

Psychiatric Comorbidity in Children and Adolescents with Reading Disability

Erik G. Willcutt

University of Colorado at Boulder, U.S.A.

Bruce F. Pennington

University of Denver, U.S.A.

This study investigated the association between reading disability (RD) and internalizing and externalizing psychopathology in a large community sample of twins with ($N = 209$) and without RD ($N = 192$). The primary goals were to clarify the relation between RD and comorbid psychopathology, to test for gender differences in the behavioral correlates of RD, and to test if common familial influences contributed to the association between RD and other disorders. Results indicated that individuals with RD exhibited significantly higher rates of all internalizing and externalizing disorders than individuals without RD. However, logistic regression analyses indicated that RD was not significantly associated with symptoms of aggression, delinquency, oppositional defiant disorder, or conduct disorder after controlling for the significant relation between RD and ADHD. In contrast, relations between RD and symptoms of anxiety and depression remained significant even after controlling for comorbid ADHD, suggesting that internalizing difficulties may be specifically associated with RD. Analyses of gender differences indicated that the significant relation between RD and internalizing symptoms was largely restricted to girls, whereas the association between RD and externalizing psychopathology was stronger for boys. Finally, preliminary etiological analyses suggested that common familial factors predispose both probands with RD and their non-RD siblings to exhibit externalizing behaviors, whereas elevations of internalizing symptomatology are restricted to individuals with RD.

Keywords: ADD/ADHD, comorbidity, externalizing disorder, gender, reading disorder.

Abbreviations: ADHD: attention-deficit/hyperactivity disorder; CBCL: Child Behavior Checklist; CD: conduct disorder; CDI: Children's Depression Inventory; CLDRC: Colorado Learning Disabilities Research Center; DBD: disruptive behavior disorders; DICA-P(C): Diagnostic Interview for Children and Adolescents, Parent Report Version (Child Report Version); FSIQ: Full Scale IQ; NVLD: nonverbal learning disability; OAD: Overanxious Disorder; ODD: oppositional disorder; PIAT: Peabody Individual Achievement Test; RD: reading disability; WAIS: Wechsler Adult Intelligence Scale; WISC-R: Wechsler Intelligence Scale for Children-Revised.

Reading disability (RD) is a developmental disorder that is characterized by specific impairments in single word reading, reading fluency, and reading comprehension, usually resulting from impaired phonological processing (e.g., Foorman, Francis, Novy, & Liberman, 1991; Stanovich, Cunningham, & Cramer, 1984; Wagner & Torgesen, 1987). RD occurs in 3–10% of school-aged children, and is nearly equally frequent in males and females in community samples (Shaywitz, Shaywitz, Fletcher, & Escobar, 1990; Wadsworth, DeFries, Stevenson, Gilger, & Pennington, 1992). In addition to specific deficits in reading, individuals with RD have been shown to exhibit more frequent emotional and behavioral difficulties than children without reading problems (Beitchman & Young, 1997).

RD and the disruptive behavior disorders (DBD) co-occur more frequently than expected by chance in both epidemiological and clinical samples (see Hinshaw, 1992, for a review). Specifically, RD and attention-deficit/hyperactivity disorder (ADHD) are significantly comorbid whether individuals are initially selected for RD (Gilger, Pennington, & DeFries, 1992; Shaywitz, Fletcher, & Shaywitz, 1995; Willcutt & Pennington, 2000) or for ADHD (e.g., Semrud-Clikeman et al., 1992), although some studies suggest that this relation is stronger for males than for females (Smart, Sanson, & Prior, 1996; Willcutt & Pennington, 2000). Similarly, early epidemiological studies indicated that children with specific deficits in reading were nearly five times more likely to exhibit antisocial behaviors than were children in the general population (Rutter & Yule, 1970), and more recent studies have found elevated rates of specific reading problems and general academic failure in samples of conduct disordered or delinquent children (Frick et al., 1991; Hawkins & Lishner, 1987). However, further multivariate analyses suggest that conduct problems are

Requests for reprints to: Erik G. Willcutt, University of Colorado at Boulder, Institute for Behavioral Genetics, Campus Box 447, Boulder, CO 80309, U.S.A.
(E-mail: willcutt@colorado.edu).

not specifically associated with academic underachievement, but instead that this relation is mediated by comorbid ADHD (Frick et al., 1991; Maughan, Pickles, Hagell, Rutter, & Yule, 1996).

A relative paucity of data exists regarding the association between RD and internalizing symptomatology such as anxiety, depression, or social withdrawal (Beitchman & Young, 1997). A few previous studies have indicated that children falling within the broad categorization of "learning disabled" exhibit more symptoms of depression (Colbert, Newman, Ney, & Young, 1982; Hall & Haws, 1989) and more frequent deficiencies in social functioning (Kavale & Forness, 1996) than children without a learning disability. However, interpretation of these results is complicated by the inclusion of children with a variety of academic difficulties in samples of individuals with learning disabilities. In their comprehensive review, Rourke and Fuerst (1996) concluded that individuals with specific nonverbal learning disability (NVLD) were at higher risk for emotional difficulties than comparison children without a learning disability, whereas individuals with learning difficulties restricted to reading did not exhibit a higher frequency of internalizing symptoms. Therefore, the higher prevalence of internalizing symptoms documented in these studies may be limited to the subset of children with NVLD.

