Genetic Influences on Childhood Competencies: A Twin Study

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ABSTRACT

Objective: To estimate genetic, environmental, and rater contrast influences on parental reports of Activities, Social, School, and Total Competence scales of the Child Behavior Checklist (CBCL). Method: Parents of 492 twin pairs aged 8–12 years completed CBCLs. Genetic, shared and unique environmental, and rater bias effects were estimated for the Activities, Social, School, and Total Competence scales. Data on boys and girls were analyzed separately. Results: Moderate genetic influences were found only for the School scale (60%–76%), while shared environment accounted for most of the variance in Activities, Social, and Total Competence scales. Gender differences are reported. Similar to a prior twin study of CBCL problem syndromes, there was no evidence of rater bias. Conclusions: Estimates of genetic influence on these child competence domains were high for School Competence, while social competence and activity competence evidenced higher levels of shared environmental influences. Organization and wording of CBCL items may avoid rater biases in reporting. These findings have implications for interventions to improve school, social, and activities competence. J. Am. Acad. Child Adolesc. Psychiatry, 2003, 42(3):357–363. Key Words: twins, informant effects, competence, social competence, academic competence, Child Behavior Checklist.
scored significantly lower on all competence scales, with referral status accounting for 36% of the variance in the School scale and in the Total Competence scale, 25% of the variance in the Social scale, and 19% of the variance in the Activities scale (Achenbach and Rescorla, 2001). These scales have also proven useful in predicting specific types of emotional and behavioral problems. Despite these findings, the CBCL competence scales have received less attention in the research literature than the CBCL problem syndromes, and few studies have reported heritability estimates for the competence scales.

McGuire and colleagues (1994, 1999) studied perceived competence and self-worth in a sample of twins, full siblings, and step-siblings. Subscales of scholastic, social, physical, and athletic competence showed significant genetic influences, whereas shared environment effects were not significant on any of the scales. Analyses at a 3-year follow-up continued to support the significant genetic influences for six of seven subscales, and no significant shared environment effects. Longitudinal analyses indicated genetic contributions to stability for scholastic, athletic, physical appearance, and general self-worth, while social competence showed nonshared environmental mediation across time. These studies provide preliminary support for genetic influences on some competence scales.

Only one study has estimated the heritability of the CBCL competence scales (Edelbrock et al., 1995). Estimates derived from multiple regression analyses supported significant genetic influence on school competence, but not on the social or activity scales. The heritability estimate for the School scale was 0.48, which is consistent with findings for heritability of intellectual abilities (e.g., Casto et al., 1995). Significant shared environmental influences were found for Social, Activities, and Total Competence scales. These findings provide some contrast to twin studies of the CBCL problem scales that have uniformly supported moderate to large genetic influences on the problem syndromes. Because the sample was too small for separate analyses of boys and girls, gender differences in genetic effects may have been missed. Unlike previous research, genetic influences were found only for school competence. These divergent findings may reflect differences in the types of competence assessed, in the sample, or in the informants, i.e., parent versus self. A methodological issue raised by twin studies of children’s problems involves biases that may affect reporting practices. If informants provide systematically distorted ratings of a particular construct, then the resulting heritability estimates may be skewed. One type of bias, known as "rater contrast bias," arises from parents’ tendencies to use siblings as references in rating children on specific behaviors. With twins, parents may exaggerate similarities, thus inflating shared environmental influences. However, if one twin displays extreme degrees of some behavior, then the parent may exaggerate differences between the twins (Neale et al., 1992; Simonoff et al., 1998a). Biases of this sort have been revealed primarily in interviews and rating forms in which items are grouped by a common construct, thus revealing assumptions about how items should aggregate. Eaves and colleagues found evidence for these rater contrast effects in studies using typical DSM-style interviews (Eaves and Carbonneau, 1998; Eaves et al., 1997). Previous research has not found rater contrast effects on the CBCL (Hudziak et al., 2000), perhaps because items are listed mainly alphabetically, rather than by disorder. The items of the competence scales, however, are presented separately from the problem items and are grouped mainly by content area.

The Current Research

Few studies have estimated the heritability of competencies in children. The purpose of this study was to use twin study methodology in a large cohort of twins, aged 8–12 years, to determine estimates of genetic, shared environment, and nonshared environment effects. This study also assessed gender differences and rater contrast effects that have been observed when parents report on behavior problems in multiple children. We tested models both including and excluding a rater contrast term.

