

Longitudinal Study of Reading Disability and Attention-Deficit/Hyperactivity Disorder: Implications for Education

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ABSTRACT—The majority of children who receive special education services meet criteria for reading disability (RD) or attention-deficit/hyperactivity disorder (ADHD), but additional research is needed to understand the long-term academic outcome of children in these groups. Individuals with RD only ($N = 71$), ADHD only ($N = 66$), both RD and ADHD ($N = 51$), or neither disorder ($N = 118$) were identified through the ongoing Colorado Learning Disabilities Research Center twin study and retested 5 years later. Results of the follow-up testing indicated that, in addition to ongoing reading difficulties, individuals with RD exhibited higher rates of academic difficulties, depression, and adolescent-onset conduct disorder. Initial ADHD status was associated with academic and social difficulties and elevated rates of nearly all comorbid disorders 5 years later. The group with comorbid RD and ADHD had more stable reading deficits than the group with RD without ADHD and exhibited greater impairment than groups with either disorder alone on outcome measures of academic functioning and social difficulties. These results suggest that individuals with both RD and ADHD are at increased risk for negative outcomes as adolescents and young adults and that when RD and ADHD co-occur, interventions should be provided for both disorders.

LONGITUDINAL STUDY OF READING DISABILITY AND ATTENTION-DEFICIT/HYPERACTIVITY DISORDER: DIAGNOSTIC STABILITY AND DEVELOPMENTAL OUTCOMES IN LATE ADOLESCENCE

Reading disability (RD) is a common childhood disorder that is defined by significant underachievement in reading that is unexpected based on an individual's age and development (e.g., American Psychiatric Association, 2000). Attention-deficit/hyperactivity disorder (ADHD) is characterized by difficulties with inattention and hyperactivity-impulsivity that are inconsistent with the individual's developmental level (American Psychiatric Association, 2000).

Children with RD, ADHD, or both disorders account for a large proportion of all children receiving special education services. In a nationally representative sample of students receiving special education services, approximately half of all individuals received services due to a learning disability (e.g., Schnoes, Reid, Wagner, & Marder, 2006). Similarly, the majority of children in the special education categories of "emotional disturbance" and "other health impaired" met criteria for ADHD. In contrast, Schnoes et al. also found that most individuals with RD or ADHD spend more time in a regular classroom setting than in a special education setting, and nearly all spend at least some time each week in a regular classroom. Therefore, most school personnel are likely to play a role in the education of children with RD or ADHD.

These data underscore the need to understand better the specific educational implications of RD and ADHD, as well as the need for focused training around these issues for all school personnel. This article describes results of a longitudinal study that assessed the specific educational, social, and

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behavioral outcomes of groups with RD, ADHD, or both RD and ADHD over a 5-year period that ended when participants were adolescents or young adults. By identifying the long-term outcomes that are impaired by RD or ADHD, these results will help educators target these areas in both general classroom instruction and individualized interventions in the special education environment. In the remainder of this introduction, we summarize what is already known about the key developmental outcomes of children with ADHD, RD, and other related disorders, then describe the goals of the current study.

Academic Outcomes of RD and ADHD

Although some researchers initially suggested that ADHD was a transient condition that would dissipate by adolescence, most individuals who meet criteria for ADHD in childhood continue to exhibit both ADHD symptoms and associated impairments in adolescence and adulthood (e.g., Faraone et al., 2000). Academic difficulties are one of the most pervasive and persistent consequences of ADHD. In comparison to their peers without ADHD, children and adolescents with ADHD get lower grades and experience a range of other academic difficulties, are less academically motivated and less likely to complete high school and pursue higher education, and are more likely to be retained at least one grade or expelled from school (e.g., Carlson, Booth, Shin, & Canu, 2002; McGee, Prior, Williams, Smart, & Sanson, 2002; Murphy, Barkley, & Bush, 2002).

Reading difficulties also tend to be highly stable over time (e.g., Betjemann et al., in press; Shaywitz et al., 1999; Wadsworth, DeFries, Olson, & Willcutt, in press) and often lead to impairment across a wide range of academic and educational outcomes. For example, in comparison to individuals without RD, adolescents and adults with RD report lower academic motivation and higher frustration in school (Goldston et al., 2007), are more likely to drop out prior to completing high school (Daniel et al., 2006; McGee et al., 2002), and often reach a lower level of educational and occupational attainment (e.g., Boetsch, Green, & Pennington, 1996).

The Importance of Comorbidity

Comorbidity Between RD and ADHD

Although previous studies clearly suggest that RD and ADHD are associated with numerous negative outcomes, interpretation of these studies is complicated by the fact that RD and ADHD co-occur in 25%–40% of individuals with either disorder, a phenomenon known as *comorbidity* (e.g., Semrud-Clikeman et al., 1992; Willcutt & Pennington, 2000a). The causes of comorbidity between RD and ADHD remain uncertain. Some longitudinal studies suggest that attention deficits lead to later reading problems because they interfere with

reading instruction (e.g., Fergusson & Horwood, 1992), whereas others suggest that early reading difficulties also predict later attention problems (e.g., McGee et al., 2002).

