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The Co-occurrence of Reading Disorder and ADHD: Epidemiology, Treatment, Psychosocial Impact, and Economic Burden

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Abstract

The co-occurrence of reading disorder (RD) and attention-deficit/hyperactivity disorder (ADHD) has received increasing attention. This review summarizes the epidemiology, treatment strategies, psychosocial impact, and economic burden associated with the co-occurrence of these conditions. Common genetic and neuropsychological deficits may partially explain the high degree of overlap between RD and ADHD. Children who face the additive problems of both disorders are at greater risk for academic failure, psychosocial consequences, and poor long-term outcomes that persist into adulthood. However, few studies have evaluated interventions targeted to this patient population, underscoring the importance of identifying effective multimodal treatments that address the neuropsychological deficits of RD and ADHD through carefully planned clinical research.

Keywords

ADHD, reading disorder, dyslexia, epidemiology

Reading disorder (RD), or dyslexia, is the most common learning disability (LD) and is characterized by "difficulties with accurate and/or fluent word recognition and poor spelling and decoding abilities" (Lyon, Shaywitz, & Shaywitz, 2003, p. 2). The prevalence of RD in the general population ranges from 4% to 10% (Flannery, Liederman, Daly, & Schultz, 2000; Maughan & Carroll, 2006; Miles, Haslum, & Wheeler, 1998; Pastor & Reuben, 2008; Pennington, 1990), with some estimates as high as 17.5% (Shaywitz et al., 1994; Shaywitz, Fletcher, Holahan, & Shaywitz, 1992). Higher rates are generally observed in boys as compared to girls. Studies on the etiology and epidemiology of RD in general population and clinical samples have consistently found that attention-deficit/hyperactivity disorder (ADHD) is the most common disorder that co-occurs with RD (Carroll, Maughan, Goodman, & Meltzer, 2005; Maughan & Carroll, 2006). ADHD is a persistent and pervasive pattern of disruptive behavior characterized by behaviors such as inattention, hyperactivity, and impulsivity (American Psychiatric Association, 2000). A recent metaregression analysis of the worldwide prevalence of ADHD in children and adolescents younger than 18 years old found that it was 5.3%, with somewhat higher estimates in North America (Polanczyk, de Lima, Horta, Biederman, & Rohde, 2007).

There is a growing body of literature examining RD and ADHD as co-occurring disorders with shared pathophysiological pathways. As noted by Kaplan, Crawford, Cantell, Kooistra, and Dewey (2006), the overlap of the disorders is more appropriately described as co-occurring rather than comorbid, which implies that their underlying pathophysiologies are independent and not causally related. Findings from studies evaluating genetic and environmental factors (Petryshen & Pauls, 2009; Willcutt & Pennington, 2000a), cognitive processes (Shanahan et al., 2006; Tridas, 2007; Willcutt, Pennington, Olson, Chhabildas, & Hulslander, 2005), aspects of brain anatomy and functioning (Eden & Vaidya, 2008), and treatment interventions (Bental & Tirosh, 2008) suggest that RD and ADHD are highly related. The disruption of attentional mechanisms has been suggested as a possible causal factor in reading difficulties (Shaywitz & Shaywitz, 2008), and evaluating the functional anatomy of disordered executive control and reading-related skills in relation to intervention efficacy has been identified as an important direction for future research (Eden & Vaidya, 2008).

Despite increasing attention to the co-occurrence of these disorders in empirical and theoretical articles (e.g., Eden & Vaidya, 2008; Shaywitz & Shaywitz, 2008) as well as in

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larger reviews on the overlap of literacy problems and mental disorders (Maughan & Carroll, 2006), the literature on co-occurring RD and ADHD has not been systematically reviewed. Rather than treating each of these disorders in isolation, it is critical for clinicians and researchers to consider the overlap of these conditions in evaluating results from studies assessing epidemiology, treatment, psychosocial consequences, and economic burden.

Objective

The purpose of the present study was to review the literature on the co-occurrence of RD and ADHD with a focus on understanding the epidemiology, effects of different treatments and interventions, psychosocial impact, and economic burden in this patient population.

Method

The studies reviewed were identified via a systematic search conducted in the PsycINFO, Education Resources Information Center (ERIC), Excerpta Medica Database (Embase), and the National Library of Medicine's collection of Medline literature databases. The search was targeted to identify articles published in peer-reviewed journals from 1999 to 2009 and focused on the intersection of RD and ADHD. Keyword descriptors entered into the search were *dyslexia*, *word blindness*, *specific language disability*, *reading difficulty*, *reading disability*, *reading disorder*, *attention deficit*, *ADHD*, *attention deficit hyperactivity disorder*, *hyperkinetic disorder*, and *hyperactivity disorder*. A total of 858 articles were identified in the initial search of terms for RD and ADHD (335 in PsycINFO, 85 in ERIC, 438 in Embase and Medline). Of these, 228 were duplicates. The abstracts of the remaining 630 articles were reviewed, and 161 (25.6%) were found to be empirical or theoretical articles specifically addressing the co-occurrence of RD and ADHD. Thus, 161 articles composed the final sample of articles in this systematic review.

Estimates of the prevalence of co-occurring RD and ADHD were characterized in tabular format with respect to sample (e.g., epidemiological, clinical, other selected sample) and method of assessment. A high-level text summary of the common features of RD and ADHD and behavioral genetic and neurobiological evidence of their co-occurrence follows. Empirical findings from studies evaluating educational interventions and pharmacological treatment for co-occurring RD and ADHD were characterized in tabular format with special attention to reading outcomes and outcomes related to cognitive and neuropsychological domains commonly implicated in ADHD. Information about the psychosocial impact and economic burden of RD and ADHD was extracted from both qualitative and quantitative studies. Finally, in reviewing the articles obtained from these two searches, key studies published prior to 1999 were identified and are described, where relevant, to provide important context.

Results

Epidemiology of Co-occurring RD and ADHD

Evidence from epidemiological, clinical, behavioral, and genetic studies demonstrates that RD and ADHD commonly co-occur. Epidemiological data provide an estimate of co-occurrence that is drawn from the population rather than biased by selection based on the presence or absence of either disorder. Data from selected and clinical samples are also informative because the disorders of interest are well defined and well characterized, allowing for more information to be obtained from a smaller sample size. However, findings from studies based on clinical or selected samples should be interpreted carefully because referrals to clinics, or the selection criteria for these samples, usually identify more severe cases of the disorder of interest; consequently, rates of co-occurrence in these samples are often inflated compared to those in the general population.