METHOD

Subjects and Procedure

The current research was part of a larger project, the Missouri Twin Study (MO-Twin). Parents of all twin pairs born in the state of Missouri between 1979 and 1991 were randomly selected for participation (5,349 of 7,681 twin births; 69.6%). A parent was contacted and invited to complete a brief screening interview including zygosity questions (5,008 total; 93.6% participation rate). Parents were then mailed CBCL forms for each twin. They were asked to fill out the two forms at least 2 days apart and then return by mail (60.7% return rate). There was no compensation for participation in this portion of the study. The current sample comprised 492 same-sex twin pairs aged 8–12 at the time of CBCL completion. The twin’s mother was most often the informant (96%). Zygosity was determined by a series of questions that correlate closely with genotype determination. All twin pairs in this analysis were living together with at least one biological relative. There were no significant differences in mean age between monozygotic and dizygotic groups for either gender. The average socioeconomic status of the families from which the twin pairs came was 58.58 (SD = 22.73).
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Measures

The CBCL is a standardized questionnaire for parents to rate 118 behavioral and emotional problems exhibited by their child in the past 6 months. Respondents rate each problem on a 3-point scale: 0 = not true; 1 = somewhat or sometimes true; and 2 = very true or often true. The 118 problems have been factor-analyzed into eight empirically based syndrome scales. The psychometric properties of the CBCL are well established (Achenbach and Rescorla, 2001) as are the relations between some CBCL syndromes and DSM diagnostic categories (Biederman et al., 1993; Chen et al., 1994; Edelbrock and Costello, 1988). The CBCL also contains seven sections that assess different areas of competence as discussed above.

Models

To investigate the influence of genetic differences, same-sex monozygotic pairs were compared with dizygotic pairs using structural equation modeling. We initially fit the Activities, Social, School, and Total Competence scales with the most general model to estimate the contribution of the genotype (A), shared environment (C), and unshared environment (E). If findings were similar for dizygotic and monozygotic twins, then there would be little evidence for genetic (A) influence. We included a rater contrast term (rc) to estimate the degree to which ratings of the twins might be biased by the symptoms of the other twin. This term, which measures the effect of one twin’s reported scores on the scores of the other twin, is functionally equivalent to a sibling interaction term; thus these two processes are confounded in the current design. For a model diagram that includes a rater contrast term, see Simonoff et al. (1998a).

Model Fitting

All model fitting was performed with Mx (Neale, 1994), a statistical software package designed expressly for genetic analyses. Mx compares the relations (covariance) between the ratings of twin pairs on a given dimension to a theoretically predicted pattern of covariances. If, for example, no difference is found between patterns for monozygotic versus dizygotic pairs, then there is no evidence for genetic (A) contributions to the behavior. However, genetic influences are inferred when the observed covariation indicates that monozygotic twins are more alike than dizygotic twins. To test for possible reporting biases, we compared the goodness of fit of the full ACE model, versus a model that added a rc parameter, using a likelihood-ratio χ² test and likelihood-based 95% confidence intervals (Neale, 1994). In addition, two other standard fit indices, Akakie’s information criterion, a transformation of χ², and the root mean square error of approximation (RMSEA), were used in selecting the best model (Neale et al., 1992).

Separate analyses were performed for boys and girls. Following the example of van der Valk and colleagues (1998), we initially fit the most general ACErc model. We then systematically omitted the rater contrast as well as A, C, and/or E effects.

RESULTS

Nonnormal distributions were transformed to correct skewness and kurtosis. In Table 1, variances are listed on the diagonal of each scale within zygosity grouping. Correlations and covariances between cotwins for each scale are also reported. As expected, the correlations were stronger in monozygotic twins than in dizygotic twins.

Male and female twin pairs were analyzed separately. For each scale, the full model with all terms (A for genetic influences, C for shared environment, E for unique environment, and rc for rater contrast) was initially analyzed for goodness of fit. Then terms were systematically dropped from the model. Tables 2, 3, and 4 show the model fitting results for Activities, Social, and School scales. RMSEA values of <0.10 are considered a good fit and those below 0.05 are very good (McDonald, 1989). RMSEAs for all models were below 0.1; most were below 0.05. Models printed in boldface type provided the best fit of the observed data. When two models are listed in bold, this suggests that they both fit the data equally well and were impossible to distinguish by inferential tests. In these instances, the more parsimonious model—the one with fewer parameters to be estimated—is conventionally accepted as the better.