A third possibility is that RD and ADHD may be due to a shared risk factor that increases risk for both disorders. For example, previous studies by our group and others suggest that comorbidity between RD and ADHD may be due to genes that lead to deficits in the ability to quickly process information (e.g., Purvis & Tannock, 2000; Shanahan, Yerys, Scott, Willcutt, & Pennington, 2006; Trzesniweski, Moffitt, Caspi, Taylor, & Maughan, 2006; Willcutt, Betjemann, et al., 2007; Willcutt, Pennington, Chhabildas, Olson, & Hulslander, 2005; Willcutt, Pennington, Olson, & DeFries, 2007). In this model, other genetic or environmental risk factors specifically affect RD or ADHD alone, leading to related but separable disorders.

Understanding comorbidity is important for several reasons. First, there is the practical question of which condition to treat first, especially if limited resources are available. In addition, a number of studies suggest that comorbidity may identify a subgroup of individuals who differ in important ways from individuals with that disorder in isolation. For example, recent results suggest that genetic influences on RD and ADHD are stronger in individuals with both disorders than those with either RD or ADHD alone (Willcutt, Pennington et al., 2007), and several studies have found that the comorbid group exhibits more severe weaknesses on some cognitive measures (e.g., Purvis & Tannock, 2000; Seidman, Biederman, Monuteaux, Doyle, & Faraone, 2001; Willcutt et al., 2005). On a more practical level, one of the first treatment studies to test the influence of comorbidity found that reading tutoring led to improvements in reading achievement in groups with inattention without reading problems and reading difficulties in the absence of inattention but had no impact for the group with both reading and attentional difficulties (Rabiner & Malone, 2004).

Comorbidity With Other Disorders

In addition to comorbidity with one another, nearly half of individuals with RD and 80% of individuals with ADHD also meet criteria for at least one additional emotional or behavioral disorder (e.g., Arnold et al., 2005; Faraone, Biederman, Weber, & Russell, 1998; Willcutt & Gaffney-Brown, 2004; Willcutt, Pennington, Chhabildas, Friedman, & Alexander, 1999). RD and ADHD appear to be independently associated with elevations of anxiety and mood disorders (e.g., Goldston et al., 2007; Willcutt & Pennington, 2000b), but these findings are inconsistent across studies and may be stronger for RD in younger than in older children (Maughan, Rowe, Loeber, & Stouthamer-Loeber, 2003). In contrast, whereas the relation between ADHD and antisocial behavior remains significant whether or not the child also has RD, several

studies suggest that the relation between RD and antisocial behavior may be largely restricted to the subset of individuals with comorbid ADHD (e.g., Frick et al., 1991; Maughan et al., 2003; Willcutt & Pennington, 2000b).

The Current Study

This article describes a longitudinal follow-up study of a sample initially collected as part of the Colorado Learning Disabilities Research Center (CLDRC), an ongoing twin study of the genetic and environmental causes and cognitive weaknesses associated with RD, ADHD, and their comorbidity (e.g., DeFries et al., 1997). This study expands on earlier research in several specific ways:

1. These data provide important new information regarding the stability of RD, ADHD, and their comorbidity during adolescence and young adulthood and facilitate a direct test of the hypothesis that RD and ADHD may be most stable when they co-occur.
2. Measures of a range of educational and functional outcomes were administered at the follow-up assessment to clarify the impact of ADHD and RD on important developmental outcomes. Our primary hypothesis was that RD would predict negative academic and educational outcomes at follow-up, whereas ADHD would be associated with academic impairment and significant social difficulties.
3. Finally, internalizing and externalizing disorders were systematically assessed, and these variables were analyzed both as outcome measures and as markers for different outcomes in children with RD or ADHD.

METHOD

Participants in the Initial CLDRC Study

Recruitment and testing procedures for the initial CLDRC study are described in detail elsewhere (DeFries et al., 1997; Willcutt et al., 2005). Due to space constraints, we provide an abbreviated summary in this section.

Screening Procedures

Without regard to RD or ADHD status, permission was sought from parents of all twin pairs between 8 and 18 years of age in 22 local school districts to review the school records of both members of each pair for evidence of reading problems and to obtain parent and teacher ratings of *Diagnostic and Statistical Manual of Mental Disorders (DSM-IV)* ADHD symptoms on the *Disruptive Behavior Rating Scale* (DBRS; Barkley & Murphy, 1998). If either member of a twin pair had a history

of reading difficulties or met screening criteria for ADHD, the pair and any siblings between 8 and 18 years of age were invited to participate in the full study. A comparison group of control twins were selected from the overall sample of pairs who did not meet the screening criteria for RD or ADHD. Because the primary focus of the CLDRC is the etiology of RD and ADHD, pairs at risk for one or both disorders were oversampled (approximately 70% of the final tested sample) to increase statistical power for analyses of these extreme groups.