Prevalence of co-occurring RD and ADHD in epidemiologic samples. To understand and interpret the epidemiological evidence of the co-occurrence of RD and ADHD, it is helpful to first understand what might be expected purely by chance. The *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (*DSM-IV*; American Psychiatric Association, 1994) cites the prevalence of RD as 4% in children and the prevalence of ADHD as 5% in children. Given these prevalence rates, it would be expected that 0.2% (i.e., 4% × 5%) of children would have both disorders purely by chance, assuming the disorders were totally unrelated. Prevalence estimates of co-occurrence that are higher than this suggest that the two disorders share significant etiological risk factors, such as common genetic variants, etiological mechanisms, or environmental factors, which contribute to the development of both disorders. Results from studies in population-based samples are reviewed below and in Table 1.

Two population-based studies evaluating the prevalence of RD with ADHD were identified in this review, though one of these studies assessed learning disorders (LD) in general (Pastor & Reuben, 2008). In the United States, 2004–2006 data from the National Health Interview Survey (NHIS) provided information on the co-occurrence of ADHD and LD (inclusive of RD, but also including other LD; Pastor & Reuben, 2008). The NHIS sample included 23,051 children and adolescents 6 to 17 years of age, and classification of the children as LD or ADHD was based on parent report. The overall prevalence of co-occurring cases of the two disorders was 3.7%, with a higher prevalence rate in boys (5.1%) than girls (2.3%). Interestingly, comorbid LD and ADHD increased with age; 2.9% of children ages 6–11 years had co-occurring disorders, whereas 4.4% of 12- to 17-year-olds had both LD and ADHD. There are a number of limitations to these findings. First, the diagnosis of LD was used rather than RD, thereby limiting specific conclusions about the co-occurrence of RD and ADHD. Second, the diagnoses were based on parent report of the disorders using a single question for each

Table 1. Prevalence of RD With Comorbid ADHD: Population-Based Samples

Authors	Year Published	*N*	Sample	Country	RD Assessment Method	ADHD Assessment Method	% Comorbid RD and ADHD
Carroll et al.	2005	5,752	Children aged 9–15 years from a national survey of child mental health carried out by the U.K. Office for National Statistics in 1999	United Kingdom	Regression method predicting children's reading and spelling scores on the basis of their vocabulary	*Developmental and Well-Being Assessment*, a child interview, and a teacher questionnaire (*DSM-IV* diagnoses based on information)	0.4% of children had comorbid RD and ADHD 18.9% of children with ADHD also had RD 8.7% of children with RD also had ADHD Children with RD were more likely to have ADHD (9.0%) compared to children without RD (2.0%; OR = 3.82, CI = 2.37–6.14)
Pastor & Reuben	2008[a]	23,051	Children aged 6 to 17 years from the National Health Interview Survey	United States	Parent response to the question, "Has a representative from a school or a health professional ever told you that (sample child) had a learning disability?"	Parent response to the question, "Has a doctor or health professional ever told you that [sample child] had attention deficit hyperactivity disorder [ADHD] or attention deficit disorder [ADD]?"	3.7% of children had comorbid LD and ADHD 44.0% of children with ADHD also had LD 42.5% of children with LD also had ADHD

Note: RD = reading disorder; ADHD = attention-deficit/hyperactivity disorder; *DSM* = *Diagnostic and Statistical Manual of Mental Disorders*.
a. Assessed the prevalence of LD.

disorder (e.g., "Has a doctor or health professional told you that [sample child] had attention deficit hyperactivity disorder [ADHD] or attention deficit disorder [ADD]?" and "Has a representative from a school or a health professional ever told you that [sample child] had a learning disability?"). The sensitivity and specificity of this method of assessing ADHD and LD are unknown, and children who had not previously been identified for screening or diagnosis for either disorder would be overlooked in the classification method. As a consequence of these limitations, rates of both LD and ADHD in this study may have been underdiagnosed (or overdiagnosed).

The second general population sample epidemiological study was carried out using data from a national survey of child mental health conducted by the U.K. Office of National Statistics in 1999. In this study, Carroll et al. (2005) investigated a large sample of 5,752 children aged 9 to 15 years old and compared psychiatric diagnoses of children with and without literacy difficulties. Data from up to three informants were collected. Literacy difficulties were assessed by using a regression equation to predict children's reading and spelling scores on the basis of their vocabulary scores. Presence of ADHD and presence of other psychiatric disorders were assessed via standardized interviews with children and their parents and experienced clinician review of computer-generated case summaries. A total of 25 of the 5,752 children (0.4%) had co-occurring RD and ADHD. Among those with and without literacy difficulties, rates of ADHD were 9% and 2%, respectively. Children with literacy difficulties were significantly more likely to have a diagnosis of ADHD (OR = 3.82, 95% CI = 2.37–6.14, results adjusted by sex and family social class). Findings on the relative strength of associations between literacy difficulties and inattentive type ADHD versus hyperactive ADHD were inconclusive, in part because of a lack of statistical power. Logistic regression analyses confirmed that both subtypes of ADHD were significantly associated with RD, although the odds ratios between subtypes were not significant. However, when scores on both the Parent and Teacher Inattention subscales had been entered into the analysis, ADHD diagnosis was no longer significantly associated with literacy difficulties, suggesting that inattention was the predominant behavioral correlate of literacy difficulties.

To our knowledge, there are no other recent epidemiological studies that present data related to the co-occurrence of RD and ADHD, and further research in population-representative samples with contemporary methods of assessment is needed.

Prevalence of co-occurring RD and ADHD in clinical samples. In addition to the results of epidemiological studies, data from clinical studies suggest a high degree of overlap between these two disorders. Results from studies in samples selected for ADHD and RD, respectively, are reviewed in the sections below and in Tables 2 and 3. Common across studies was the use of a significant discrepancy between observed reading

Table 2. Prevalence of RD with Comorbid ADHD: Selected Samples, Recruited for ADHD