Three studies have tested whether internalizing symptoms are associated with RD. In the epidemiological study described previously, children who met criteria for Specific Reading Retardation did not differ significantly from children without reading difficulties on a measure of neuroticism (Rutter et al., 1976). In contrast, Smart, Sanson, and Prior (1996) found that children with RD with comorbid behavior problems exhibited significantly more anxious/fearful behaviors than control children. However, children with RD without comorbid behavior problems did not differ from controls on either parent or teacher ratings, suggesting that the relation between RD and anxious/fearful symptomatology may also be mediated by comorbid behavior problems. Finally, Boetsch, Green, and Pennington (1996) compared both clinic-referred and community samples of children, adolescents, and adults with RD to a normal control sample. Consistent with the findings of Smart et al. they found that children with RD exhibited significantly more internalizing symptoms than controls on the parent report version of the Child Behavior Checklist (Achenbach, 1991). RD children also endorsed more symptoms on the Children's Depression Inventory (Kovacs, 1988), but were not significantly different from controls on a self-report diagnostic interview for Overanxious Disorder (OAD). However, Boetsch et al. did not examine the potential influence of associated behavior problems, leaving open the possibility that the significant relation between RD and symptoms of depression may have been mediated by an additional association with ADHD or other behavior problems.

The Present Study

This study utilized a community sample of twins to assess the extent to which RD is associated with concomitant behavioral or emotional symptomatology. Because the number of available pairs is not large enough to provide sufficient power for behavioral genetic analyses, the present report describes phenotypic analyses of the

overlap between RD and internalizing and externalizing psychopathology. Four specific questions were investigated:

- (1) Is there a significant phenotypic relation between RD and ADHD, ODD, CD, OAD, or depression in this community sample?
- (2) Are there significant gender differences in the profile of psychopathology associated with RD?
- (3) Is the relation between RD and some disorders mediated by comorbidity with another disorder such as ADHD?
- (4) Is the association between RD and psychopathology specific to individuals with RD, or are siblings of RD probands at risk for comorbid psychopathology even if they do not meet criteria for RD?

Method

Participants

Participants completed the measures described in this report as part of the Colorado Learning Disabilities Research Center twin project, an ongoing study of the etiology of learning disabilities (CLDRC; DeFries et al., 1997). Through collaboration with school administrators and personnel, all twin pairs from 27 school districts within a 150-mile radius of the Denver/Boulder area were contacted and parental permission was requested to review each child's academic records for evidence of reading problems. Individuals with pervasive developmental disorder, an early closed-head injury, or other more specific genetic or environmental risk factors such as lead exposure, maternal alcohol or substance use during pregnancy, neurofibromatosis, Fragile X syndrome, or other sex chromosome anomalies were eliminated from the study, as were participants with Full Scale IQ (FSIQ) scores below 70.

Identification of participants with RD. If either member of a twin pair exhibited a positive history of reading difficulty (e.g., low reading achievement test scores, referral to a reading therapist because of poor reading performance, reports by classroom teachers or school psychologists, etc.), both members of the pair were invited to complete a battery of tests in the laboratories of the CLDRC. Participants were then classified as RD only if they had a positive school history of reading problems and met criteria for RD on the battery of reading achievement measures.

The definition of Reading Disorder in the fourth edition of the *Diagnostic and statistical manual of mental disorders* (DSM-IV; American Psychiatric Association, 1994) specifies that reading achievement scores must not only fall significantly below the score typical of other children of the same age, but must also be significantly discrepant from the achievement that would be predicted based on the individual's overall cognitive ability. However, several studies have suggested that the same etiological factors and neurocognitive deficits are associated with RD with and without an IQ discrepancy, and that the inclusion of an IQ discrepancy as a diagnostic criterion adds little to the external validity of the diagnosis (e.g., Fletcher, Francis, Rourke, Shaywitz, & Shaywitz, 1993; Pennington, Gilger, Olson, & DeFries, 1992; Siegel, 1989). On the other hand, a recent twin study found that the etiology of RD varied as a linear function of IQ, suggesting that IQ differences may be relevant to the definition of RD (Wadsworth, Olson, Pennington, & DeFries, 2000). In order to ensure that the present sample met stringent criteria for RD, only those individuals with reading scores that fell below *both* what would be expected based on their age and their overall intellectual functioning were included in the RD sample.

Identification of comparison samples. The community control sample consisted of individuals from twin pairs in which neither twin exhibited evidence of reading problems in their school records or met criteria for RD on the battery of cognitive

tests. The family control sample included co-twins of probands with RD who did not meet criteria for either the age- or IQ-discrepancy criterion for RD.

Issues in the utilization of twins for phenotypic analyses. The utilization of twins for analyses in which each participant is considered as an individual data point presents a methodological dilemma, as the scores of the twins in each pair do not represent independent observations. Therefore, for each twin pair in which both twins met criteria for RD (concordant pairs) or both qualified for the comparison sample, one twin was selected at random for inclusion in the analyses. For those pairs in which one twin met criteria for RD and one twin did not (discordant pairs), the twin with RD was included in the RD sample and the twin without RD was included in the family control sample. The final RD sample included 209 individuals (120 males, 89 females), with 87 individuals from concordant pairs (54 males, 33 females) and 120 individuals from discordant pairs (66 males, 56 females). The community control sample included 192 individuals (95 males, 97 females), and the family control sample included 75 co-twins of RD probands who did not meet criteria for RD based on either the age- or IQ-discrepancy formula.