Definition of ADHD at Time 1

The algorithm from the *DSM-IV* field trials for the disruptive behavior disorders was used to combine parent and teacher ratings of ADHD symptoms (Lahey et al., 1994). This procedure codes each symptom as positive if it is endorsed by either the parent or the teacher. Consistent with *DSM-IV* criteria, participants were categorized as ADHD only if symptoms were present prior to age 7 and if these symptoms caused significant functional impairment across two or more settings. As part of the larger study, participants with ADHD were separated into the predominantly inattentive, predominantly hyperactive-impulsive, and combined subtypes described in *DSM-IV*. However, because results of the analyses described in this article were similar across subtypes, all participants who met criteria for *DSM-IV* ADHD were combined into a single group. For dimensional analyses, inattention, hyperactivity-impulsivity, and total ADHD composite scores were created by summing the 9 inattention, 9 hyperactivity-impulsivity, or 18 total ADHD items on the DBRS.

Definition of RD at Time 1

A composite single-word reading measure was created by calculating the mean of standardized, age-regressed scores on the Peabody Individual Achievement Test Reading Recognition subtest (Dunn & Markwardt, 1970) and a time-limited word recognition test (Olson, Forsberg, Wise, & Rack, 1994). A standard score 1.75 standard deviations below the estimated population mean was used as the cutoff score for RD because this cutoff selects approximately 5% of the population, consistent with the estimated prevalence of RD.

Exclusion Criteria

Because the focus of the overall project is on the etiology and correlates of familial RD and ADHD, potential participants with a documented brain injury, significant hearing or visual impairment, or other rare genetic or environmental etiology (e.g., Fragile X syndrome, Down syndrome, or other sex chromosome anomalies) were excluded from the sample. Pairs were also excluded if one of the twins had received a diagnosis of autism, psychosis, bipolar disorder, or pervasive

developmental disorder, and three participants were excluded from analyses due to a Full Scale IQ score below 75 on the Wechsler Intelligence Scale for Children, Revised (Wechsler, 1974).

Participants in the Follow-Up Assessment

Subjects who completed the RD and ADHD assessments for the initial CLDRC study between January 1, 1997, and April 30, 2002, were contacted by mail approximately 5 years after their initial participation and invited to participate in the follow-up study (see Wadsworth et al., in press, for an overview of the follow-up project). As of April 2007, 62% of those recontacted had completed the follow-up testing, with a somewhat higher rate of participation among control pairs (68%) than at-risk pairs (59%). The total retested for whom both RD and ADHD data were available included 71 individuals with RD only, 66 participants with ADHD only, 51 participants with both RD and ADHD, and 118 participants without RD or ADHD.

Procedures

Each subject was tested individually by a trained examiner at the Institute for Behavioral Genetics. A second staff member obtained the parent rating scales and administered the Diagnostic Interview for Children and Adolescents-IV (DICA-IV) to both parents. Examiners were unaware of results of the Time 1 testing and the diagnostic status of the child. Participants who were currently taking psychostimulant medication were asked to refrain from taking the medication on the day of the study.

Outcome Measures

Age- and sex-adjusted standardized scores were created for each individual measure after correcting for outlying values and nonnormality using procedures described previously (Willcutt et al., 2005). As described in the subsequent sections, composite scores were created for each outcome of interest by calculating the mean of the individual's standardized scores on the measures of that construct.

RD and ADHD

Reading and Spelling Achievement

The *single-word reading composite* is the mean of the untimed word recognition score from the Peabody Individual Achievement Test, Revised (PIAT-R; Markwardt, 1989) and the Sight-Word Efficiency subtest from the Test of Word Reading Efficiency (Torgeson, Wagner, & Rashotte, 1999). The Sight-Word Efficiency subtest requires the participant to read as many words as possible from a list in 45 seconds.

Similar to the procedure used for the initial CLDRC study, a cutoff score 1.75 standard deviations below the estimated population mean of the single-word reading composite was used to define RD status at Time 2.

The *reading comprehension composite* is the mean of the PIAT-R Comprehension subtest and the Reading Comprehension subtest from the Wechsler Individual Achievement Test, Second Edition (WIAT-II; Wechsler, 2002). The PIAT-R requires the participant to choose the picture that best represents the content of a story from four possibilities, whereas the WIAT-II requires verbal responses to open-ended questions about each passage. The *spelling composite* is the mean of the multiple-choice PIAT-R Spelling subtest and the written Spelling subtest from the Wide Range Achievement Test, Third Edition (Wilkinson, 1993).

ADHD

Composite measures of inattention, hyperactivity-impulsivity, and total ADHD behaviors were created based on parent and teacher ratings on the DBRS. The parent-report version of the DICA-IV (Reich, Welner, & Herjanic, 1997) was used in combination with the DBRS to determine current ADHD diagnostic status.

Academic and Social Outcomes

Questions and scales from three questionnaires were used to assess key developmental outcomes, and composite scores for each outcome were then created using the procedure described previously. Parents and twins completed a questionnaire designed for this study that assesses academic functioning and interventions or other services that the participant has received. Parents and twins also completed the Child Behavior Checklist (CBCL) or Youth Self Report (YSR) from the Achenbach System of Empirically Based Assessment (Achenbach & Rescorla, 2001), a widely used system that assesses potential comorbid psychopathology and multiple domains of adaptive functioning.