Authors	Year Published	*N*	Sample	Country	RD Assessment Method	ADHD Assessment Method	% Comorbid RD and ADHD
August & Garfinkel	1990	115 ($n = 45$ with RD and ADHD)	Clinic-referred children between 7 and 17 years of age who met *DSM-III-R* criteria for ADHD	United States	A score at least 1 standard deviation below the mean on either the reading and/or spelling subtests of the WRAT-R; and these scores were at least 1 *SD* below the participant's full-scale IQ	*DSM-III-R* criteria for ADHD based on semistructured interview with parents	39% of children with ADHD were also found to have RD
Dykman & Ackerman	1991	182 with ADHD	Clinic-referred children aged 7–11 years of age, who met *DSM-III* criteria for ADD	United States	WRAT-R reading plus spelling standard score less than 90, and that score was at least 10 points lower than child's full scale WISC-R IQ.	Primary caretaker reports regarding the child using the *Diagnostic Interview for Children and Adolescents*	45% of children with ADD were found to have RD
Hechtman et al.	2005	597 with ADHD	Clinic-referred children aged 7–10 who met *DSM-IV* criteria for ADHD, Combined Type	United States	Learning disorder (in reading) was defined by a regression-based discrepancy between ability and achievement at the 5% significance level (WISC-III and WIAT scores)	*DSM-IV* criteria for ADHD, Combined Type using the *Diagnostic Interview Schedule for Children*, parent report, Version 3.0	Rates of RD are presented by treatment groups; no significant differences were found: total sample: 15.8%; community comparison, 21.3%; medication management, 13.7%; combined treatment, 12.1%; behavior treatment, 16.3%
Mayes & Calhoun	2006	617 with ADHD	Clinic-referred children meeting diagnostic criteria for ADHD	United States	Reading score significantly lower than what was predicted based on WISC-III Full Scale IQ	Semistructured interview with the parent and child, review of records, clinical observations, and questionnaire and rating scale data	33% of children with ADHD had RD
Semrud-Clikeman et al.	1992	60 with ADHD	Clinic-referred children meeting diagnostic criteria for ADHD	United States	RD was assessed using WRAT-R and *Gilmore Reading Tests*; three separate cutoff scores were used (10, 20, and 85 standard score points below full scale IQ)	Clinical child psychiatry assessment by a child psychiatrist to determine *DSM-III* criteria for ADDH	38% comorbid with 10+ cutoff; 23% comorbid with 20+ cutoff; 15% comorbid with 85+ cutoff

Note: RD = reading disorder; ADHD = attention-deficit/hyperactivity disorder; *DSM* = *Diagnostic and Statistical Manual of Mental Disorders*; WRAT-R = *Wide Range Achievement Test–Revised*; WISC-R = *Wechsler Intelligence Scale for Children–Revised*; WISC-III = *Wechsler Intelligence Scale for Children–III*; WIAT = *Wechsler Individual Achievement Test*.

Table 3. Prevalence of RD With Comorbid ADHD: Selected Samples, Recruited for RD

Authors	Year Published	*N*	Sample	Country	RD Assessment Method	ADHD Assessment Method	% Comorbid RD and ADHD
Roongpraiwan et al.	2002	31 with RD	First to sixth grade students from an elementary school in Thailand with RD	Thailand	Reading ability assessed through a stepwise process involving screening by classroom teachers, by researchers examining individual items, and thorough special education assessment; students reading two or more grade levels below their actual grades were diagnosed with RD	Parent and teacher rating scales of *DSM-IV* criteria for ADHD were assessed via the *Conners's* parents and teachers rating scales	8.7% of the students with RD had a diagnosis of ADHD
Shanahan et al.	2006	146 with RD, 249 without RD	Twin pairs 8–18 years of age recruited through the Colorado Learning Disabilities Research Center Twin Project	United States	*Peabody Individual Achievement Test* was used to assess reading; a standardized score 1.75 *SD* below the mean of the control sample was used as a cutoff for RD	Parent and teacher ratings of *DSM-IV* ADHD symptoms were assessed via the *Disruptive Behavior Rating Scale*	33% of the twins with RD had ADHD
Willcutt & Pennington	2000a	494 with RD	Twin pairs 8–18 years of age recruited through the Colorado Learning Disabilities Research Center twin project	United States	Participants were identified based on a positive school history of reading difficulty, classification as RD was based on a significant discrepancy between reading achievement and the achievement which would be expected based on the individual's age	Parent and teacher reports of *DSM-IV* ADHD symptoms based on a symptom checklist	Girls with RD (compared to those without RD) were significantly more likely to have ADHD Inattentive (IN) subtype (24% vs. 4%), but no differences were found for Hyperactivity/ Impulsivity (H/I) subtype Boys with RD (compared to those without RD) were significantly more likely to have ADHD-IN (30% vs. 2%) and ADHD-H/I (60% vs. 6%)

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

ability and that expected as measured by an intelligence quotient (IQ) to assess the clinical diagnosis of RD. However, there is considerable debate over the validity of distinguishing between children who have a large discrepancy between reading ability and IQ and those who do not have this discrepancy (Fletcher et al., 2004). RD does not have a distinct threshold or dividing line between impairment and normality; thus, diagnosis inherently involves creating an arbitrary threshold or cutoff value on the continuum of reading ability (Pennington et al., 2009). Poor readers with and without the IQ discrepancy have been observed to have similar underlying deficits in phonological processing, and both respond to similar types of treatment (Fletcher, Shaywitz, & Shaywitz, 1999). In addition, children who are older or of lower socioeconomic status are less likely to be diagnosed by discrepancy criteria because measures of IQ are strongly related to socioeconomic status and decline with advancing age in children with RD (Fisher & DeFries, 2002). Alternative identification criteria, such as incorporating response to instruction in the assessment process or requiring a significant lag in reading age, have been suggested (Fletcher et al., 2004). Lack of consensus surrounding the choice of diagnostic measure of RD is an important limitation to the extant research.

Prior clinical studies suggest that 15% to 45% of children with ADHD also have RD. In the Multimodal Treatment Study of ADHD (MTA), a large clinical trial ($N = 579$; ages 7–9 years) of children with the combined type of ADHD (the most common type at this age), based on *DSM-IV* criteria, 15.8% of the final sample met criteria for an LD in reading at baseline (Hechtman et al., 2005). In a sample of 115 boys consecutively referred to a university child psychiatry outpatient clinic for ADHD, 39% ($n = 45$) were diagnosed with RD (August & Garfinkel, 1990). Similarly, a study of 949 children evaluated in an outpatient diagnostic clinic from a child psychiatry unit found that 33% of children with ADHD had co-occurring RD (Mayes & Calhoun, 2006). In a sample of 182 clinic-referred children with *DSM-III* diagnoses of ADD, 45% ($n = 82$) of the children also met criteria for RD (Dykman & Ackerman, 1991). In a clinically referred sample of children and adolescents with *DSM-III* defined ADHD (then referred to as ADDH), the prevalence of RD ranged from 15% to 38% depending on the method used to determine reading disability, with more liberal criteria for RD yielding higher co-occurrence estimates (Semrud-Clikeman et al., 1992).