Procedures

The cognitive and achievement testing was conducted during an initial testing session at the University of Colorado at Boulder Institute for Behavioral Genetics, and the emotional and behavioral measures were administered during a second session scheduled approximately 2 weeks later at the University of Denver. All measures at both sites were administered by trained examiners with at least a bachelor's degree in psychology who had previous experience working with children. Examiners who obtained the measures of psychopathology were unaware of the results of the cognitive and achievement testing.

Measures

General cognitive ability. The revised version of the Wechsler Intelligence Scale for Children (WISC-R; Wechsler, 1974) was used to assess the FSIQ of participants 16 years of age or younger, and the Wechsler Adult Intelligence Scale (WAIS; Wechsler, 1981) was utilized for participants who were 17 or 18 years of age.

Reading achievement. Academic achievement in reading and spelling was assessed with the Peabody Individual Achievement Test (PIAT; Dunn & Markwardt, 1970). A normally distributed composite score was created based on a discriminant function analysis of the Reading Recognition, Reading Comprehension, and Spelling subtests conducted in separate samples of nontwin individuals with and without a history of significant reading problems (DeFries, 1985). As recommended by Reynolds (1984), a standard score 1.65 *SDs* below the mean of the community control sample was utilized as the age-discrepancy criterion for RD. This cutoff selects approximately 5% of the control sample, a prevalence that is consistent with estimates from epidemiological studies (e.g., Shaywitz et al., 1990).

The procedure described by Frick et al. (1991) and Pennington et al. (1992) was utilized to compute an IQ-discrepancy score. This method takes into account the expected regression to the mean of reading scores when an individual has an IQ score higher or lower than the population mean. In this way, we avoid the overselection of children with high IQ scores and the underselection of children with low IQ scores that occurs if a simple subtraction discrepancy is used (Kamphaus, Frick, & Lahey, 1992). A cutoff score 1.65 *SDs* below the community control mean on the standardized discrepancy score was utilized as the criterion for IQ-discrepant RD.

Parent-report measures of psychopathology. Modules for ADHD, ODD, and CD from the parent-report version of the DSM-III Diagnostic Interview for Children and Adolescents, Parent Report Version (DICA-P; Reich & Herjanic, 1982) were

utilized to assess the disruptive behavior disorders. The inter-interview reliability of the DICA is reported to be high, and diagnoses based on the DICA have been shown to be concordant with blind clinical assessments approximately 90% of the time (Werner, Reich, Herjanic, Jung, & Amado, 1987). Due to the substantially higher availability of maternal report (approximately 95% of all subjects) as compared to paternal report (51%), maternal report was used for the analyses reported here.

Due to the time constraints of the larger study, DICA-P modules for the anxiety and depressive disorders were added only recently to the assessment battery, and were not available for the majority of participants. Therefore, the parent-report version of the Child Behavior Checklist (CBCL; Achenbach, 1991) was administered to obtain parent ratings of each child's internalizing symptoms, as well as a second measure of externalizing behaviors. The CBCL includes broad-band Internalizing and Externalizing dimensions, each of which includes several specific narrow-band Syndrome scales. The internal consistency and test-retest reliability for the Internalizing and Externalizing factors are both above .90, and the mean test-retest reliability of the narrow-band scales is .89. Validity studies have demonstrated that CBCL Syndrome scales are significantly associated with DSM diagnoses and with similar dimensions on other standardized behavior rating scales (Achenbach, 1991; Edelbrock & Costello, 1988).

Child-report measures of psychopathology. The OAD module from the child self-report version of the Diagnostic Interview for Children and Adolescents (DICA-C, Reich & Herjanic, 1982) was utilized to assess symptoms of OAD. Because the DICA-C Major Depression module was only administered to a subset of participants, symptoms of depression were assessed with the Children's Depression Inventory (CDI; Kovacs, 1988). The test-retest reliability of the CDI is high for time intervals of less than 1 month (Finch, Saylor, Edwards, & McIntosh, 1987) and moderate for longer temporal intervals (Smucker, Craighead, Craighead, & Green, 1986; Weiss et al., 1991). The validity of the CDI is supported by significant correlations with other self-report measures of depression (Asarnow & Carlson, 1985; Shain, Naylor, & Alessi, 1990) and with clinician's ratings of depressive symptomatology (Hodges & Craighead, 1990; Shain et al., 1990).

Creation of categorical diagnoses. The diagnostic cutoff scores specified in the DICA manual were utilized to create dichotomous diagnoses of ADHD, ODD, CD, and OAD for categorical analyses. In addition, consistent with previous research (e.g., Rende, Plomin, Reiss, & Hetherington, 1993), a score of 13 on the CDI was utilized as a cutoff score indicative of significant depressed mood.

Data Analysis

Prior to any analyses of the continuous data, the distribution of each variable was assessed for significant deviation from normality. A logarithmic transformation was implemented to approximate a normal distribution for variables with skewness or kurtosis greater than one. Due to the nature of the rating scales, no participant's score fell more than 3 *SDs* from the overall sample mean nor more than 0.5 *SD* beyond the next most extreme score. Therefore, corrections for outlying data points were not necessary.

The relation between RD and the dimensions of psychopathology was assessed by 2 × 2 (RD diagnosis × Gender) factorial analysis of covariance (ANCOVA). Because individuals with and without RD differed significantly on socioeconomic status (SES) and intelligence, FSIQ and the total score on the Hollingshead 2-factor SES inventory (Hollingshead, 1975) were included as covariates in all initial models. Each covariate was retained in the final model if it was at least marginally significant ($p < .10$). A dummy code for zygosity was also included in all initial models to control for any differences between probands from monozygotic and dizygotic pairs, but this code was dropped from all final models because it had no significant impact on any result. Parallel logistic

regression models were utilized to examine the relation between RD and the categorical disorders.