Academic/Educational Outcomes

The *academic performance composite* is the mean of measures of current grade point average, CBCL and YSR ratings of current academic performance, and parent- and self-report ratings of the total number of academic domains in which the individual currently experiences significant difficulty. In addition, to test whether RD or ADHD has a negative impact on the development or implementation of specific skills that are essential for academic success, an *academic skills composite* was created based on participant's self-report ratings comparing themselves to their peers on academic skills such as taking notes in class, understanding

instructions for assignments, preparing for tests, completing long-term projects and term papers, and using reference materials.

Social Functioning

The *positive social interactions composite* is the mean of items from the study questionnaire that asks about the participant's total number of friends and amount of time spent with friends, along with CBCL and YSR questions regarding the strength of relationships between the individual and their peers, parents, and siblings. The *social difficulties composite* is the mean of scores on the CBCL and YSR Social Problems factor. Finally, the *extracurricular activities composite* is based on the total number of extracurricular activities in which the student participates and the quality of the participant's performance in each activity in comparison to others.

Comorbid Disorders

Internalizing Disorders

Categorical diagnoses of generalized anxiety disorder (GAD) and major depressive disorder (MDD) were obtained from the DICA-IV. Diagnoses were coded as positive if the individual met criteria based on either the parent-report or the self-report interview. Because results were somewhat different for anxiety and depression, separate composites were created for these two constructs. The *anxiety composite* included DSM-IV GAD symptoms, the CBCL/YSR somatic complaints and anxious/depressed scales, and the total score on the Revised Children's Manifest Anxiety Scale (Reynolds & Richmond, 1978). The *depression composite* included DSM-IV MDD symptoms, ratings on the CBCL/YSR depressed/withdrawn and anxious/depressed scales, and the total score on the Children's Depression Inventory (Kovacs, 1988).

Externalizing Disorders

The DICA-IV provides categorical diagnoses of oppositional defiant disorder (ODD) and conduct disorder (CD). CD diag-

noses were coded as positive if the individual met criteria based on either parent- or self-report, whereas ODD questions were only obtained from parents. The *externalizing composite* is the mean of standardized measures of DICA-IV CD and ODD symptoms and CBCL and YSR ratings of Aggressive Behavior and Delinquent Rule-Breaking Behaviors. In addition, the DICA-IV includes questions about other specific antisocial behaviors such as associations with delinquent peers, contact with the juvenile justice system, suspensions and/or expulsions from school, and initiation of substance use.

Data Analyses

Because the scores of twins in a pair are not fully independent observations, analyses were conducted using the "CLUSTER" option in *M-plus* (Muthén & Muthén, 1998–2007) to obtain standard errors, test statistics, and *p* values that are robust to nonindependence. To test whether RD or ADHD at Time 1 was associated with significant negative outcomes at Time 2, linear or logistic regressions were conducted in which each outcome measure was regressed onto RD and ADHD status at Time 1. If the initial analysis revealed a significant effect of RD or ADHD, planned post hoc comparisons were conducted among the four groups. In addition, the analysis was run again with composite measures of Time 1 antisocial behavior (DICA ODD and CD symptoms and CBCL externalizing total) and Time 1 internalizing behavior (DICA GAD and MDD symptoms and CBCL internalizing total) included in the model to test if the negative outcome was explained by these comorbid disorders rather than RD or ADHD per se.

RESULTS

Characteristics of the Sample at Initial Testing

There were no group differences in mean age or span between the two test sessions (Table 1). In contrast, participants in the comparison group were more likely to be female, and the mean Full Scale IQ scores of the three clinical groups fell significantly below the mean of the comparison group.

Table 1

Descriptive Statistics for the Four Groups at Initial Testing

Measure	RD and ADHD groups based on initial testing			
	Control, <i>N</i> = 118	RD, <i>N</i> = 71	ADHD only, <i>N</i> = 66	RD + ADHD, <i>N</i> = 51
Age at initial testing	10.9 (2.2)	10.3 (1.9)	10.7 (2.7)	10.4 (1.7)
Age at follow-up testing	16.3 (2.4)	15.8 (2.0)	16.1 (3.0)	16.0 (2.6)
Span between tests	5.4 (1.0)	5.5 (0.6)	5.4 (0.8)	5.5 (0.8)
Percent female (%)	63.2 _a	46.5 _b	40.9 _b	23.5 _c
Full Scale IQ	114.8 (10.5) _a	99.1 (10.0) _b	106.1 (11.2) _c	97.3 (10.2) _b

Note. Groups with no common subscripts are significantly different ($p < .05$). ADHD = attention-deficit/hyperactivity disorder; RD = reading disability.

Longitudinal Stability of RD and ADHD Symptoms

As expected based on the way the groups were defined, the groups with RD scored significantly lower than the groups without RD on the Time 1 reading composite measure, and the groups with ADHD were more impaired on the three measures of ADHD obtained during the initial assessment (Table 2). Each of these group differences remained significant on the follow-up measures, and longitudinal stability correlations were significant for both reading ($r = .66-.85, p < .001$) and ADHD ($r = .44-.51, p < .001$).