Similar rates of overlap with ADHD have been found in clinical studies of children referred and diagnosed with RD, ranging from 9% to 60%. In a sample of 251 individual twins recruited through school districts in the state of Colorado and selected to participate in the study because at least one twin had RD, 33% ($n = 51$) had co-occurring RD and ADHD (note: only a single twin from each twin pair was included in the analyses to maintain independence of observations; Shanahan et al., 2006). Another study, which included a sample of 867 individual twins (494 with RD, 373 without RD) between the ages of 8 and 18 years found significantly higher rates of ADHD in those with a diagnosis of RD (Willcutt & Pennington, 2000b). This study included gender and ADHD subtype analyses, which revealed that girls with RD compared to girls without RD were significantly more likely to have the inattentive subtype of ADHD (24% vs. 4%), though no differences were found among girls for the hyperactive-impulsive subtype. Boys with RD compared to boys without RD were significantly more likely to have both the inattentive subtype (30% vs. 2%) and the hyperactive-impulsive subtype (60% vs. 6%). Finally, a clinical study of children in a school in Thailand found a lower rate: Of children with RD, 8.7% also had ADHD (Roongpraiwan, Ruangdaraganon, Visudhiphan, & Santikul, 2002).

Common features of RD and ADHD. Children with RD exhibit impairments in many of the same domains as children with ADHD, including processing speed and time processing (de Jong, Van De Voorde, Roeyers, Raymaekers, Oosterlaan, et al., 2009; Ghelani, Sidhu, Jain, & Tannock, 2004; Rucklidge & Tannock, 2002; Shanahan et al., 2006; A. Smith, Taylor, Rogers, Newman, & Rubia, 2002; Tannock, Martinussen, & Frijters, 2000; Willcutt et al., 2005); attention, concentration, and verbal working memory (Dakin & Erenberg, 2005; de Jong et al., 2009; Rucklidge & Tannock, 2002; Tridas, 2007; Willcutt et al., 2003); ability to plan (Klorman et al., 1999); response inhibition and inhibitory control (de Jong, 2009; Purvis & Tannock, 2000; Willcutt et al., 2003); impairments in lexical decision (de Jong, et al., 2009); and deficits in visuospatial working memory (de Jong, et al., 2009; Martinussen & Tannock, 2006; Purvis & Tannock, 2000). In addition to exhibiting the primary deficits found in children with pure RD or ADHD, children with RD and ADHD have more severe deficits in working memory (Bental & Tirosh, 2007) and a unique impairment in rapid naming of alphanumeric symbols (Bental & Tirosh, 2007; Rucklidge & Tannock, 2002; Tannock et al., 2000). By contrast, reading performance in pure ADHD has been linked to rapid naming and executive functions rather than linguistic functions of phonological processing (Bental & Tirosh, 2007), and phonological processing deficits have been found to pertain more to RD than ADHD (Ghelani et al., 2004; Pennington, Groisser, & Welsh, 1993). As Banaschewski and colleagues (2005) point out, this distinction may be related to an auditory temporal processing deficit (Tallal, 1980), deficits in rapid sequential processing (Wagner & Torgesen, 1987), or a deficit in the automatization of skills (Nicolson & Fawcett, 1999) found in individuals with RD. Supporting this, some evidence suggests that children with ADHD tend to have difficulties with visual searches, whereas children with RD have difficulty with auditory processing (Weiler, Bernstein, Bellinger, & Waber, 2002) and are more inclined to exhibit problems with overall decoding processing—regardless of whether or not they have co-occurring ADHD (de Jong, et al., 2009).

There is also a growing consensus in the literature that the attentional aspects of ADHD account for academic problems more so than hyperactivity and that they mediate the relationship between ADHD and other conditions, including LD such as RD as well as disruptive behaviors (Carroll et al., 2005; Hinshaw, 1992; Willcutt & Pennington, 2000b). Children with the inattentive and combined subtypes show greater impairment on neuropsychological measures and tests of academic performance than do children with the hyperactive-impulsive subtype (Chhabildas, Pennington, & Willcutt, 2001; Todd et al., 2002). Furthermore, as discussed in subsequent sections, a number of studies have found that bivariate associations between conduct or oppositional behaviors and RD were reduced to nonsignificance when co-occurring hyperactivity and ADHD diagnoses were controlled (Carroll et al., 2005; Frick et al., 1991; Maughan, Pickles, Hagell, Rutter, & Yule, 1996; Willcutt & Pennington, 2000b).

Behavioral genetic evidence of the co-occurrence of RD and ADHD. There is strong and consistent evidence for the shared genetic etiology of RD and ADHD (for reviews, see Fisher & DeFries, 2002; Pennington, 1991). Analyses of community samples of twins who have been selected because at least one member of the twin pair exhibited RD or symptoms of ADHD suggest that there are common genetic influences on RD and inattention symptoms of ADHD and specific genes that confer risk for both RD and ADHD (Gayán et al., 2005; Willcutt, Betjemann, et al., 2007; Willcutt et al., 2002). Molecular genetic studies suggest that there are genomic regions that confer risk to one disorder or the other, as well as overlapping genomic regions thought to contain genes influencing both disorders. Importantly, genotype–phenotype concordance is not perfect, indicating that the genetic influences account for only a portion of the variance that is observed between individuals. Furthermore, specific gene variants within regions implicated in the development of both disorders have not yet been identified (Smith, 2007). Very little research exists examining the role of shared environmental risks, which may contribute to the development of co-occurring RD and ADHD. Although genotype is fixed within individuals, examining the environment throughout development is difficult and costly, and few genetic studies incorporate extensive environmental measurements within their research design.

Neurobiology of the co-occurrence of RD and ADHD. Results from functional magnetic resonance imaging studies indicate some shared structural abnormalities among RD and ADHD, including structural and functional problems in the frontal and parietal cortices and the cerebellum, though it should be noted that these tend to occur in the left hemisphere for RD patients and bilaterally among ADHD patients (Eden & Vaidya, 2008). Recently, a theory linking attention and reading processes postulated that attention systems in the prefrontal cortex interact in a top-down fashion with reading circuits in the inferior parietal cortex and that malfunction in this system may offer an explanation for the co-occurrence of ADHD and RD (Nakamura, Dehaene, Jobert, Le Bihan, & Kouider, 2005). Although these findings are only preliminary, they align well with reports that medications stimulating the prefrontal catecholaminergic systems are effective in reducing ADHD and RD symptoms occurring in concert (Grizenko, Bhat, Schwartz, Ter-Stepanian, & Joober, 2006; S. E. Shaywitz & Shaywitz, 2008). Neurological dysfunctions have been shown to be additive, as children with co-occurring ADHD and RD demonstrated reduced EEG coherences compared to those with ADHD alone (Barry, Clarke, McCarthy, & Selikowitz, 2009). Given the uncertainty and complexity surrounding the neurological basis of these disorders, it has been suggested that future research evaluate successful treatment as a way to uncover the brain regions responsible for the co-occurrence (Eden & Vaidya, 2008).