In order to ensure that the random selection of one twin from each concordant pair did not inadvertently bias the results, analyses were repeated in a sample in which the selected twin from each concordant pair was replaced by the co-twin that was excluded from the first set of analyses. Results were virtually identical for the two samples, indicating that the random selection of a single twin from the concordant pairs did not bias the findings. Results were also similar when analyses were run separately with individuals from concordant or discordant pairs.

Results

Demographic Characteristics

Table 1 presents mean scores of individuals with and without RD on the demographic variables and measures of IQ and RD. The mean age of the two groups was not significantly different, but mean family SES as measured by the Hollingshead (1975) 2-factor inventory was significantly lower for individuals with RD than individuals without RD (higher scores on the Hollingshead inventory indicate lower SES). As expected, the mean of participants with RD was lower than the mean of the group

without RD on the WISC-R and reading composite. The ethnic composition of the overall sample was 85 % White, 8 % Hispanic, 4 % Black, 2 % Asian, and 1 % American Indian, and was not significantly different between the two groups.

The Relation between RD and Externalizing Symptoms and Disorders

Continuous analyses. Table 2 presents means and standard deviations of males and females with and without RD on the measures of comorbid psychopathology. Results of factorial ANCOVAs controlling FSIQ and SES revealed significant main effects of RD and gender for symptoms of ADHD, ODD, and CD. Moreover, the RD \times Gender interaction was significant for symptoms of ADHD, such that the relation between RD and ADHD is stronger among males. The RD and gender main effects were also significant for the CBCL broad-band Externalizing scale, although the results from the two narrow-band scales were somewhat distinct. Whereas only the RD main effect was significant for the Delinquent Behavior scale, both the RD and gender main effects and the RD \times Gender interaction were significant for the

Table 1
Means of Individuals with and without RD on Demographic and Cognitive Measures

	Individuals without RD ($N = 192$)		Individuals with RD ($N = 209$)		t
	Mean	(SD)	Mean	(SD)	
Age	10.7	(2.3)	10.5	(2.2)	n.s.
SES	27.1	(14.6)	34.2	(15.1)	6.12***
WISC-R FSIQ	112.9	(10.8)	100.8	(10.8)	12.25***
WISC-R Verbal IQ	113.6	(11.2)	98.9	(11.4)	14.26***
WISC-R Performance IQ	109.5	(11.9)	103.1	(11.5)	5.94***
Reading discriminant function Z-score	0.12	(0.9)	-2.79	(0.8)	35.68***

*** $p < .001$.

Table 2
Mean Scores of Males and Females with and without RD on the Measures of Psychopathology

Measure	Females		Males		Main effects		RD × Gender interaction <i>F</i>
	Without (<i>N</i> = 97)	With (<i>N</i> = 89)	Without RD (<i>N</i> = 95)	With RD (<i>N</i> = 120)	RD	Gender	
	Mean (<i>SD</i>)	Mean (<i>SD</i>)	Mean (<i>SD</i>)	Mean (<i>SD</i>)	<i>F</i>	<i>F</i>	
<i>Parent report measures</i>							
DICA-P							
ADHD	1.84 _a (2.7)	4.48 _b (3.7)	2.85 _c (3.2)	6.53 _d (4.3)	89.16***	14.83***	5.76*
ODD	1.64 _a (1.8)	2.25 _a (2.0)	1.95 _a (2.1)	3.01 _b (2.5)	11.95***	5.64*	n.s.
CD	0.37 _a (0.8)	0.85 _b (1.4)	0.84 _b (1.4)	1.54 _c (1.5)	8.29**	12.61***	n.s.
CBCL Externalizing							
Broad-band	5.11 _a (5.3)	7.98 _b (6.6)	6.29 _{ab} (6.4)	11.68 _c (8.8)	14.70***	6.57*	n.s.
Aggressive Behavior	4.37 _a (4.4)	6.51 _b (5.5)	5.08 _{ab} (5.0)	9.53 _c (8.6)	22.90***	7.03**	5.02*
Delinquent Behavior	0.72 _a (1.4)	1.81 _b (2.4)	1.14 _a (1.7)	2.17 _b (2.1)	20.27***	1.76	n.s.
CBCL Internalizing							
Broad-Band	4.75 _a (4.4)	9.98 _b (7.6)	4.99 _a (4.3)	7.23 _b (6.9)	17.18***	2.48	3.94*
Withdrawn	1.25 _a (1.6)	2.78 _b (2.7)	1.51 _a (1.8)	1.70 _a (2.2)	15.44***	2.81*	7.86**
Somatic Complaints	1.05 _a (1.5)	2.13 _b (2.9)	0.85 _a (1.4)	2.23 _b (2.8)	7.61**	0.08	n.s.
Anxious/Depressed	2.35 _a (2.4)	5.22 _b (5.3)	2.64 _a (2.9)	3.50 _{ab} (4.4)	22.91***	1.90	5.14*
<i>Child Self-report Measures</i>							
DICA-C Anxiety	2.15 (2.0)	2.85 (2.4)	2.22 (2.1)	2.75 _c (2.3)	8.99**	0.07	n.s.
CDI	4.51 _a (4.5)	8.28 _b (6.1)	4.27 _a (3.9)	6.81 _b (5.3)	21.10***	2.62	n.s.

* $p < .05$, ** $p < .01$, *** $p < .001$.