Analyses of the stability of the categorical group categorizations indicated that the majority of participants who met criteria for RD or ADHD based on the initial testing continued to meet criteria at the follow-up assessment (RD = 71%, ADHD = 62%; Table 3). The stability of RD was significantly higher if the individual also met criteria for ADHD at Time 1 (86%) than if they were in the group with RD alone (59%). The longitudinal stability of ADHD was not significantly different in probands with RD (64%) and without RD (60%), but the comorbid group was more likely to have received a diagnosis of ADHD and a prescription for stimulant medication (Figure 1). Finally, although most individuals in the three clinical groups either remained in the same group or no longer met criteria for any diagnosis, a small but significant subset of probands in the RD-only group at initial testing met criteria for ADHD at the follow-up assessment (two ADHD-only and nine comorbid; Table 3). Four of these 11 individuals exhibited subclinical elevations of ADHD symptoms at the time of the initial testing, but the other 7 participants had few or no symptoms of ADHD at Time 1.

Outcomes of Groups With RD and ADHD

Academic Outcomes

Significant main effects indicated that RD and ADHD were independently associated with negative outcomes on all three academic measures administered at the follow-up assessment (Table 4). The comorbid group exhibited lower grades and weaker academic skills than the other three groups and were also more likely to receive special education services (Figure 1). Moreover, these differences remained significant even when initial ADHD and reading scores were included as covariates, suggesting that the greater impairment in the comorbid group does not simply reflect a difference in severity.

Social Outcomes

Groups with ADHD at the initial assessment were reported to have fewer positive social interactions and more frequent negative social interactions at the follow-up assessment (Table 4). Although the RD main effect was not significant for these measures, significant RD \times ADHD interactions indicated that the comorbid group had more severe social difficulties than the group with ADHD alone. In contrast to the results for measures of specific social difficulties, individuals with initial reading difficulties participated in fewer extracurricular activities and were less successful in the activities in which they did participate, whereas initial ADHD symptoms were not related to later extracurricular participation (Table 4).

Other Comorbidity

Both groups with ADHD exhibited elevated rates of all comorbid disorders and scored significantly higher on the

Table 2
Reading and ADHD Scores of the Four Groups at Initial and Follow-Up Testing

	Groups based on the initial assessment				Main effects	
	Control, N = 118, M (SD)	RD only, N = 71, M (SD)	ADHD only, N = 66, M (SD)	RD + ADHD, N = 51, M (SD)	RD	ADHD
					t	t
Time 1 reading measure						
Single-word reading	0.5 (0.7) _a	-1.5 (0.6) _b	-0.1 (0.6) _c	-1.7 (0.6) _b	20.7***	5.2***
Time 2 reading measures						
Single-word reading	0.4 (0.8) _a	-1.2 (0.7) _b	0.0 (0.8) _c	-1.6 (0.8) _d	16.0***	3.7***
Reading comprehension	0.5 (0.8) _a	-1.0 (1.0) _b	-0.2 (0.9) _c	-1.2 (0.9) _b	11.3***	3.9***
Spelling	0.4 (0.7) _a	-1.2 (0.7) _b	-0.1 (0.7) _c	-1.7 (0.6) _d	17.0***	4.9***
Time 1 ADHD measures						
Inattention	0.4 (0.8) _a	-0.1 (0.8) _b	-1.2 (0.6) _c	-1.5 (0.5) _c	3.7***	15.3***
Hyperactivity-impulsivity	0.3 (0.8) _a	0.2 (0.9) _a	-1.1 (0.9) _b	-1.0 (1.1) _b	0.1	10.2***
Total ADHD	0.3 (0.8) _a	0.0 (0.8) _a	-1.1 (0.9) _b	-1.3 (0.8) _b	3.4***	14.1***
Time 2 ADHD measures						
Inattention	0.3 (0.8) _a	-0.4 (1.1) _b	-0.7 (1.2) _b	-1.3 (1.3) _c	4.6***	5.9***
Hyperactivity-impulsivity	0.2 (0.7) _a	-0.1 (1.1) _a	-0.6 (1.3) _b	-0.8 (1.6) _b	1.6	4.6***
Total ADHD	0.3 (0.7) _a	-0.3 (1.1) _b	-0.7 (1.2) _c	-1.2 (1.4) _d	3.7***	5.8***

Note. Groups with no common subscripts are significantly different ($p < .05$). ADHD = attention-deficit/hyperactivity disorder; RD = reading disability.

*** $p < .001$.

Table 3
RD and ADHD Status at the Initial and Follow-Up Assessments

Initial group	Total (N)	Group at the follow-up assessment ^a			
		Control, N (%)	RD only, N (%)	ADHD only, N (%)	RD + ADHD, N (%)
Control	118	111 (94.1)	3 (2.5)	4 (3.3)	0 (0.0)
RD only	69 ^a	26 (37.7)	32 (46.4)	2 (2.9)	9 (13.0)
ADHD only	65 ^a	24 (36.9)	2 (3.1)	37 (56.9)	2 (3.1)
RD + ADHD	50 ^a	4 (8.0)	14 (28.0)	3 (6.0)	29 (58.0)

Note. ADHD = attention-deficit/hyperactivity disorder; RD = reading disability.