### TABLE 1

<table>
<thead>
<tr>
<th>Zygosity (N Pairs)</th>
<th>Competence Scales</th>
<th>Covariance/Variance Matrix for Competence Scales, by Zygosity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Social</td>
<td>Activities</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DZM (156)</td>
<td>2.095</td>
<td>1.302</td>
</tr>
<tr>
<td>MZF (91)</td>
<td>1.903</td>
<td>1.471</td>
</tr>
<tr>
<td>DZF (115)</td>
<td>1.948</td>
<td>1.381</td>
</tr>
</tbody>
</table>

Note: Variances are on diagonal, covariances are above the diagonal, and correlations (in boldface type) are below the diagonal. MZM = monozygotic males; DZM = dizygotic males; MZF = monozygotic females; DZF = dizygotic females.
Parameter estimates for the best-fitting models provide additional evidence for choosing the best model (Table 5). Terms are standardized so that $a^2$ and $e^2$ represent estimates of the percentage of variance due to genetic and nonshared environment, respectively, and will thus sum to 1. For female Total Competence, $a^2$ confidence intervals encompassed zero. For all other models, the confidence intervals of $a^2$ and $e^2$ terms never encompassed zero. For the three analyses in which AE versus Aerc models could not be distinguished on statistical grounds, visual comparison of AE with Aerc models yielded a consistent pattern. Although $a^2$ and $e^2$ estimates were comparable for the School scale among boys and girls and for Total Competence among girls, confidence intervals on AE models were generally smaller than on Aerc. In addition, $rc$ terms were small and confidence intervals all encompassed zero. Hence the most parsimonious models for all scales did not support the presence of significant rater biases of any form.

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While significant genetic influences were found for School scale scores across genders, some gender differ-
ences emerged. Genetic influences were significant on male Social and Total Competence, whereas the best-fitting model on female Social Competence did not include any genetic influence. Similarly, Total Competence for girls was best described by a model (CE) that did not include a genetic factor. Finally, the best-fitting models for the Activities scale did not include genetic factors for either boys or girls.

**DISCUSSION**

The purpose of this study was to use a large cohort of twins aged 8–12 years to estimate genetic, shared environmental, and nonshared environmental effects on measures of competence. Overall, our results supported previous findings of significant genetic influences for School competence and significant shared environmental influences for Activities. We also identified significant genetic contributions to social competence in boys. A rater contrast term was added to statistical models to assess the degree to which either parent may systematically bias their ratings based on comparisons of siblings. While a number of good-fitting models supported rater contrast terms, these models did not provide a significantly better statistical fit than more parsimonious models. Furthermore, all confidence intervals for rater contrast terms encompassed zero. Thus our findings support previous work that suggests no significant rater contrast biases on CBCL scales and competence scales (Hudziak et al., 2000).

Twin studies of the CBCL syndrome scales have supported significant genetic influences for all scales, whereas analyses of the competence scales have produced varied results. Consistent with previous findings, School competence displayed a strong genetic influence for both girls and boys with heritability estimates of 0.60 and 0.68, respectively. It is possible that genetic effects on School competence may be related to the heritability of intelligence in general, although this study does not specifically address this concern. The Activities scale displayed significant shared environmental effects for both genders. On
the Social scale, results were mixed, with males displaying both genetic and shared environmental influences, whereas female findings indicate only strong shared environmental effects. As noted, genetic influences have not been previously found for the Social scale and may be attributed to the power of the current study to test gender effects.

The gender difference in genetic influences on the Social scale may be related to different patterns of socialization for boys and girls. Certain common childhood disorders, such as oppositional defiant disorder and attention-deficit/hyperactivity disorder (ADHD), appear to be more prevalent in boys and also to have strong genetic influences. These disorders are often associated with difficulty in making and maintaining friendships with others. It is plausible that increased levels of hyperactivity and aggression in boys may be related to the genetic influences found for boys on the Social scale. Correlations between CBCL syndromes assessing hyperactivity and aggressive behavior and the Social scale indicate moderate relations between these constructs, although bivariate genetic analyses would be necessary to test the shared genetic variance hypothesis between externalizing problems and the Social competence scale. Scores on a measure of social interactions, the Social Reciprocity Scale, have shown significant genetic variance for boys (Constantino and Todd, 2000), independent of genetic variance on the CBCL syndrome scores, although bivariate genetic analyses have not been tested with the Social scale. It is interesting that socialization research has supported higher levels of social skills in girls than in boys in childhood (e.g., Crombie, 1988). Thus shared and nonshared environmental effects on social functioning for boys may increase during late childhood and adolescence. Splitting the male sample on the basis of age would allow one to test for differences in parameter estimates across childhood.