Means with no common subscripts are significantly different when covarying FSIQ and SES ($p < .05$).

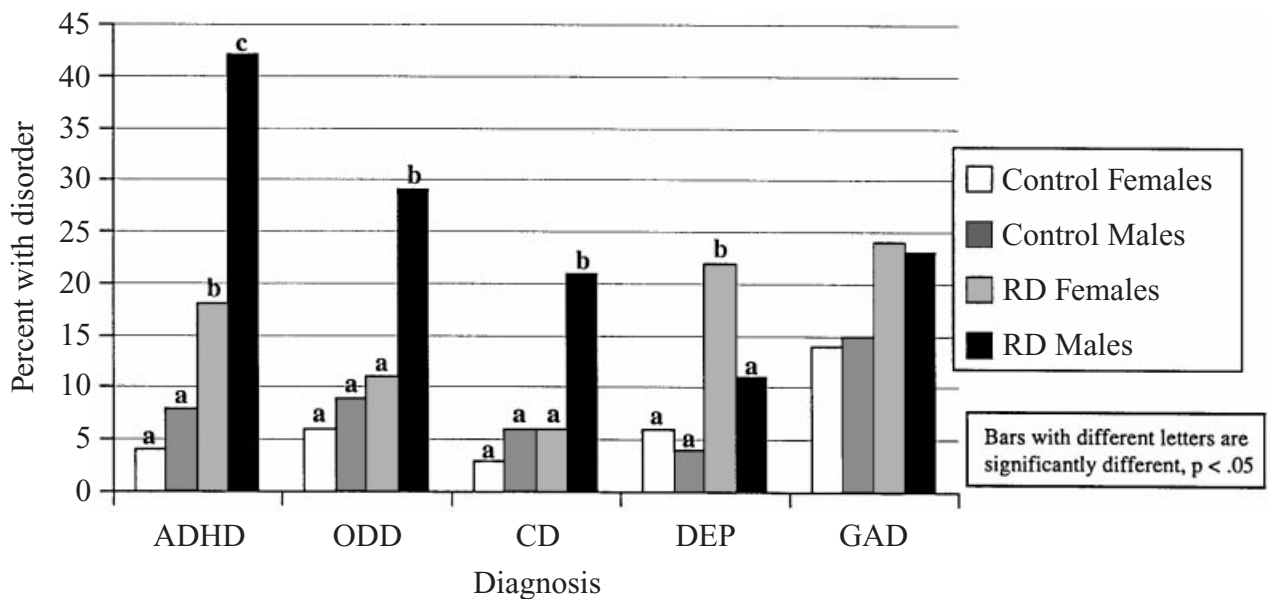


Figure 1. Prevalence of comorbid diagnoses in females and males with and without RD.

Aggressive Behavior subscale. A closer examination of the group means suggests that although RD is associated with elevations of aggressive behavior in both males and females, this effect is stronger for males.

Categorical analyses. Results of logistic regression analyses generally mirrored the findings from the continuous analyses (Fig. 1). The RD main effect was significant for all three DBD diagnoses (Wald $\chi^2 = 33.35$ for ADHD, Wald $\chi^2 = 12.20$ for ODD, Wald $\chi^2 = 10.59$ for CD, all $p < .01$). Similarly, significant gender main effects indicated that males were more likely to exhibit each DBD diagnosis than females (Wald $\chi^2 = 13.06$ for ADHD, Wald $\chi^2 = 7.30$ for ODD, Wald $\chi^2 = 10.59$ for CD, all $p < .01$). Moreover, follow-up pairwise comparisons indicated that the rates of comorbid ADHD, ODD, and CD were significantly higher among RD males than any other group, suggesting that the RD main effect may be stronger for males than for females.

The Relation between RD and Internalizing Symptoms and Disorders

CBCL Internalizing scales. Analyses of parent ratings on the Internalizing broad-band scale of the CBCL revealed a significant main effect of RD and a significant RD \times Gender interaction, such that females with RD scored significantly higher than males or females without RD, whereas males with RD were not significantly different from individuals without RD (Table 2). The pattern of results on the Withdrawn and Anxious/Depressed narrow-band scales were similar to the broad-band findings, suggesting that RD is associated more strongly with elevations in these areas in females than males. In contrast, only the RD main effect was significant for the CBCL Somatic Complaints subscale, suggesting that physical symptoms are associated similarly with RD among females and males.

Child self-report. The RD main effect was significant for child self-reports of symptoms of anxiety and depression (Table 2), but there was not a significant main effect of gender or a significant RD \times Gender interaction. Results of logistic regression analyses also revealed significant main effects of RD for categorical diagnoses

of OAD, Wald $\chi^2 = 6.78$, $p < .01$, and depression, Wald $\chi^2 = 10.60$, $p < .01$. However, females with RD were significantly more likely to exhibit comorbid depression than members of the other three groups, which did not differ significantly from one another. This finding suggests that although the RD \times Gender interaction was not significant, the RD main effect for the categorical measure of extreme depressive symptomatology is largely restricted to females.

Tests of the Independence of the Relations between RD and Each Comorbid Disorder

Stepwise logistic regression analyses were utilized to test if RD was associated independently with each of the five disorders under consideration, or if the relation between RD and some diagnoses was mediated by comorbidity with another disorder. By considering RD diagnostic status as the dependent variable and including ADHD, ODD, CD, OAD, and depression as predictor variables, this analysis provides a test of the significance of the association between RD and each disorder independent of the relation between RD and the other four disorders.