Hypotheses for the co-occurrence of RD and ADHD. As described previously, research conducted to date suggests that it is highly unlikely that RD and ADHD co-occur by chance (August & Garfinkel, 1990; Maughan & Carroll, 2006; Shanahan et al., 2006; Willcutt et al., 2001; Willcutt et al., 2005). Numerous hypotheses for the co-occurrence of RD and ADHD have been proposed. The "phenocopy model" suggests that there is a bidirectional influence between the two disorders, whereby problems associated with ADHD disrupt learning whereas problems with reading make children appear inattentive (Hinshaw, 1992; Pennington et al., 1993). Consistent with this first hypothesis, at least one prospective study has demonstrated that reading problems and behavior problems are bidirectional risk factors, with early reading problems strongly predicting later behavior problems and poor task engagement (attentional and behavioral processes) predicting later reading problems (Morgan, 2008). A second model, the "cognitive subtype hypothesis," suggests that distinct etiological factors influence the appearance of a third disorder (seen in the comorbid group; Rucklidge & Tannock, 2002). Although competing theories still exist, evidence to date favors a "multiple deficit model" that suggests that the co-occurrence between RD and ADHD is attributable to shared genetic risk factors that influence a pathophysiological pathway that increases susceptibility to both disorders (Shafritz, Marchione, Gore, Shaywitz, & Shaywitz, 2004; Shanahan et al., 2006; Willcutt et al., 2003; Willcutt et al., 2005). As described previously, RD and ADHD share a common cognitive deficit in processing speed, and results of twin analyses suggest that this shared weakness is primarily the result of common genetic influences (Willcutt et al., 2010; Willcutt, Pennington, Olson, & DeFries, 2007). RD in combination with ADHD is believed to have an additive effect on memory deficits (Johnson, Altmaier, & Richman, 1999), and partialling out processing speed has been shown to reduce the correlation between RD and ADHD (Shanahan et al., 2006). Thus, although previous research has been focused on identifying cognitive deficits specific to each disorder alone, such as executive functioning in ADHD or phonological deficits in RD, an accumulating body of research suggests that each disorder may result from a combination of cognitive deficits and genetic risk factors—some shared and some not shared.

Future research is needed to further explore identified and potential risk factors for co-occurring RD and ADHD and unique and common pathways for both disorders.

Intervention and Treatment Studies

Only a few experimental studies have explicitly evaluated treatment effects for co-occurring RD and ADHD. Most recruited school-aged children, the majority of whom were male, with ages ranging from 6 to 12 years (Bental & Tirosh, 2008; de Jong, Van De Voorde, Roeyers, Raymaekers, Allen, et al., 2009; Forness, Cantwell, Swanson, Hanna, & Youpa, 1991; Forness, Swanson, Cantwell, Youpa, & Hanna, 1992; Grizenko et al., 2006; Hechtman et al., 2005; Jensen, 2001; Keulers et al., 2007; Richardson & Puri, 2002), whereas two sampled older children and adolescents aged 12 to 17 (Shafritz et al., 2004) and 10 to 16 (Sumner et al., 2009), respectively, and one sampled postsecondary students aged 19 to 25 years (Hecker, Burns, Elkind, Elkind, & Katz, 2002). Pharmacological intervention was investigated in 10 studies evaluating treatment effects in samples with ADHD and RD (Bental & Tirosh, 2008; de Jong, Van De Voorde, Roeyers, Raymaekers, Allen, et al., 2009; Forness et al., 1991; Forness et al., 1992; Grizenko et al., 2006; Hechtman et al., 2005; and Jensen, 2001[1]; Keulers et al., 2007; Shafritz et al., 2004; Sumner et al., 2009; Tannock et al., 2000), whereas the remaining studies investigated the effects of non-FDA regulated substances (M. Johnson, Ostlund, Fransson, Kadesjo, & Gillberg, 2009; A. J. Richardson & Puri, 2002) and educational interventions (Hecker et al., 2002; Rabiner & Malone, 2004).

These studies are discussed below and presented in Table 4, organized by type of intervention. Where available, information about effect size is provided. For Cohen's *d* an effect size of .2 to .3 is generally considered a small effect, around .5 is a medium effect, and .8 to infinity is a large effect (Cohen, 1998). In general, effect sizes were small (de Jong, Van De Voorde, Roeyers, Raymaekers, Allen, et al., 2009; Keulers et al., 2007; Tannock et al., 2000) to medium (Hechtman et al., 2005; Jensen, 2001; Keulers et al., 2007; Shafritz et al., 2004).

Educational interventions in co-occurring RD and ADHD. A wealth of research suggests the importance of early intervention programs to prevent and remediate reading difficulties in children at risk of developing RD (Alexander & Slinger-Constant, 2004; Tangel & Blachman, 1995). Interventions emphasizing phonological awareness have been shown to result in improvements in reading accuracy and reading fluency in many languages, with longer durations and more intensive treatments needed to sustain benefits in older and more severely impaired children. In general, better outcomes are found in younger children (kindergarten through first grade) who receive more frequent instruction (4–5 days per week) via small-group instruction that combines phonologic awareness training with letter knowledge and explicit phonics instruction (Alexander & Slinger-Constant, 2004; Snow, Burns, & Griffin, 1998). In older children (second to sixth grade) who have been diagnosed with RD, intensive one-on-one and small-group interventions continue to result in improvements in reading and spelling—though gains tend to be less pronounced (Alexander & Slinger-Constant, 2004; Snow et al., 1998).

Few studies have evaluated educational interventions in samples with co-occurring RD and ADHD. However, problems with attention and behavior have been associated with poor outcomes in both prevention programs targeted at reducing the risk for development of reading disability in younger children and intervention programs designed to improve reading in children with RD (Alexander & Slinger-Constant, 2004; Snow et al., 1998). This underscores the importance of identifying co-occurring attention and behavior problems as early as possible and evaluating interventions in this subgroup.

Rabiner and Malone (2004) examined the relative benefits of a phonics-based tutoring intervention designed for low-readiness children from disadvantaged backgrounds and compared children with and without attention problems. The authors found that as children's attention problems approached clinically elevated levels, differences in first grade reading achievement for intervention and control participants were negligible. The authors speculate that a more intensive intervention, beyond the three 30-min sessions per week provided in their program, coupled with tutoring specifically targeted to address both attention problems and reading difficulties, may have improved outcomes for children at risk for co-occurring RD and ADHD.

