive genetic influences; shared environment was negligible. A similar set of findings was obtained when Jang et al. (1998) examined the non-pathological dissociation scores (DES-NP, remaining DES items not included in the DES-T), with 55% of the variance accounted for by genetic factors, and 45% nonshared environment. Jang et al. (1998) further estimated that pathological and non-pathological dissociation scores shared 45% of the genetic and 34% of the environmental variance. The authors suggest that pathological and non-pathological dissociation scores are influenced by a common genetic predisposition to dissociate, but are differentiated by environmental factors.

While most research on dissociation has had a clinical focus and has primarily used measures of pathological dissociation, the study of non-pathological dissociation is also important in its own right. For example, Putnam (1997) has proposed a discrete behavioral state model to explain children's gradual development of emotion regulation. In this model, children gradually develop the ability to move smoothly between emotional and behavioral states (such as from a crying state to a calm state), a process that is facilitated by metacognitive abilities. As children develop the ability to transition between states, they can be thought of as becoming less dissociative. In this way, non-pathological dissociation may be connected to Theory of Mind, inhibitory control and other metacognitive abilities of interest to developmental researchers. Another line of research has connected non-pathological dissociation to fantasy proneness or imagination. In children, what might be considered a sign of pathological dissociation in adults is often considered a sign of creativity. Imaginary companions are a classic example. People who grow up to be adept pretenders (actors, for example) may benefit from a healthy dose of non-pathological dissociation.

The present study represents, to our knowledge, the first genetic analysis of dissociative behaviors in both childhood and adolescence, whereas previous research has included adolescents and adults. Dissociation measured in school-age children may differ in some ways from the construct of dissociation as measured in adolescence and adulthood. Further, heritability and environmental estimates can change throughout development. Furthermore, the current study goes beyond previous studies by estimating environment and genetic effects in both twin and adoption samples. This is important because both twin and adoption designs have complementary strengths and weaknesses. While twin designs provide a direct estimate of nonshared environmental effects, adoption designs provide a direct estimate of shared environment effects. In addition, the previous studies relied on self-report questionnaires whereas the present study used both parent and teacher

Table 1 Summary of findings from two genetic studies of dissociation

				Parameter estimates		
Study	Sample	*n*	Measure	h^2	c^2	e^2
Waller & Ross (1997)	Adolescent twin	140 MZ and 74 DZ pairs	DES-T (sum of DES-T items)	.00	.45	.55
			DES-T (taxon membership)	.03	.31	.66
Jang et al. (1998)	Adult twin	177 MZ and 152 DZ pairs	DES-T (taxon membership)	.48	.00	.52
			DES-NP	.55	.00	.45

ratings of children's behavior. The goal of the study is to apply the twin and adoption designs using parent and teacher ratings as a first step towards understanding the relative influence of genetic and environmental factors in the development of dissociative tendencies in children.

Method

Sample

The current behavior genetic study included two samples: participants in the Colorado Adoption Project (CAP; Plomin & DeFries, 1985), and participants in the British Register for Child Twins (British Twins; Eley, Lichtenstein, & Stevenson, 1999).

Colorado Adoption Project. Only those sibling pairs where both children had complete data were included in this study. Thus, the sample size differed depending on the data source (with somewhat higher sample sizes for parents' reports compared to teachers' reports). The study included 75 pairs of unrelated adoptive siblings with complete parent-rated data (10 same-sex male, 8 same-sex female, and 57 opposite-sex) and 91 pairs of related full-siblings with complete parent-rated data (34 same-sex male, 20 same-sex female, and 37 opposite-sex). For teachers' ratings, the sample included 61 pairs of adoptive siblings with complete data (5 same-sex male, 9 same-sex female, and 47 opposite-sex) and 77 pairs of full-siblings with complete data (24 same-sex male, 19 same-sex female, and 34 opposite-sex). Four annual assessments were made when each child was 9, 10, 11, and 12 years old.

The adoptive families in CAP were recruited through several adoption agencies in Colorado from 1975 to 1982, when the child was an infant; adopted children had been placed at 29 days on average. The adoptive families were middle class and well educated. Selective placement of adopted children was found to be negligible. A comparison group of families was recruited from the same area using birth records and telephone interviews. The families were matched on five factors: sex of the first child, number of children in family, father's age (±5 years), father's occupational status (±8 points on NORC scale), and father's years of education (±2 years). Because of this matching, the non-adoptive comparison families were similar to the adoptive families in demographic attributes. For more details on the CAP design and sample, see Plomin and DeFries (1985).