Among males, results revealed that ADHD was most strongly associated with RD independent of the other diagnoses, Wald $\chi^2 = 26.30$, $p < .0001$. After ADHD was entered into the model, RD was not associated independently with either the symptom dimensions or diagnoses of ODD, CD, OAD, or depression (Fig. 2). Similarly, neither of the two broad-band CBCL scales nor any of the five narrow-band scales were significantly associated with RD independent of the association between RD and ADHD. Taken together, these findings suggest that among males the association between RD and internalizing or externalizing psychopathology is mediated by ADHD.

RD was also significantly associated with ADHD independent of the other disorders among females, Wald $\chi^2 = 21.98$, $p < .0001$ (Fig. 3). In contrast to the findings for males, however, the main effect of depression was also significant independent of the association between RD and ADHD, Wald $\chi^2 = 4.01$, $p < .05$. Moreover, RD was

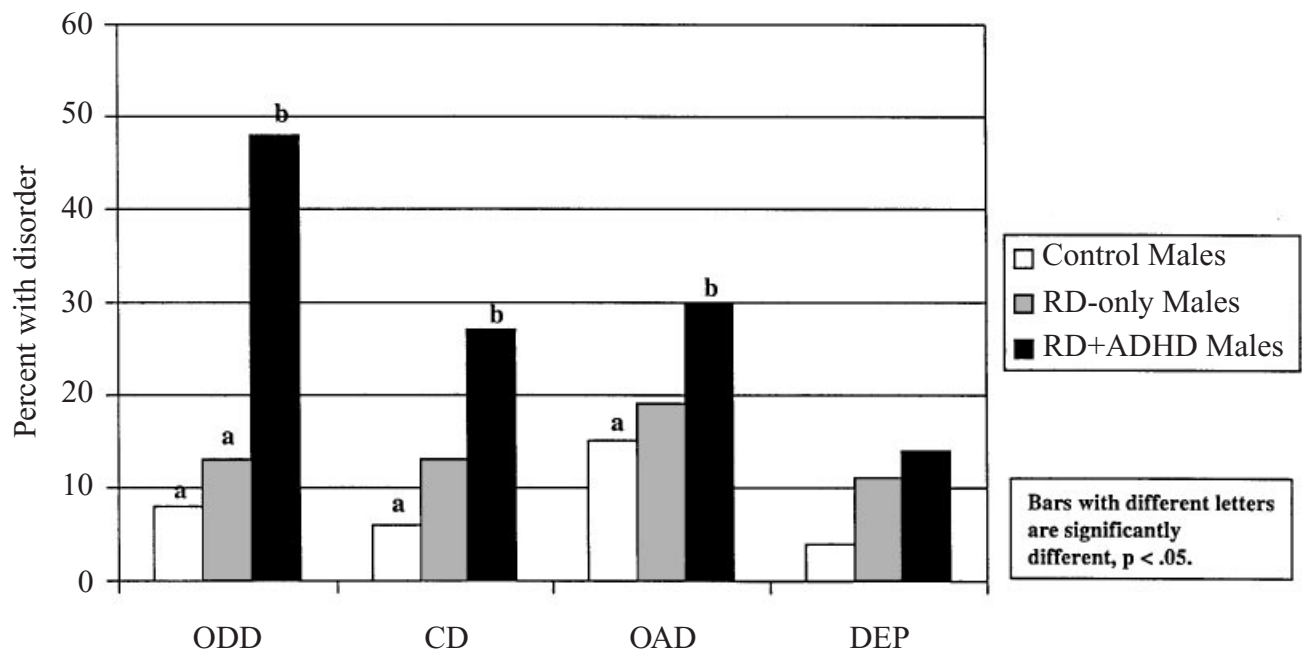


Figure 2. The influence of comorbid ADHD on the prevalence of other disorders among males with RD.