^aDue to missing data, Time 2 classification was not available for one participant in each of the clinical groups.

anxiety, depression, and externalizing composites (Figure 2; Table 5). In contrast, the only disorders that were significantly elevated in the RD-only group were MDD and the adolescent-onset subtype of CD.

Other Comorbid Symptoms at Time 1 as Moderators of Outcome 5 Years Later

Parent ratings of antisocial behavior at the initial assessment were significantly associated with later social difficulties and externalizing behaviors. Nonetheless, all initial results for ADHD and RD remained significant when measures of internalizing and antisocial behavior were included as covariates.

meet full criteria for both disorders, they often exhibit sub-clinical elevations of the other disorder. This pattern is consistent with results of twin studies that suggest that one or more genes increase risk for both RD and ADHD, with the strongest influence on the comorbid group (Willcutt et al., 2007). Studies of neuropsychological functioning suggest that RD and ADHD may both be due in part to a cognitive weakness in the ability to rapidly and efficiently process information (e.g., Shanahan et al., 2006; Willcutt et al., 2007). In the following section, we briefly highlight and discuss the key results of this study, then conclude the article by summarizing the implications of these results for educators and other individuals who play important roles in children's academic development.

DISCUSSION

Results of this study confirm that RD and ADHD frequently co-occur and that this comorbidity is often stable over time. Moreover, even when individuals with RD or ADHD do not

Stability of RD, ADHD, and Their Comorbidity

Participants in the group with comorbid RD + ADHD at the initial assessment were significantly more likely to continue to meet criteria for RD at Time 2 than were participants with

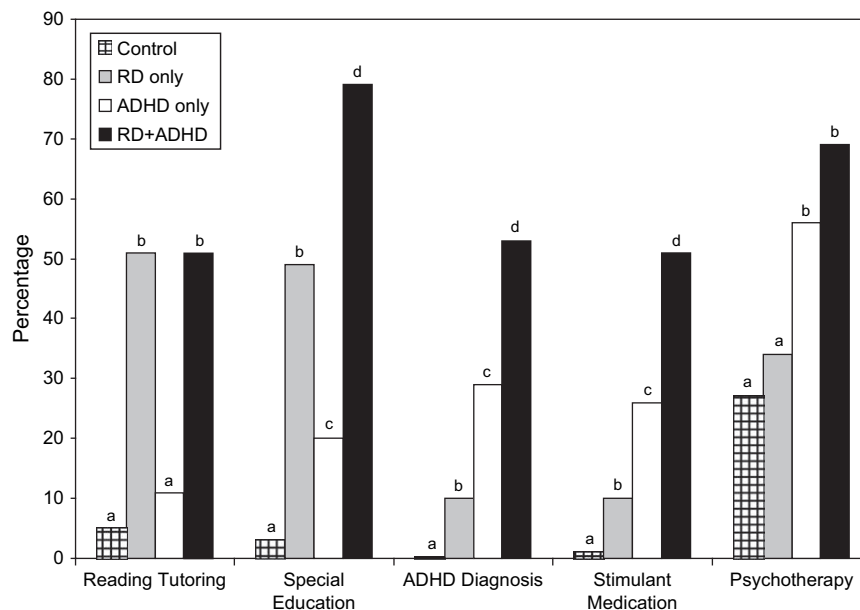


Fig. 1. Frequency of interventions received by members of groups with and without reading disability or attention-deficit/hyperactivity disorder.

Table 4

Academic and Social Outcomes of Groups With and Without RD and ADHD at Time 1

Outcome variable	Groups based on the initial assessment				Main effects ^a	
	Control, N = 118, M (SD) or %	RD only, N = 71, M (SD) or %	ADHD only, N = 66, M (SD) or %	RD + ADHD, N = 51, M (SD) or %	RD	ADHD
					<i>t</i> or χ^2	<i>t</i> or χ^2
Academic outcome						
Academic performance	0.5 (0.7) _a	-0.9 (0.8) _b	-0.2 (0.9) _c	-1.6 (1.2) _d	12.2***	6.3***
Academic/study skills	0.3 (0.9) _a	-0.8 (0.8) _b	-0.1 (1.1) _c	-1.2 (1.0) _d	8.7***	3.3**
Retained 1+ grades	0.0% _a	21.1% _b	9.1% _c	29.4% _b	16.9***	6.3*
Social outcome						
Positive social interactions ^b	0.2 (1.1) _a	0.2 (0.9) _a	-0.2 (1.0)	-0.5 (1.2) _b	0.3	2.7**
Social difficulties ^c	0.3 (1.0) _a	0.1 (0.7) _a	-0.3 (1.1) _b	-0.8 (1.7) _c	1.6	3.1***
Extracurricular activities	0.1 (1.1) _a	-0.3 (0.6) _b	0.1 (0.9) _a	-0.2 (0.8) _b	2.4**	0.1

Note. Groups with no common subscripts are significantly different ($p < .05$). ADHD = attention-deficit/hyperactivity disorder; RD = reading disability.

^aTest statistics are *t* values for dimensional dependent variables and Wald χ^2 from binary logistic regression models for categorical dependent variables. RD × ADHD interactions were not significant except as noted, so were dropped from all other models. ^bRD × ADHD interaction was significant, $t = 2.01$, $p < .05$.