British Register for Child Twins. The participants in this study included 218 pairs of identical twins (101 male, 117 female) and 173 pairs of fraternal twins (92 same-sex male, 81 same-sex female), ranging in age from 8–16 years of age (M = 11.67 years, SD = 2.81 years). Valid data for both siblings was required for children to be included in the analysis. The twin register began as a population sample of 13-year-old twins, and was expanded to include twins of other ages using contacts through twin clubs throughout the British Isles. These families were higher in socioeconomic status compared to the British population, although the full range of socioeconomic circumstances was represented in the sample. The genetic similarity (i.e., zygosity) of the twins was determined using a questionnaire completed by parents (Cohen, Dibble, Grawe, & Pollin, 1973) and shown to be highly reliable (Goldsmith, 1991). For more details on the British Twin sample, see Eley et al. (1999).

Measures

Parents completed the 115-item Child Behavior Checklist (CBCL; Achenbach, 1991) for both samples. In the CAP, teachers' ratings were also completed, using the Teacher Report Form (TRF; Achenbach, 1991). In the CAP, teachers' and parents' ratings were completed each year when the child and sibling were 9, 10, 11, and 12 years old. In the British Twin study, a single parent-rated assessment was conducted. The CBCL and TRF are widely used, validated, and highly reliable measures of children's and adolescents' social-emotional adjustment.

Malinosky-Rummel and Hoier (1991) selected six CBCL items that were similar in content to CDC items and reported reasonable internal consistency (coefficient alpha = .71) for these 6 items as a measure of dissociation in a sample of sexually abused and non-abused children. In their sample, the 6-item CBCL scale was positively correlated with the CDC, a standard measure of dissociation in children ($r = .63$). In a separate study of abused and non-abused preschool children, the CBCL dissociation scale was correlated with the dissociation subscale of the Trauma Symptom Checklist for Young Children (Briere et al., 2001) ($r = .67$; Becker, Pears, & Freyd, 2001). These six items selected by Malinosky-Rummel and Hoier (1991) comprise the dissociative behavior scale used in this study. This scale included: CBCL and TRF items 1 (acts too young for his/her age), 8 (can't concentrate, can't pay attention for long), 13 (confused or seems to be in a fog), 17 (daydreams or gets lost in his/her thoughts), 80 (stares blankly) and 87 (sudden changes in mood or feeling). Similar dissociation subscales have been used previously with longitudinal datasets (e.g., Carlson, 1998; Ogawa et al., 1997). Each item is scored as 0, 1, or 2, based on how true each item is for the child. In the CAP data, the six items were subjected to principal components analysis separately for teachers' and parents' ratings, and separately for each assessment. The factor structure was consistent across teachers' and parents' ratings, and across each of the four annual assessments. For both samples, all six items loaded on a single factor (loadings from .37 to .83, explained variance from 34% to 51%). Internal consistency was acceptable (teacher ratings, alpha = .75 to .80; parent ratings, alpha = .57 to .68). This factor structure was replicated in the British Twin data (loadings >.46, 37% variance); internal consistency of the scale was acceptable (alpha = .63).

In the longitudinal CAP data, individual differences were stable across each of the consecutive annual assessments (teacher ratings $r = .43$ to .48; parent ratings $r = .56$ to .64). In light of this stability and in order to maximize the reliability of measurement, teacher-rated and parent-rated composite scores were computed by averaging the four assessments. Agreement between teachers and parents was moderate

($r = .54$, $df = 261$, $p < .001$). Given that multiple assessments were used to create these composite scores, we conducted a detailed analysis comparing the means on available dissociation scores for those children who did have 2 or more assessments (and had an averaged composite score) to those with only one assessment. These analyses were conducted separately for teachers' and parents' ratings and for each of the four assessments (i.e., eight independent-samples *t*-tests). Analysis of parents' ratings yielded no differences in dissociation scores for those with and without an averaged composite score. In contrast, there was the suggestion in the teachers' ratings data that those with only one assessment may have been higher in non-pathological dissociation than those with two or more assessments. In three of the four annual assessments, visual inspection of means revealed that those with only one assessment had higher dissociation scores than those with two or more assessments. This mean difference was statistically significant at age 9 years ($t = -2.23$, $df = 298$, $p < .05$) and marginally significant at age 11 years ($t = -1.70$, $df = 259$, $p < .10$). Thus, children with higher levels of non-pathological dissociation may have been underrepresented in the teacher-rated composite used in these analyses, a caveat that should be considered when interpreting the results for teachers' ratings.