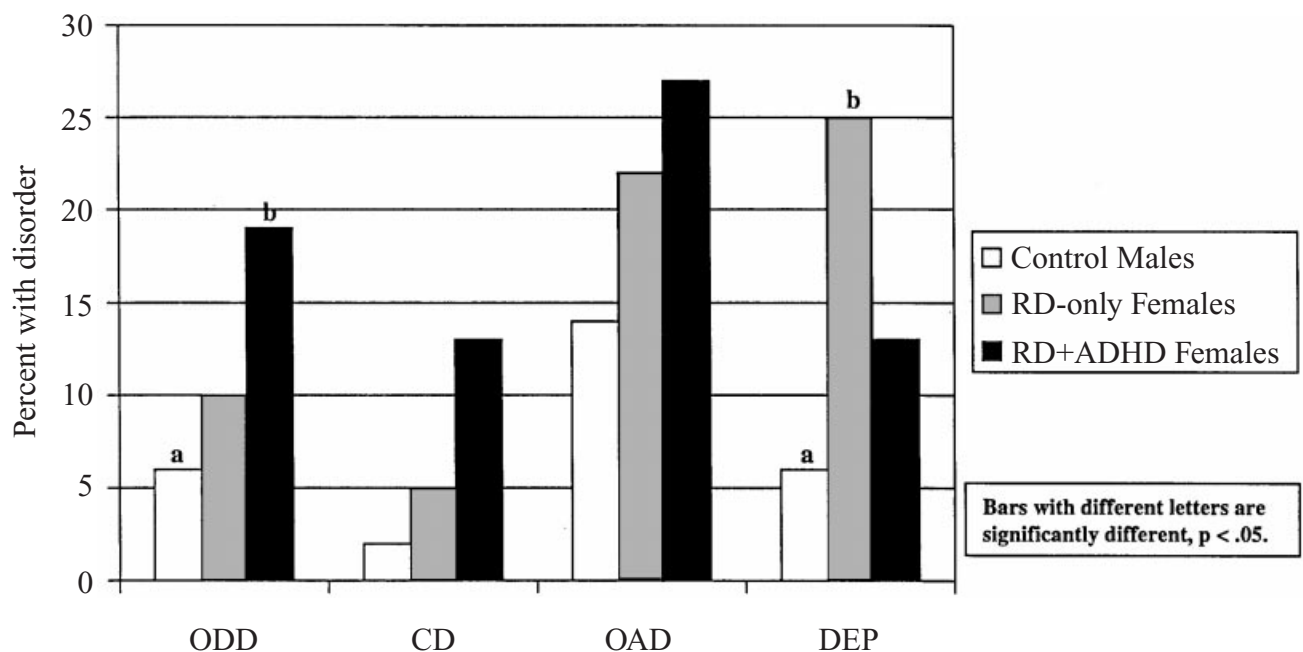


Figure 3. The influence of comorbid ADHD on the prevalence of other disorders among females with RD.

associated with elevations independent of ADHD on the CBCL Withdrawn subscale, Wald $\chi^2 = 6.80, p < .01$, and Somatic Complaints subscale, Wald $\chi^2 = 3.91, p < .05$.

Symptoms of Psychopathology Exhibited by Non-RD Co-twins of RD Probands

The present sample is too small to provide sufficient statistical power for behavioral genetic analyses. However, the number of symptoms of psychopathology exhibited by non-RD co-twins of RD probands (family controls) can be used to test if comorbid psychopathology is specifically associated with RD or if psychopathology is present at higher rates among individuals from at-risk

families whether or not that individual meets criteria for RD. Means on the measures of psychopathology were not significantly different in males and females from the family control group, so all three groups were collapsed across gender for the analyses described in this report (Table 3).

Externalizing symptoms. Individuals with RD exhibited higher scores than individuals from the family control group on all externalizing measures except symptoms of ODD. In addition, the mean of the family control group was significantly higher than the mean of the community control sample on all externalizing measures. These results suggest that having RD represents a specific risk factor for externalizing psy-

Table 3

Means of Individuals with RD and Individuals from the Family and Community Control Samples on the Measures of Psychopathology

	Individuals without RD (<i>N</i> = 192)	Non-RD co-twins of RD probands (<i>N</i> = 75)	RD probands (<i>N</i> = 209)	
Measure	Mean (<i>SD</i>)	Mean (<i>SD</i>)	Mean (<i>SD</i>)	<i>F</i>
<i>Parent report measures</i>				
DICA-P				
ADHD	2.30 _a (3.0)	4.38 _b (4.0)	5.87 _c (4.2)	16.77***
ODD	1.80 _a (1.9)	2.62 _b (2.2)	2.71 _b (2.3)	7.03**
Conduct	0.60 _a (1.1)	0.67 _a (1.5)	1.28 _b (1.5)	6.11**
CBCL Externalizing				
Broad-band	5.80 _a (5.9)	8.75 _b (7.2)	10.67 _c (8.1)	9.69***
Aggressive Behavior	4.73 _a (5.2)	7.24 _b (6.1)	8.49 _c (7.8)	12.93***
Delinquent Behavior	0.93 _a (1.6)	1.51 _b (1.3)	2.18 _c (2.6)	10.54***
CBCL Internalizing				
Broad-band	4.87 _a (4.4)	5.38 _a (5.6)	8.52 _b (7.3)	8.89***
Withdrawn	1.38 _a (2.0)	1.70 _a (2.3)	2.29 _b (2.4)	6.50**
Somatic Complaints	0.95 _a (1.6)	0.86 _a (1.8)	2.20 _b (3.3)	5.32**
Anxious/Depressed	2.50 _a (2.6)	2.80 _a (2.9)	4.22 _b (4.2)	10.91***
<i>Child self-report measures</i>				
DICA-C Anxiety	2.18 _a (2.1)	2.79 (2.6)	2.81 _b (2.3)	4.68*
CDI	4.40 _a (4.2)	5.14 _a (4.5)	7.03 _b (5.6)	12.81***

* $p < .05$, ** $p < .01$, *** $p < .001$.

Means with no common subscripts are significantly different when covarying FSIQ and SES ($p < .05$).

chopathology, but that broader familial influences are also associated with elevations of externalizing symptoms.

Internalizing symptoms. Participants with RD exhibited significantly more internalizing symptoms than individuals from the family control sample on all measures except the DICA-C OAD module (Table 3). In contrast, the means of the family control and community control groups were not significantly different for any measure of internalizing psychopathology, suggesting that general familial influences do not place siblings of individuals with RD at increased risk for internalizing difficulties.

Discussion

This study investigated the prevalence of psychiatric comorbidity associated with reading disability (RD) in a large community sample of 8–18-year-old twins with and without RD. Results indicated that RD is associated with significant elevations on all measures of internalizing and externalizing symptoms. Moreover, individuals with RD were significantly more likely than individuals without RD to meet criteria for categorical diagnoses of ADHD, ODD, CD, OAD, and depression. The finding that RD is significantly associated with externalizing symptomatology provides further replication of numerous previous studies (Hinshaw, 1992). In contrast, this is the first study to our knowledge that has documented a significant relation between RD and elevations on the CBCL Internalizing narrow-band scales. The significant relation between RD and higher scores on the Somatic Complaints scale is particularly intriguing, as this association has frequently been observed in our assessment clinic but has never been documented empirically. Our clinical experience suggests that some children with RD develop physical symptoms such as headaches or stomachaches in response to the stress of academic work.