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

RD alone. In contrast, the stability of ADHD did not differ as a function of RD status at the time of the initial testing. A small but significant subset of the initial RD-only group also met criteria for ADHD 5 years later at the follow-up assessment. Four of these 11 individuals exhibited subclinical elevations of ADHD symptoms at the time of the initial testing, suggesting that their negative ADHD status at Time 1 may simply reflect small fluctuations in symptoms or measurement error. In contrast, the other seven participants had few or no symptoms of ADHD at Time 1. Although this pattern should be interpreted with caution due to the extremely small

sample in this subgroup, it is consistent with results of studies that found that early reading difficulties may cause later attentional dysfunction in at least a subset of individuals with comorbid RD and ADHD (e.g., McGee et al., 2002).

Academic, Socioemotional, and Behavioral Outcomes of RD and ADHD

Academic and Social Outcomes

RD status based on the initial testing strongly predicted academic difficulties 5 years later. The relations between initial

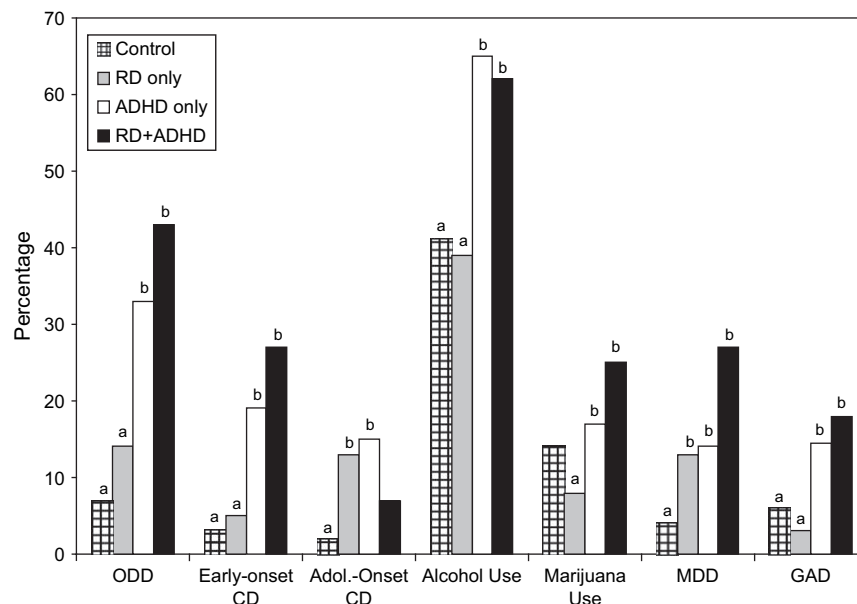


Fig. 2. Prevalence of comorbid disorders at the follow-up assessment in groups with and without reading disability or attention-deficit/hyperactivity disorder based on the initial testing.

Table 5

Rates of Comorbidity at Follow-Up Testing in Groups With and Without RD and ADHD at Time 1

Outcome variable	Groups based on the initial assessment				Main effects ^a	
	Control, N = 118, M (SD) or %	RD only, N = 71, M (SD) or %	ADHD only, N = 66, M (SD) or %	RD + ADHD, N = 51, M (SD) or %	RD t or χ^2	ADHD t or χ^2
Internalizing comorbidity						
Anxiety composite	0.1 (0.8) _a	0.1 (0.7) _a	-0.3 (0.8) _b	-0.4 (0.8) _b	0.1	2.6**
Depression composite	0.3 (0.8) _a	0.1 (0.7) _{ab}	-0.2 (0.7) _b	-0.5 (0.8) _b	1.6 [^]	3.2***
Externalizing comorbidity						
Externalizing composite	0.3 (0.5) _a	0.0 (0.6) _a	-0.5 (0.7) _b	-0.9 (0.9) _b	2.1*	6.2***
Suspended from school	16.9% _a	18.3% _a	40.9% _b	43.1% _b	0.1	14.7***
In the justice system	1.7% _a	7.0% _a	4.5% _a	19.6% _b	4.1*	1.8
Friends break the law	2.5% _a	11.3% _b	15.2% _b	21.2% _b	1.1	5.5*

Note. Groups with no common subscripts are significantly different ($p < .05$). ADHD = attention-deficit/hyperactivity disorder; RD = reading disability.

^aTest statistics are t values for dimensional dependent variables and Wald χ^2 from binary logistic regression models for categorical dependent variables. RD \times ADHD interactions were not significant, so were dropped from all other models.

[^] $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

ADHD status and later academic difficulties were smaller but significant for all academic measures, and the comorbid group was at highest risk for poor educational outcomes. Negative social outcomes were primarily attributable to ADHD status at Time 1, although individuals with RD participated in fewer extracurricular activities, and the comorbid group was once again the most impaired on several measures of social functioning. Perhaps as a consequence of greater academic and social impairment, the comorbid group was more likely than the group with ADHD alone to be diagnosed with ADHD and prescribed stimulant medication and was most likely to receive special education services.