Analysis plan

Sibling similarity was estimated using sibling intra-class correlations. The quantitative genetic parameter estimates were estimated using the standard univariate structural equations model (Neale & Cardon, 1992). Three independent latent variables are estimated in this model for each sibling using variance/covariance matrices: additive genetic influences (A), shared environment influences (C), and nonshared environment influences + error (E). The variance estimates (e.g., genetic variance or heritability, shared environmental variance, and nonshared environmental variance) are derived from the path estimates, and confidence intervals are used to interpret the statistical reliability of these estimates. In the CAP adoption design, the correlation between the additive genetic effects (A) is fixed to be equal to .5 for full-siblings, and 0 for adoptive siblings. The correlation between the two shared environment latent variables (C) is fixed to be equal to 1 for both biological and adoptive siblings, because these influences are by definition shared by siblings regardless of their genetic similarity. The correlation between the two nonshared environment latent variables (E) is fixed to be equal to 0 for both groups of siblings, because nonshared environmental influences are by definition unique to each sibling. A very similar model is used to derive these parameter estimates in the British Twin design. The one difference is that the correlation between the additive genetic effects (A) is fixed to be equal to 1 for identical twins, and .5 for fraternal twins. In some of these models, genetic dominance is estimated. In that case, the correlation between the two dominance latent variables (D) is fixed to be equal to 1 for MZ twins, .25 for DZ twins and full siblings, and 0 for adoptive siblings. We used a model fitting approach, where we tested alternative models to derive the model that provided the best fit to the data. The specific models that were tested and compared are described below in the Results. For example, in an ACE model, all three sources of variance are being estimated. In the AE model, C is fixed to be 0. In the CE model, A is fixed to be 0, and so on. We examined differences in model fit by comparing the AIC (including negative values, the lower this value the better the fit) and RMSEA (the closer this positive value is to 0, the better the fit).

Results

The descriptive statistics for the teachers' and parents' ratings of dissociative behaviors are presented in Table 2. Sibling birth order effects were examined. In the CAP, there was no birth order difference for teachers' ratings (1st born $M = 1.51$, $SD = 1.69$, 2nd born $M = 1.54$, $SD = 1.76$, $t = -.19$, $df = 137$, $p > .84$). In contrast, there was a modest birth order effect for parents' ratings in the CAP data: 1st born children had higher scores ($M = 1.48$, $SD = 1.50$) than did 2nd born children ($M = 1.16$, $SD = 1.35$), $t = 2.35$, $df = 165$, $p < .05$, a difference of about one-sixth of a standard deviation. There was not a significant birth order effect among the twins ($t = 1.15$, $df = 390$, $p = .25$).

Next, sex and age differences were examined. In the CAP, both parents' and teachers' ratings showed evidence for higher levels of dissociative behaviors for boys than for girls: for teachers' ratings, boys ($n = 139$) $M = 1.91$, $SD = 1.93$, girls ($n = 137$)

Table 2 Children's and adolescents' dissociative behaviors in the CAP and British Twin Register: descriptive statistics and sibling intra-class correlations

	Colorado Adoption Project		British Twin Register	
	Adoptive *M* (*SD*) *r*	Nonadoptive *M* (*SD*) *r*	Fraternal *M* (*SD*) *r*	Identical *M* (*SD*) *r*
Teacher ratings:				
1st born	2.12 (2.04) –.02	1.03 (1.15).32*	– – –	– – –
2nd born	2.09 (2.05) –	1.12 (1.37) –	– – –	– – –
Parent ratings:				
1st born	1.90 (1.75).06	1.14 (1.15).29*	1.55 (1.72).21***	1.58 (1.82).60***
2nd born	1.47 (1.62) –	.90 (1.00) –	1.82 (1.94) –	1.58 (1.77) –

*$p < .05$; ***$p < .001$.

$M = 1.14$, $SD = 1.38$, $t = 3.85$, $df = 274$, $p < .001$, and for parents' ratings, boys ($n = 182$) $M = 1.46$, $SD = 1.52$, girls ($n = 150$) $M = 1.15$, $SD = 1.30$, $t = 1.95$, $df = 330$, $p < .06$. In the British Twin study, there was not a significant sex difference in parents' ratings, $t = 1.49$, $df = 392$, $p < .14$: for boys, $M = 1.70$, $SD = 1.93$; for girls, $M = 1.44$, $S = 1.60$. We also examined child age as a within-subjects variable in the CAP and a between-subjects variable in the twin study. There were no age differences. In the CAP, average dissociation scores were highly similar across each of the four assessments for both parents' and teachers' ratings. In the British Twin study, age and dissociation scores were uncorrelated ($r = .05$, $p > .15$, $df = 781$).