Gender Differences in RD Comorbidity

Although both males and females with RD exhibited higher levels of externalizing behaviors than individuals without RD, significant interactions revealed a stronger association between RD and ADHD or aggressive behavior among males. In contrast, females with RD reported more symptoms of depression than males with RD, and the relation between RD and parent ratings of somatic complaints and withdrawn behaviors was significantly stronger in females than males.

Gender differences in the type of psychopathology associated with RD have implications for the discrepancy between the gender ratios obtained in referred versus population samples of children with RD. Whereas the gender ratio for RD in referred samples is approximately 3 to 1 males to females (Pennington, 1991; Shaywitz et al., 1990), the ratio in population samples is much closer to unity, generally about 1.5 to 1. At least two plausible hypotheses can be generated to account for this discrepancy. One hypothesis is that boys with RD may be more likely to act out in a disruptive manner and will therefore be identified more frequently by parents and teachers as in need of clinical attention. In contrast, an alternative hypothesis would propose that parents and teachers tend to value male academic achievement more than female academic achievement, and consequently expend greater effort to correct reading problems in male children. The results reported here are consistent with the first hypothesis, in that boys with RD tended to exhibit elevations of externalizing behaviors, whereas girls with RD exhibited higher levels of internalizing symptomatology that might be less apparent to parents or teachers. In fact, whereas the overall male:female ratio in our RD sample was relatively equal (120:89 or 1.3:1), the gender ratio among RD subjects with one or more disruptive behavior diagnoses was similar to the ratio observed in clinic samples (72:28 or 2.6:1).

Specificity of the Associations between RD and Domains of Comorbid Psychopathology

Results of step-wise logistic regression models suggest that the relations between RD and ODD, CD, and aggression are mediated by ADHD, such that only those individuals with comorbid RD and ADHD are at higher risk for other disruptive disorders. This finding replicates in a larger sample results from previous studies of a community sample of individuals ascertained for RD (Maughan et al., 1996) and a clinical sample of children with ODD/CD (Frick et al., 1991). In combination with the present findings, these results suggest that the significant relation between RD and CD is mediated by comorbid ADHD whether the sample is initially selected for reading difficulties or one of the DBDs. In contrast, RD was significantly associated with elevations of depressive symptoms and somatic complaints among females even when symptoms of ADHD and the other DBDs were controlled. This result suggests that at least for girls a specific association exists between RD and internalizing symptomatology.

Psychopathology in the Non-RD Co-twins of RD Probands

Non-RD co-twins of RD probands exhibited more externalizing symptoms than children from the community control group, but fewer symptoms than the RD probands on all externalizing measures except symptoms of ODD. Although the present sample is not yet large enough to provide sufficient power for behavioral genetic analyses, this finding suggests that the association between RD and externalizing symptoms is at least partially attributable to common familial factors. Results from several previous twin studies suggest that the phenotypic association between RD and ADHD is largely attributable to common genetic influences (Light, Pennington, Gilger, & DeFries, 1995; Stevenson, Pennington, Gilger, DeFries, & Gillis, 1993; Willcutt, Pennington, & DeFries, 2000). In contrast, results from another twin study indicated that RD and conduct problems are not attributable to common genes (Stevenson & Graham, 1993), suggesting that the common genetic influences that contribute to RD and ADHD may not be associated directly with other externalizing psychopathology. Instead, it is possible that the common genetic influences associated with RD and ADHD may interact with the social environment, leading to a higher risk for aggressive or conduct disordered behaviors. Specifically, numerous previous studies have suggested that familial factors such as family adversity (Moffitt, 1990), parental psychopathology (e.g., Taylor, Sandberg, Thorley, & Giles, 1991), and inconsistent or punitive parenting techniques (Barkley, Fischer, Edelbrock, & Smallish, 1991; Gomez & Sanson, 1994) may partially determine which children with ADHD develop later CD.

In contrast to the findings for externalizing symptoms, non-RD co-twins of probands with RD did not exhibit a higher rate of internalizing symptoms than community control children. This result suggests that internalizing symptoms are specifically associated with RD and are not attributable to more general familial factors. One possible interpretation of this association is that the academic difficulties associated with RD may predispose children with RD to become more withdrawn, anxious, and depressed than children without RD.

Limitations of the Current Study and Directions for Future Research

- (1) The results described in this report were obtained in a large sample of twins. Although previous studies have found few significant differences between twins and nontwins (e.g. Plomin, DeFries, McClearn, & Rutter, 1997), these analyses should be replicated in an independent sample of singletons to test if the present findings generalize to the population at large.
- (2) The version of the DICA utilized in the current study was designed to assess symptomatology defined in DSM-III. Although the DSM-III and DSM-IV criteria are quite similar for most diagnoses under consideration, future studies should test if similar findings are obtained with measures of DSM-IV symptoms.
- (3) As noted previously, results of twin studies suggest that RD and ADHD share a small but significant common genetic etiology. In contrast, little is known about the etiology of the relation between RD and the other dimensions of psychopathology described in this report. Therefore, future studies utilizing etiologically informative methods will be essential to specify further the causal influences that underlie the phenotypic association between RD and other disorders.

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