Supporting this speculation, interventions designed to increase attentional processes implicated in ADHD have demonstrated benefits in samples of children with either RD (Liddle, Jackson, & Jackson, 2005; Solan, Shelley-Tremblay, Ficarra, Silverman, & Larson, 2003) or ADHD (DuPaul & Eckert, 1988). For example, eye movement training designed to improve visual attention and the speed of visual processing in reading disabled children has been associated with significant gains in reading comparable to benefits associated with comprehension training (Donfrancesco & Ferrante, 2007; Solan et al., 2003; Solan, Larson, Shelley-Tremblay, Ficarra, & Silverman, 2001). Focusing on the physiological response to attention, Liddle et al. (2005) demonstrated improvement in reading fluency in dyslexic adults following a visual-motor task that participants performed in synch with heart rate. Computer-assisted instruction may also be a promising tool to enhance reading and academic performance in children with ADHD (DuPaul & Eckert, 1988; Hecker et al., 2002), though evidence to date suggests improvements in some domains (e.g., duration of reading and concentration) more so than others (e.g., reading comprehension).

Interventions designed to reduce the symptoms of ADHD may also have implications for future treatment directions in co-occurring RD and ADHD. EEG biofeedback has been shown to reduce inattentive symptoms in children with ADHD (Fuchs, Birbaumer, Lutzenberger, Gruzelier, & Kaiser, 2003; Monastra, Monastra, & George, 2002), and findings from the MTA study suggest that combination therapy involving best

Table 4. Treatment Studies in Children and Adolescents With Co-occurring RD and ADHD

Authors, Year	Study Sample and Method	Intervention or Treatment	Outcomes	Improvement	No Improvement
Educational interventions in RD with ADHD					
Hecker et al., 2002	Study sample: $N = 20$ postsecondary students with attention disorder. Five were also considered to have RD, assessed via GORT-3 and WJ-R Age: 19–25 years Country: United States Inclusion criteria: primary diagnosis of attention disorder according to *DSM-IV* criteria Method: Postsecondary students with a primary diagnosis of attention disorder were assessed when reading normally, and when reading with assistive software	Intervention: Assistive reading software used to read assignments for most of a semester. It was composed of a synchronized visual and auditory presentation of text, incorporating study skills tools for highlighting and note taking Comparison: Normal reading (no assistive software). All participants acted as their own controls	Reading speed Reading comprehension (above assessed via *Nelson-Denny Reading Test*) Time to complete reading assignments (self-reported by students in a reading log) Reading comprehension Distractions Stress Fatigue Duration of reading (above self-reported by students using a questionnaire created by the authors)	54% increase in number of pages read per minute ($p < .05$) 29% decrease in time to read passages 50% reduction in number of distractions/hour ($p < .01$) 60% increase in duration of reading ($p < .01$) 66% increase in concentration time before needing a break ($p < .05$) 80% agreed reading with software was less stressful ($p < .05$)	Reading rates Reading comprehension
Rabiner & Malone, 2004	Study Sample: $N = 581$ children at high risk of conduct problems Age: 5.7 years (mean age) Country: United States Inclusion criteria: children scoring in the top 10% of sites from the Fast Track study on a combined screen of Aggression scales of the CBCL, the *Revised Problem Behavior Checklist*, and other nonspecified items generated by investigators Method: Children with externalizing problems were either given special tutoring during first grade or received standard teaching	Intervention: Phonics-based tutoring in reading individually throughout first grade 3 times/week for 30-min sessions Comparison: No tutoring	Word Attack subtest from the *Diagnostic Reading Scales* *ADHD Rating Scale* Vocabulary subtest of the WISC-R Block Design subtest of the WISC-R	Treatment effects on early reading ability and attention problems were significant ($p < .05$) Beneficial effect of treatment: $b = .31$, $SE = .07$, $t(2369) = 4.18$, $p < .0001$ Effect of early reading ability: $b = .37$, $SE = .04$, $t(2230) = 9.37$, $p < .0001$ Treatment was of greater benefit to students with early reading difficulty: $b = -.21$, $SE = .07$, $t(4051) = 2.88$, $p < .005$ Interaction between attention problems and treatment: $b = -.16$, $SE = .07$, $t(3310) = 2.21$, $p < .03$	There was no evidence that tutoring provided any benefit when students presented with early reading difficulties and attention problems

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Table 4. (continued)

Authors, Year	Study Sample and Method	Intervention or Treatment	Outcomes	Improvement	No Improvement
Treatment interventions: Methylphenidate (MPH) in RD with ADHD					
Bental & Tirosh, 2008	Study Sample: N = 25 boys with ADHD and RD Age: 7.9–11.7 years Country: Israel Inclusion criteria: "boys with intellectual functioning and receptive oral language skills in the reference range" (Note: "reference range" = defined by Bental & Tirosh, 2007) Method: A double-blind, randomized, placebo-controlled crossover trial with a single dose of MPH	Intervention: Single MPH dose of 0.3 to 0.4 mg/kg Comparison: Placebo	RR: Passage fluency Word accuracy Nonword accuracy Spelling accuracy Verbal fluency Phonemic synthesis Phonemic deletion Rapid naming (measures unspecified) *Matching Familiar Figures Test* Porteus Maze *Wisconsin Card Sorting Test* *Listening Sentence Span Test* *Listening Number Span Test* *Animal Retrieval and Food Retrieval Tests*	Comparison of differences between MPH and placebo compared to baseline: Word accuracy $M = 0.379 \pm 0.812, t = 2.335, p = .028$ Nonword accuracy $M = 0.245 \pm 0.524, t = 2.245, p = .035$ Rapid naming $M = -0.262 \pm 0.6, t = -2.142, p = .043$	Comparison of differences between MPH and placebo compared to baseline: Passage fluency $M = -0.098 \pm 0.577, t = -0.846, p > .5$ Spelling accuracy $M = 0.034 \pm 0.386, t = 0.436, p > .5$ Verbal fluency $M = 0.297 \pm 1.004, t = 1.355, p > .5$ Phonemic synthesis $M = 0.077 \pm 0.852, t = 0.440, p > .5$ Phonemic deletion $M = -0.108 \pm 0.552, t = -0.961, p > .5$ Response inhibition $M = 0.197 \pm 0.653, t = 1.382, p > .5$ Planning $M = -0.139 \pm 0.703, t = -0.904, p > .5$ Rule abstraction/set shifting $M = 0.023 \pm 1.027, t = 0.101, p > .5$ Working memory $M = 0.146 \pm 0.568, t = 1.179, p > .5$
Forness et al., 1991	Study sample: N = 56 boys n = 27 with hyperactivity disorder (HD), 4 boys also had LD n = 28 with hyperactive-aggressive (HA), 4 boys also had LD Age: 8–11 Country: United States Inclusion criteria: IQ > 85, ADHD diagnosed by *DSM-III-R* criteria and *Conners's Ten-Item Index Questionnaire*, the *SNAP DSM III Questionnaire*, and the Iowa *Conners's* Questionnaire. Each participant was also administered WISC-R, PIAT, WRMT, and the *Key Math Diagnostic Test*, to test for LD	Intervention: MPH 3 times a day as a low dose (0.3 mg/kg), intermediate dose (0.6 mg/kg), or high dose (1.0 mg/kg) Comparison: Placebo 3 times a day	GORT: Oral reading Reading comprehension	Significant improvement for HA pts with MPH on: Reading comprehension accuracy Mean number of correct responses vs. placebo ranging from 0.7 to 0.9 ($p < .03$) Significant improvements for HA + LD pts with MPH on: Reading comprehension speed vs. placebo ($p < .04$)	No significant improvements for any group on: Oral reading Mean speed improvement vs. placebo ranging from 1.3 s to 3.8 s in HA pts and ranging from 1 s to 4.1 s in HD pts Mean accuracy improvement vs. placebo ranging from 0.1 to 0.3 less errors in HA pts and 0.9 to 1.0 less errors in HD pts Reading comprehension Mean speed vs. placebo ranging from +2.8 to +15.5 s in HD pts and ranging from –26.7 s to –12.6 s in HA pts Mean number of correct responses vs. placebo ranging from –0.6 to –0.3 in HD patients