Next, sibling type (adoptive, nonadoptive, fraternal twin, identical twin) differences were examined within each of the two studies. In the CAP, adoptive children were consistently rated as being higher in dissociative behaviors than were nonadoptive children: for teachers' ratings, adopted children ($n = 122$) $M = 2.10$, $SD = 2.04$, and nonadopted children ($n = 154$) $M = 1.07$, $SD = 1.26$, $t = 4.91$, $df = 191.56$, $p < .001$; for parents' ratings, adopted children ($n = 150$) $M = 1.68$, $SD = 1.70$, and nonadopted children ($n = 182$) $M = 1.03$, $SD = 1.15$, $t = 4.15$, $df = 243.42$, $p < .001$. Also noteworthy is the finding that there was about twice as much variance in the adopted children's scores as there was in the nonadopted children's scores (Levene's test, teachers' ratings $F = 39.20$, $p < .001$ and parents' ratings $F = 36.25$, $p < .001$). These patterns were also evident in the more detailed descriptive statistics derived as a function of birth order (see Table 2). In contrast, in the British Twin study, there was no effect of zygosity (identical or fraternal twin pair) on parents' ratings, $F = .03$, $df = 1, 392$, $p = .87$, and the variance in scores was similar for MZ and DZ twins.

Sibling similarity

The sibling intra-class correlations were estimated as a function of sibling genetic similarity, and are shown in Table 2. In the CAP data, teachers' reports of dissociative behavior were uncorrelated for adoptive siblings, but showed a moderate correlation for nonadoptive biological siblings. A similar pattern was found for parents' reports in the CAP – adoptive siblings' dissociation scores showed a negligible correlation, whereas the correlation for nonadoptive siblings was somewhat higher. This pattern within the CAP adoption design suggested that nearly all of the sibling similarity in teacher- and parent-rated dissociation was accounted for by the genetic similarity of the siblings. In contrast, the negligible correlation found for adoptive siblings – a direct estimate of shared environmental variance – suggested little shared environmental variance. A similar pattern was found for the fraternal and identical twin pairs, also shown in Table 2. Fraternal twin similarity in parents' ratings of dissociative behaviors was moderate ($r = .21$, $p < .001$), whereas identical twin similarity in parents' ratings was substantial ($r = .60$, $p < .001$).

The gender composition of the sibling pair showed discernible influences on these estimates of sibling similarity in the CAP, although given the sample sizes it was not possible to detect these modest differences as statistically significant. For teachers' ratings, among adoptive siblings sibling similarity was slightly higher among same-sex pairs ($r = .18$, n.s., $n = 14$ pairs) than opposite-sex pairs ($r = -.08$, n.s., $n = 47$ pairs). The opposite pattern was found for parents' ratings; sibling similarity was greater for opposite-sex pairs ($r = .14$, n.s., $n = 57$ pairs) than it was for same-sex pairs ($r = -.24$, n.s., $n = 18$ pairs). Among the biological full siblings in the CAP, sibling similarity was more marked for same-sex than for opposite-sex pairs: teachers' ratings, same-sex $r = .35$, $p < .05$, $n = 43$ pairs, opposite-sex $r = .26$, n.s., $n = 34$ pairs; parents' ratings, same-sex $r = .39$, $p < .01$, $n = 54$ pairs, opposite-sex $r = .16$, n.s., $n = 37$ pairs. Sibling intra-class correlations were similar for male and female pairs of MZ twins (females, $r = .55$, males, $r = .63$) and DZ twins (females, $r = .19$, males, $r = .23$) in the British twin study.

Before proceeding, we were curious as to whether the patterns just described for the CAP study were represented in the annual assessments – recall that these analyses were based on composite scores based on averaging across four assessments. Examination of sibling similarity yielded patterns that were very similar to those described above. In each of the four years and for both parents' and teachers' ratings (i.e., 8 pairs of correlations), visual inspection of these correlations suggested that full siblings were more similar than adoptive siblings, although there was one exception – for parents' ratings in year 10, the biological sibling correlation was slightly lower than the adoptive sibling correlation. This exception aside, the patterns of sibling similarity for each year were remarkably consistent with the patterns described above for the averaged composite scores.

Next, we obtained parameter estimates using model-fitting procedures. We began with the CAP data. First, we tested the full ACE model. Then, we tested two reduced models – AE and CE – to discover whether either of these offered a more parsimonious fit to the data than the full ACE model. In each case, the models included the standard constraint that the variances be equal across sibling groups. However, in the CAP, the variances differed across the adoptive and nonadoptive children. It is not uncommon to find variance differences between groups when there are multiple sibling types. For this reason, in addition to the usual model in which variances are constrained to be equal for all four groups, we also ran

Table 3 Children's dissociative behaviors in the CAP: Quantitative genetic parameter estimates of additive genetic variance (a^2), shared environment (c^2), and nonshared environment (e^2) with 95% confidence intervals, and model fit indices