Another important issue addressed in our analyses concerns possible distortions of ratings based on comparisons between twins. Findings for the CBCL have not revealed rater contrast effects like those found for DSM interviews (e.g., Eaves and Carbonneau, 1998; Eaves et al., 1997; Simonoff et al., 1998b). A number of reasons for this difference have been noted. DSM interviews typically present symptoms in diagnostic clusters that tend to reveal the underlying construct to the informant. Informants may then respond indiscriminately if they feel the underlying construct is characteristic of their child. When asked to report on a twin or sibling, a parent may use the extreme child as an anchor and downplay symptoms in the other child. Parents may thus distort their ratings in ways that decrease estimates of genetic influences. This study and a previous study of the CBCL syndromes (Hudziak et al., 2000) have included a rater contrast term in models to test for such effects. Despite differences in the constructs analyzed, both studies found no significant rater contrast effects. The CBCL may lower the potential for such bias by presenting problem items in alphabetical order and anchoring competence items to specific activities. The CBCL may thus be a useful measure for minimizing rater contrast effects in future twin studies.

Limitations

The participation rate of the current study is consistent with rates reported in other twin studies; nevertheless, 40% of contacted individuals failed to participate in the current study. In another twin study that used the CBCL, a return rate of 64% was reported (Edelbrock et al., 1995). One large twin study with 1,529 twin pairs (Gjone and Stevenson, 1997) reported a return rate of 59.9% for families contacted by mail. These studies found no significant differences between respondents and nonrespondents with regard to various demographic statistics. The necessary information to conduct such analyses is not available for the current study; thus respondents may differ significantly from nonrespondents in some areas.

When considering behaviors that occur in multiple settings, single informant data must be interpreted cautiously, as behaviors tend to vary significantly across contexts (Achenbach et al., 1987). Children in middle to late childhood often experience fundamental shifts in parental monitoring resulting from increased peer affiliation. Many behaviors related to social, activity, and academic competence may occur in settings other than the home. For example, social interactions that occur in the school setting are not likely to be captured by parents’ reports. Reports from teachers and children themselves are therefore needed for comprehensive assessment of competence. Aggregation of data from these different perspectives is a primary goal of the CBCL family of instruments (Achenbach and Rescorla, 2001). In the case of ADHD, evidence suggests that teachers may be more accurate informants than parents because they have a larger comparison group for rating each child’s attention problems (Sherman et al., 1997b). Despite suggestions that informant discrepancies reflect less reliability, Achenbach and colleagues (1987) argued that different informants may contribute meaningful but different information based
on observations of different samples of behavior. Similarly, Jensen et al. (1999) found that discrepant findings with regard to diagnostic conditions usually reflect clinically meaningful information. Our ongoing longitudinal research using multiple informants on larger samples of children will enable us to further discriminate developmental and informant effects.

Clinical Implications

A robust body of literature suggests that children who do not meet DSM criteria for a disorder may nevertheless be impaired in significant domains of functioning (Angold et al., 1999). Researchers have suggested that children with impairment in psychosocial functioning should be considered as suffering from a disorder, thus extending our therapeutic attention beyond the current psychiatric nomenclature. One way to assess psychosocial impairment is to identify deficits in competence. Deficits in competence are often associated with diagnostic conditions, but they may also represent isolated areas of impairment. Conversely, children with the same diagnostic condition may also differ in their competence in important domains. In either case, information on competencies may provide meaningful information about functioning and, perhaps, treatment response. A broader commitment to the assessment of competencies may help to identify more children in need of clinical services and to design appropriate interventions. Success in improving competence may also provide improvement in other areas of functioning. The competence scales of the CBCL may provide an important indicator of success at addressing areas of impairment associated with psychopathology.

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