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Table 4. (continued)

Authors, Year	Study Sample and Method	Intervention or Treatment	Outcomes	Improvement	No Improvement
	Method: Boys with HA or HD received MPH vs. placebo in a double-blind study. Reading performance was measured.				
Forness et al., 1992	Study sample: $N = 42$ boys with ADHD Age: 8–11 years Country: United States Inclusion criteria: ADHD diagnosed via *DSM-III-R* criteria; a score of 15 or more on the *Conners's* 10-item *Index Questionnaire*; Method: Boys with ADHD who had previously responded to study medication (demonstrated significant improvement) were examined after 6 weeks of receiving MPH, followed by 1 week of placebo and a further week of MPH for improvements in reading	Intervention: MPH 3 times a day as a low dose (0.3 mg/kg), intermediate dose (0.6 mg/kg), or high dose (1.0 mg/kg) for 6 weeks Comparison: All pts received 1 week of placebo	GORT: Oral reading Reading comprehension	No significant improvements	No significant improvements in: Oral reading speed: 8–10 s improvement from baseline, $p > .05$ Oral reading accuracy: 1.3–1.5 improvement in errors from baseline, $p > .05$ Comprehension: 0.5–0.9 improvement in comprehension score, $F(2, 80) = 2.57$, $p < .08$
Grizenko et al., 2006	Study sample: $N = 95$ children (81 M, 14 F) with ADHD: $N = 42$ ADHD with LD $N = 53$ ADHD without LD Age: 6–12 years Country: Canada Inclusion criteria: diagnosis of ADHD according to *DSM-IV*, IQ > 70 on WISC-III Method: A prospective, double-blind, placebo-controlled, randomized, 2-week crossover trial with MPH	Intervention: 0.5 mg/kg of body weight MPH daily Comparison: Placebo daily	Therapeutic response assessed by consensus clinical response	Therapeutic response: 55% ADHD + LD 75% ADHD – LD Difference: $\chi^2_1 = 4.5$, $p = .034$	Therapeutic response: 45% ADHD + LD 25% ADHD – LD

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Table 4. (continued)

Authors, Year	Study Sample and Method	Intervention or Treatment	Outcomes	Improvement	No Improvement
Jensen, 2001 Hechtman et al., 2005	Study sample: $N = 579$ children with ADHD Age: 7–9 years (mean age = 8.5 years) Country: United States Inclusion criteria: normal intelligence (not specified); meeting dimensional criteria for hyperactivity (*Conners's* Hyperactivity Index) and diagnostic *DSM-IV* criteria for ADHD combined subtype (via DISC-P Version 3.0). Children with ODD, CD, anxiety disorder, depression, and LD assessed according to *DSM-IV* criteria were eligible for inclusion. LD defined by a discrepancy between ability and achievement at the 5% sig level using WISC-III Method: Children with ADHD were assigned to one of four conditions, each lasting 14 months.	Intervention: Medication Management (MedMgt) alone Behavioral treatment (Beh) alone Combination of the above (Comb) Comparison: Community comparison routine care (CC)	Probability of having/ developing a comorbid condition Impairment assess by the *Columbia Impairment Scale* SNAP: Inattention Hyperactivity ODD SSRS: Internalizing symptoms Social skills MASC: Internalizing symptoms WIAT: Reading Math Spelling	Whole group: Diagnosis of ODD: 42.4% to 19.1% ($\chi^2 = 64.44$, $df = 1$, $p < .001$) Diagnosis of CD: 14.7% to 7.2% ($\chi^2 = 18.28$, $df = 1$, $p < .001$) Diagnosis of anxiety: 34.3% to 13.1% ($\chi^2 = 72.46$, $df = 1$, $p < .001$) Comb and MedMgt groups: Significantly less impaired than CC group (diff = 3.557 for MedMgt, 4.272 for Comb; p values not shown) ADHD symptoms (data not shown) Superior to Beh and CC for ADHD outcomes Effect sizes = 0.5–0.6 Comb Significantly superior to CC (data not shown): oppositional/aggressive symptoms internalizing symptoms social skills academic functioning	Whole group: Diagnosis of LD: 15.5% to 12.8% ($\chi^2 = 3.41$, $df = 1$, $p = .065$) Diagnosis of mood disorder: 4.0% to 3.4% ($\chi^2 = 0.25$, $df = 1$, $p = .6153$) MedMgt: Not significantly different from CC on: oppositional/aggressive symptoms internalizing symptoms social skills academic functioning Beh Not significantly different from CC on any measure ($\chi^2 = 0.32$, $df = 1$, $p = .573$)
Keulers et al., 2007	Study sample: $N = 43$ $n = 24$ comorbid ADHD + RD $n = 9$ ADHD $n = 10$ RD Age: 9–12 ADHD + RD $M = 9.46$ years ADHD $M = 9.75$ years RD $M = 10.07$ years Country: Netherlands Inclusion Criteria: diagnosis of ADHD and/or dyslexia, MPH treatment in children with ADHD, information processing capacities ≥ 70	Intervention: MPH 5 mg twice a day for ADHD + RD Comparison: MPH 5 mg twice a day for ADHD alone No treatment for RD alone	Reading assessed using standardized Dutch reading tests: *One Minute Test* *Three Minutes Test* Klepel Sustained attention measured using *Bourdon-Vos Test* Automation assessed using Symbol-Digit Task of the WISC-R	Comparison of differences between experimental group (ADHD + RD) and control groups following MPH treatment: Reading performance Experimental group versus ADHD control ($p = .046$) and RD control ($p = .057$); interaction effect, $F(2, 40) = 4.63$, $p < .05$) Effect size $\eta^2_p = .19$ Nonexisting (nonsense) word reading skills Experimental group versus ADHD control ($p = .003$) and RD control ($p = .094$); interaction effect, $F(2, 38) = 7.01$, $p < .01$)	Comparison of differences between control groups for reading performance and nonexisting (nonsense) word reading skills