Variances fixed to be equal across groups							
Teacher ratings							
	a^2	c^2	e^2	$X^2(df)$	*p*	*AIC*	*RMSEA*
ACE	.70 (.03–1.0)	.00 (.00–.18)	.30 (.00–.90)	12.42 (3)	.006	6.42	.17
AE	.70 (.11–1.0)	—	.30 (.00–.89)	12.42 (4)	.014	4.42	.15
CE	—	.08 (.00–.25)	.92 (.75–1.0)	16.65 (4)	.002	8.65	.18
Parent ratings							
	a^2	c^2	e^2	$X^2(df)$	*p*	*AIC*	*RMSEA*
ACE	.93 (.38–1.0)	.07 (.00–.23)	.00 (.00–.49)	29.53 (3)	.000	23.53	.27
AE	1 (.59–1.0)	—	.00 (.00–.46)	30.23 (4)	.000	22.22	.24
CE	—	.16 (.01–.31)	.84 (.69–.99)	38.67 (4)	.000	30.67	.28
Variances free to vary across groups							
Teacher ratings							
	a^2	c^2	e^2	$X^2(df)$	*p*	*AIC*	*RMSEA*
ACE	.48 (.00–.88)	.00 (.00–.23)	.52 (.12–.98)	.19 (2)	.91	–3.81	.00
AE	.48 (.04–.88)	—	.52 (.12–.96)	.19 (3)	.98	–5.81	.00
CE	—	.13 (.00–.29)	.87 (.71–1.0)	2.59 (3)	.46	–3.41	.00
Parent ratings							
	a^2	c^2	e^2	$X^2(df)$	*p*	*AIC*	*RMSEA*
ACE	.47 (.00–.96)	.08 (.00–.30)	.45 (.04 –.87)	1.56 (2)	.46	–2.40	.000
AE	.64 (.24–.98)	—	.36 (.02 –.76)	2.09 (3)	.55	–3.91	.000
CE	—	.22 (.06 -.36)	.78 (.64 -.94)	4.00 (3)	.26	-2.00	.000

the same models again, in which we allowed the variances to be free to differ from one another. This is called a scalar effects model; it is used most commonly when examining sex differences, although it is also appropriate when analyzing other types of groups (see Neale & Cardon, 1992). The results are presented in Table 3.

There are two patterns in these estimates that should be considered before the results are described. First, model fit improved significantly when the variances were free to vary across sibling groups (shown in the bottom half of Table 3). It also should be noted that heritability estimates were unrealistically high in the models in which variances were not allowed to differ across sibling groups – another reason to interpret the models where variances were free to vary across groups. Second, dropping the C parameter (the AE model) resulted in a more parsimonious model with no decrement in model fit, whereas dropping the A parameter (the CE model) did result in a more substantial, albeit small, decrement in model fit. These patterns were found for both teachers' and parents' ratings. For these reasons, we focused on the results of the AE model results where the variances were free to vary across sibling groups. These data suggested that heritability and nonshared environment were both moderate, and shared environment was negligible, which corresponds to the results suggested by the simple correlations for adoptive and nonadoptive siblings (Table 2).

We also estimated a correlated factors multivariate genetic model (Neale & Cardon, 1992) to examine the sources of covariance that might explain the phenotypic correlation between teachers' and parents' ratings of children's dissociative behaviors ($r = .54$). In this extension of the ACE model, the correlation between parents' and teachers' ratings is accounted for by some combination of additive genetic, shared environmental, or nonshared environmental sources of covariance. Six latent variables are estimated in this model, including two additive genetic components (one for teacher ratings, one for parent ratings), two shared environmental components, and two nonshared environmental components. In this way, the model tests the extent to which additive genetic, shared environmental, and nonshared environmental sources of variance mediate the correlation between the teacher-rated and parent-rated scores. This model yielded a statistically significant genetic correlation of 1 (95% confidence interval = .52 to 1), $X^2 = 13.07$, $df = 9$, $p = .16$, AIC = -4.93, RMSEA = .041. This suggested that the same genetic factors are involved in parent and teacher ratings.

Next, we examined the data from the British Twin study. These results are shown in Table 4. Like the analyses of the CAP data, we tested three models: an ACE model, an AE model, and a CE model. In addition, because dominance was suggested in the twin correlations (see Table 2), we also estimated the parameter estimates using the full ADE model (genetic dominance, additive genetic, and nonshared environment), and a DE model. Unlike the CAP data, the variances in dissociative behavior scores were very similar across the MZ and DZ twins (see Table 2). Therefore, we constrained the variances to be equal across the two twin groups. Nonetheless, as a check, we estimated models where variances were free to vary across twin groups (i.e., the scalar effects model), and as expected the results were very similar to those reported here.