Comorbidity

Individuals with ADHD based on the initial testing exhibited higher rates of most comorbid disorders at follow-up, a pattern that is consistent with previous cross-sectional results (e.g., Faraone et al., 1998; Graetz, Sawyer, & Baghurst, 2005; Willcutt et al., 1999). In contrast, the only disorders that were significantly elevated at outcome in the RD-only group were adolescent-onset conduct disorder and MDD.

Although the significant association between RD and adolescent-onset CD should be interpreted with caution due to the small number of subjects with each CD subtype, this intriguing preliminary finding is consistent with some previous studies (e.g., McGee et al., 2002) and suggests that RD may increase risk for the development of antisocial behaviors during adolescence even in the absence of the early cognitive, temperamental, and psychosocial risk factors that are typically associated with the childhood-onset form of CD (e.g., Lahey, Waldman, & McBurnett, 1999). If this preliminary result remains significant as our sample size increases, the extensive data sets from the initial CLDRC and this follow-

up study will be useful to disentangle the specific factors that lead to this association. For example, RD could place children at risk for the development of CD as they enter adolescence due to common genetic risk factors, environmental risk factors such as associations with a delinquent peer group due to academic frustrations, or as a consequence of comorbidity with another disorder such as MDD that is associated with increased risk for CD.

Tests for Mediation of Outcome by Other Comorbidities

Previous studies suggest that it is essential to test if the presence of antisocial behavior explains the relations between RD, ADHD, and negative outcomes (e.g., Goldston et al., 2007; McGee et al., 2002). Parent ratings of antisocial behavior completed as part of the initial assessment were indeed significantly associated with negative social outcomes and elevated rates of several other disorders 5 years later. However, all RD and ADHD effects also remained significant, suggesting that RD, ADHD, and early antisocial behaviors all independently increase risk for later negative academic outcomes.

Educational Implications

Identification of RD and ADHD and Interpretation of Comorbidity

Because RD and ADHD independently predict negative academic outcomes, when these disorders co-occur, both conditions should be considered primary disorders that require intervention. Psychoeducational assessments of RD or ADHD should always screen for both disorders (along with the emotional and behavioral difficulties that sometimes co-occur with RD and ADHD), and the child's current attentional and reading abilities should each be considered carefully when developing an Individualized Education Program.

Education and Training for School Personnel

As noted previously, most children with RD or ADHD spend the majority of their time at school in a regular education classroom, suggesting that nearly all teachers and school staff play a significant role in the education of children with RD and ADHD. Therefore, in addition to the intensive focused training already provided to educators who work in special education, it is also essential for all teachers and staff to receive systematic training regarding RD, ADHD, and other related disorders. In addition to didactic information regarding characteristics of the diagnoses and effective academic interventions, a brief overview of the causal factors and cognitive weaknesses that underlie each disorder is likely to provide a useful framework to understand the specific difficulties encountered by students with RD or ADHD.

Interventions for Older Students With RD and/or ADHD

Recent studies suggest that most younger children with RD or ADHD receive accommodations at school that are consistent with current recommendations to address difficulties in the classroom (Schnoes et al., 2006). These include modified or shortened assignments, extended time on tests, and environmental interventions such as a seat near the front of the classroom and away from potential distractions, all of which may be helpful to address weaknesses in processing speed and attention. In addition to continuing these interventions, the present results suggest that adolescents and young adults with RD and ADHD may require additional assistance to develop the academic skills needed to negotiate successfully the less structured environment that is characteristic of most high school and college environments. For example, it may be useful for educators, tutors, and parents to help the student initiate and maintain an assignment notebook to track their increasingly diverse academic responsibilities. Student may also benefit from structured assistance to break down long-term projects into more manageable subcomponents, as well as specific instruction regarding the effective use of reference materials.

Limitations and Future Directions

The present results should be interpreted in light of several limitations. Due to the time constraints of the initial CLDRC study, DSM-IV ADHD was defined at the initial testing by parent and teacher ratings on the DBRS rather than a full structured diagnostic interview. However, all participants who were included in the ADHD groups were required to meet full DSM-IV criteria for ADHD at Time 1, and exploratory analyses as part of the follow-up testing indicated high concordance between diagnoses derived using the DBRS and the DICA-IV (e.g., 92% agreement for mother ratings). Nonetheless, these results warrant replication in a study that completes a full structured interview at both time points.

Although previous studies have found few significant differences between twins and nontwins (e.g., Plomin, DeFries, McClearn, & Rutter, 1997), the use of twins for phenotypic comparisons may limit the generalization of the present findings to the population at large. Finally, although our sample is larger than many previous studies, it is still too small to conduct definitive analyses of the relation between RD and ADHD and outcome variables with lower base rates in our sample, including expulsion from school, choosing to drop out prior to completing high school, and severe antisocial behaviors such as gang membership or substance abuse. We plan to continue to test additional participants to provide power sufficient to test these and other similar questions.

SUMMARY AND CONCLUSIONS

RD and ADHD are chronic conditions that have a significant impact on academic development and educational outcome. Because most children with these difficulties spend a significant proportion of time in both special education and regular classroom environments, educators in both settings should receive specific training on the characteristics and causes of both disorders, their long-term implications, and the interventions most likely to be effective.

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