Table 4 Adolescent's dissociative behaviors in the British Twin study: Quantitative genetic parameter estimates of additive genetic variance (a^2), shared environment (c^2), genetic dominance (d^2), and nonshared environment (e^2) with 95% confidence intervals, and model fit indices

	a^2	c^2	d^2	e^2	$X^2(df)$	p	AIC	RMSEA
ACE	.58 (.42–.66)	.00 (.00–.14)	–	.42 (.34–.50)	2.85 (3)	.42	–3.15	.03
AE	.58 (.50–.66)	–	–	.42 (.34–.50)	2.85 (4)	.58	–5.15	.018
CE	–	.42 (.34–.50)	–	.58 (.50–.66)	27.66 (4)	.000	19.66	.18
ADE	.19 (.00–.64)	–	.40 (.00–.67)	.40 (.33–.49)	.90 (3)	.83	–5.10	.00
DE	–	–	.60 (.51–.67)	.40 (.33–.49)	1.32 (4)	.86	–6.68	.00

Table 5 Children's and adolescents' dissociative behaviors in the combined Colorado Adoption Project and British Twin Study: Quantitative genetic parameter estimates of additive genetic variance (a^2), shared environment (c^2), genetic dominance (d^2), and nonshared environment (e^2) with 95% confidence intervals, and model fit indices

	a^2	c^2	d^2	e^2	$X^2(df)$	p	AIC	RMSEA
ACDE	.09 (.00–.65)	.08 (.00–.23)	.44 (.00–.66)	.39 (.32–.47)	3.21 (6)	.78	–8.79	.000
CDE	–	.10 (.00–.23)	.51 (.36–.66)	.39 (.32–.47)	3.25 (7)	.86	–10.75	.000
ADE	.34 (.00–.66)	–	.28 (.00–.67)	.39 (.32–.47)	3.73 (7)	.81	–10.27	.000
ACE	.60 (.43–.67)	.00 (.00–.13)	–	.40 (.33–.48)	5.13 (7)	.64	–8.87	.007
AE	.60 (.52–.67)	–	–	.40 (.33–.48)	5.13 (8)	.74	–10.87	.003
CE	–	.37 (.30–.44)	–	.63 (.56–.70)	41.11 (8)	.000	25.11	.111
DE	–	–	.62 (.54–.69)	.38 (.31–.46)	5.76 (8)	.67	–10.24	.016

The model fitting results suggested that the DE model was the most parsimonious model with the best fit to the data. However, because this model is biologically implausible, we interpreted the AE model, which offered similarly good fit. In this model, heritability accounted for just over half of the variance in the twins' dissociative behavior scores, with the remaining variance being accounted for by nonshared environment.

In the last set of genetic analyses, we estimated the full complement of possible models by combining the CAP and British Twin datasets, including: ADCE, DCE, ADE, ACE, AE, CE, and DE (Table 5). In these models, we initially allowed for differing variances for the adopted siblings, full siblings, and twins. From these models, the best fit (by AIC) was provided by the AE model, with slightly more than half of the variance being accounted for by additive genetic effects. Given the group differences in variances in the adoption study, we also tested an AE model in which the variances for the twin pairs were equated to those for the adoptive siblings, and the biological sibling group variance was allowed to vary from these other groups. This resulted in an even more parsimonious fit to the data, $X^2 = 6.48$, $df = 9$, $p = .69$, AIC $= -11.52$, RMSEA $= .000$. Heritability was estimated to be .59 (95% confidence intervals = .51–.66), and the nonshared environment component was .41 (.34–.49). The variance for the adoptive sibling and twin pairs was estimated by the model to be 1.76 (1.67–1.85), whereas the variance for the biological full-siblings was 1.06 (.96–1.18).

Discussion

In this study, we estimated the environmental and genetic contributions to variance in scores on a measure of dissociative behaviors, as rated by teachers and parents in both a twin and an adoption sample. The findings for the child adoption and adolescent twin samples, using either teacher or parent report measures of dissociative behaviors, were remarkably consistent. Data from the adoption study indicated that individual differences in children's non-pathological dissociation were moderately stable from year to year, and data from both studies revealed no change in average dissociation scores from middle childhood through early and mid-adolescence. This developmental pattern of moderate stability and virtually no change in mean dissociation scores was consistent with previous developmental work that examined pathological or more extreme dissociation in non-maltreated groups (Putnam, 1997, p. 181).

With respect to genetic and environmental factors, model fitting procedures suggested that additive genetic variance and nonshared environment accounted for these individual differences. There was also evidence to suggest that genetic dominance may be present. In addition, based on the data from the adoption study, the moderate correlation between parents' and teachers' ratings of children's dissociative behaviors was mediated largely by additive genetic factors, which suggests a type of genetic validity to the parent and teacher ratings.

Comparing the current findings to the two previous behavioral genetic studies (Jang et al., 1998; Waller & Ross, 1997) requires consideration of several factors. First, the results of the previous studies are not consistent. Jang et al. (1998) found moderate genetic and nonshared environmental effects but no shared environmental variance, whereas Waller and Ross (1997) found moderate shared and nonshared environmental effects but no genetic variance. It is not clear what accounts for the differences in these findings because the studies differed in several respects. Subjects in the study of Waller and Ross (1997) were high school students (MZ *m* age = 15.42, SD = 1.73; DZ *m* age = 15.33, *SD* = 1.91) whereas subjects were adolescents and adults in the study of Jang et al. (1998) (MZ *m* age = 31.96, *SD* = 13.71, range = 16 to 71 years; DZ *m* age = 31.16, *SD* = 11.48, range = 16 to 68 years). Further, the Jang et al. (1998) study used DES-T scores transformed for skewness whereas the Waller and Ross (1997) study included two different indices calculated with adult Bayesian weights and the sum of DES-T items (the authors did not report transforming the variables). Second, in these previous studies dissociation was assessed using the DES-T, a measure of pathological dissociation. In contrast, we used a measure of non-pathological dissociation derived from the Child Behavior Checklist. Furthermore, the nature of the volunteer twin and adoption samples used in the current study, together with the requirement that adoptive siblings had completed 2 assessments for both twins, makes it even more likely that the dissociation represented in these data is generally not trauma-induced or pathological.

For these reasons, perhaps the best comparison is between our findings for non-pathological dissociation in children and adolescents and Jang et al.'s (1998) findings for non-pathological dissociation (DES-NP) in adults. The findings from the twin and adoptive child/adolescent samples are quite similar to Jang et al.'s (1998) findings for non-pathological dissociation in adolescents and adults. Both revealed moderate genetic and nonshared environmental effects, and no shared environment effects. In addition, both studies also found evidence suggesting that dominance may be present.

Previous research has repeatedly demonstrated that environmental factors, particularly stressful childhood experiences, contribute to the development of dissociation. Finding clear evidence for environmental variance in this and the previous genetic studies strongly substantiates the role of environmental factors in the development of dissociation in childhood, adolescence, and adulthood. It is noteworthy that the bulk of this environmental contribution is of the nonshared sort. One caveat is that the nonshared environmental variance estimate includes error variance. However, to the degree that there are reliable nonshared environmental processes operating, these data suggest that in order to understand the etiology of dissociation we must assess sibling differences in childhood experiences within the same family. One possibility is that children within the same family do not experience the same stressful events. For instance, one child may be involved in a car accident or act of violence, events from which other siblings are spared. Similarly, in highly dysfunctional families one child may be neglected while another child may be the victim of intrusive sexual abuse.

It is also likely that children interpret differently the circumstances that they do share. For example, two children may both live in a family with limited financial means. One child may have difficulty with peers due to feeling self-conscious about not having the clothes and toys to fit into a peer group. Another child may find ways to cope and gain access to peer groups by helping friends with homework or being a good athlete. Similarly, two children who are both sexually abused by a caretaker may have very different outcomes. For example, according to betrayal trauma theory, children are more likely to remain unaware of betrayal traumas, such as abuse at the hands of caregivers (Freyd, 1996). Dissociation is one way that children may remain unaware of abuse. Differences in the degree to which children show dissociative symptoms may be related to the extent to which individual children are dependent on their abusers for emotional and physical support. Alternatively, but consistent with betrayal trauma theory, differences in the degree to which children show dissociative symptoms may be related to genetic factors that lead to gene–environment interactions, such as mental abilities that increase sensitivity to intimate betrayal.

In light of the controversy surrounding the recent book *The Nurture Assumption* (Harris, 1998), it should be emphasized that finding that the environment operates in a nonshared manner does not imply that parents (or other aspects of the family environment) have no effect on their children's development. The sibling adoption design provides a direct estimate of the importance of shared environment in the correlation for adoptive siblings (i.e., genetically unrelated children adopted into the same family). At the same time, identical twin differences are a direct estimate of nonshared environment (although this estimate also includes error variance), because any identical twin differences that are found must be due to child-specific environmental influences (McGonigle, Smith, Benjamin, & Turner, 1993; Reiss, Neiderhiser, Hetherington, & Plomin, 2000). In the case of adoptive siblings, why do they not correlate at all for dissociative behaviors even though they grow up together? The answer must be that those aspects of family life that may influence dissociative behaviors lead to sibling differentiation, rather than sibling similarity. At the same time, if genetic influences matter, why is it that the identical twin correlation is well below unity? Again, the answer may be that those aspects of the family environment that may influence this phenotype operate on sibling differentiation, not similarity. It is also possible that environmental influences on non-pathological dissociation operate as part of gene–environment correlation and interaction processes, a possibility that could not be tested using this design. Exploring in more detail the ways in which specific environmental factors (e.g., parental neglect, abuse) operate in transaction with genetic factors remains a very important direction in research.

As in Jang and colleagues' 1998 study of adults, this study also found a substantial genetic contribution to dissociation scores. It is possible that the measure we used particularly taps a non-pathological form of dissociation, perhaps related to absorption. This kind of dissociation may be normative, especially in children. At the same time, it may serve as a diathesis that, when coupled with traumatic experiences, produces dissociative disorders. Understanding the genetic factors involved in dissociation may contribute to our understanding of the variability in response to stressful and traumatic experiences. In addition to dissociative post-traumatic stress symptoms, depression, anxiety and conduct disorders are common in traumatized children (Hornstein & Putnam, 1992). Genetic liability may influence how children respond to seemingly identical traumatic events. Future genetic studies may also directly measure and test the usefulness of possible diatheses in explaining the similarity of dissociation scores between genetically similar pairs. Absorption has been considered because it fits with some theoretical models proposing a biological propensity to dissociate and because absorption has been shown to be about 50% heritable (Tellegen et al., 1998).

It is important to keep in mind the limitations of this study. First, like all behavioral genetic designs, the analyses presented here included the assumption of equal environments for identical and fraternal twins, and for full and adoptive siblings. In addition, the estimates of heritability were based on the assumption that gene–environment correlation and interaction effects are minimal. Some of the relevant environmental influences on non-pathological dissociation may operate through these gene–environment processes, but because we examined only the dissociation scores and not candidate environmental factors, we were not able to test this assumption in this study. Examining these gene–environment processes is an important direction in future research, as we describe in more detail below. Second, the variance for the full siblings in the adoption study was restricted when compared to the adoptive siblings and the adolescents in the twin study. In addition, with respect to the adoption study, there was some evidence to suggest that children with higher dissociation scores may have been underrepresented in the averaged teacher-rating composite (but not in the parent-rating composite). Nonetheless, the results from the adoption study were replicated in the twin study. Third, the study was limited by our measure of dissociation because it did not include all aspects of dissociation. Of the six CBCL items used to form the dissociation subscale in this study, four are related to absorption (can't concentrate, can't pay attention for long; confused or seems to be in a fog; daydreams or gets lost in his/her thoughts; stares blankly). Genetic analysis using other measures that include more aspects of depersonalization and amnesia may yield different results. In particular, because of the emphasis on absorption, this scale may measure non-pathological dissociation primarily. Whether similar or different etiologies are found for more pathological forms of dissociation in childhood remains as a question for future research. In addition to finding evidence that pathological dissociation is qualitatively different from non-pathological dissociation, Ogawa et al. (1997) found that environmental factors (including physical abuse and psychologically unavailable parenting) were important in differentiating people with and without dissociative disorders. This finding, along with Jang et al.'s (1998) finding that there is less environmental than genetic overlap between pathological and non-pathological dissociation in adults, indicates that future genetic research should also include trauma histories in order to understand more fully these environmental influences. Future studies will also benefit from including a child-report measure of dissociation, in addition to the parent- and teacher-report measures used in this study, and from examining the transmission of dissociation between parents and children. Finally, because we did not have data on trauma histories for the children and adolescents in these samples, we were not able to ascertain whether the samples were representative in terms of the prevalence of trauma. It is possible that this sample, which was relatively well educated and middle class, may have experienced less trauma and pathological dissociation as compared to the general population. If so, the range may be restricted in ways that lead to underestimations of environmental contributions to dissociation.

In conclusion, this study represents a first attempt to understand genetic and environmental contributions underlying individual differences in dissociative behaviors in childhood. Further research is required to examine these gene–environment processes that incorporates measures of both normative and pathological dissociation, and that includes candidate environmental influences such as trauma history. In so doing, we will be able to compare base rates of trauma in twin and adoption samples with prevalence rates for other populations. In addition, inclusion of trauma histories in behavioral genetic studies of dissociation will clarify which environmental events account for the environmental variance described here and in previous genetic studies. In particular, we may be able to understand better the extent to which siblings are treated differentially within the same family, and the extent to which individuals facing the same stressful events respond differently. These studies will also contribute to our understanding of the role of genetics in dissociation. For example, it may be that genetics play a larger role in normative dissociative behaviors whereas environmental factors play a larger role in the etiology of dissociative disorders. It is also likely that these genetic influences on non-pathological dissociation operate in transaction with environmental influences via gene–environment interaction and correlation processes – processes that can be defined only once each child's trauma history is assessed and included in the genetic analyses. Such research will inform not only basic questions about the development of individual differences, but also has the potential to inform the development of methods of prevention and intervention for dissociative disorders.

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