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Authors, Year	Study Sample and Method	Intervention or Treatment	Outcomes	Improvement	No Improvement
	Method: MPH given in an unblinded clinical trial to ADHD +RD children. Results compared to children with ADHD alone with MPH treatment and dyslexia children alone not receiving treatment			Effect size $\eta^2_p = .28$ Treatment with MPH: Attention accuracy Main effect for time F(1, 31) = 37.50; $p < .000$) Effect size $\eta^2_p = .56$ Attention speed Main effect for time, $F(1, 31) = 22.82$, $p < .000$) Effect size $\eta^2_p = .43$ Automation Main effect for time, $F(1, 25) = 25.90$, $p < .000$) Effect size $\eta^2_p = .52$	
Shafritz et al., 2004	Study sample $N = 27$ $n = 15$ ADHD $n = 8$ RD $n = 4$ ADHD+RD $n = 14$ healthy comparison adolescents were also included Age: 12–17 years Country: United States Inclusion criteria: diagnosis of ADHD by *DSM-IV* criteria, diagnosis of RD (if average of the Word Identification and Word Attack subtests of the *Woodcock-Johnson Psychoeducational Test Battery* were below a standard score of 90 (below the 25th percentile) or 1.5 SEM below the expected reading achievement score when using the *WISC-III* Full-Scale IQ), or diagnosis of both Method: Children with ADHD, RD, or comorbid ADHD+RD were tested on attention while in an fMRI. They received MPH or placebo. Results were compared to those of healthy adolescents.	Intervention: MPH 1.25 hr before imaging with dose adjusted for weight: under 30 kg = 15 mg, 30 to 60 kg = 20 mg, more than 60kg = 25 mg Comparison: Placebo	Selective attention task (visual and auditory) Divided attention task (visual and auditory) Neuroimaging data during attention tasks	With MPH, ADHD used the left inferior aspect of the basal ganglia (in the dorsal striatum), which was more closely related to healthy comparison participants' activation (data not shown) Performance data were collapsed across medication status (MANOVA): Accuracy group differences for: visual simple $F = 30.7, p < .001$ Effect size $\eta^2_p = .56$ Visual complex $F = 25.8, p < .001$ Effect size = $\eta^2_p = .51$ Auditory simple $F = 23.1, p < .001$ Effect size = $\eta^2_p = .49$ Auditory complex 12.7, $p < .001$ and divide $F = 22.3, p < .001$ Effect size = $\eta^2_p = .34$; and $\eta^2_p = .48$, respectively Comparison and ADHD participants performed better than participants with RD in the visual selective conditions ($p < .001$). Visual simple condition: RD participants responded slower than the comparison and ADHD participants ($p < .05$)	No effects of medication on: Selective attention Divided attention (data not shown)

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Table 4. (continued)

Authors, Year	Study Sample and Method	Intervention or Treatment	Outcomes	Improvement	No Improvement
Tannock et al., 2000	Study Sample: $N = 47$ children $n = 35$ ADHD $n = 12$ ADHD + RD Age: 7–12 years Country: Canada Inclusion criteria: Diagnosis of ADHD by *DSM-IV* criteria. Children with a standard score of 78 or less (i.e., a score of at least 1.5 *SD* below the mean) on the WRAT-3 Reading subtest were assigned to the ADHD+RD group; those in the ADHD group had a reading test score of at least 81. Method: Rapid automatized naming and effects of stimulant medication were investigated in children with ADHD with and without RD.	Intervention: Randomized placebo-controlled crossover trial with three doses (10, 15, 20 mg) of MPH Comparison: Placebo	RAN tests: Color, letters, and digits	Color naming: Linear effect for dose: $F(1, 46) = 5.34$, $p = .03$ Effect size: $\eta^2 = .10$	No change in naming speed for letters or numbers
Treatment interventions: Atomoxetine in RD and ADHD					
de Jong, Van De Voorde, Roeyers, Raymaekers, Allen, et al., 2009	Study Sample: $N = 83$ children $n = 16$ ADHD $n = 20$ ADHD + RD $n = 21$ RD $n = 26$ controls Age: 8–12 years Country: Netherlands and Belgium Inclusion criteria: Diagnosis of ADHD by *DSM-IV* criteria and parent and teacher scores on both the Inattention and Hyperactivity/Impulsivity scales on the DBD fell at least in the subclinical range (≥ 90th percentile). Diagnosis of RD was made if children had at least 15 months delay on at least two of the three reading tests. Method: Children were measured on visuospatial working memory, inhibition, and lexical decision	Intervention: Randomized placebo-controlled crossover trial of atomoxetine based on weight: 0.6 mg/kg per day for first 7 days and 1.2 mg/kg per day for next 21 days Comparison: Placebo	*ADHD Rating Scale–IV* *Corsi Block Tapping Task* *Stop Signal Paradigm* *Lexical Decision Task*	Significant treatment effects: ADHD symptoms compared to placebo: $F(2, 68) = 10.26$, $p < .001$ Effect size: $\eta^2_p = .23$ Visuospatial working memory compared to placebo: $F(1, 54) = 8.21$, $p = .006$ Effect size: $\eta^2_p = .13$ Speed of processing compared to placebo: $F(2, 108) = 16.74$, $p < .001$ Effect size: $\eta^2_p = .23$	No significant differences in ADHD symptoms between the ADHD+RD and ADHD only groups No significant differences in visuospatial working memory between the ADHD+RD groups. Neuropsychological functioning was not improved in ADHD and RD groups with atomoxetine No significant improvements in lexical decision with atomoxetine

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Authors, Year	Study Sample and Method	Intervention or Treatment	Outcomes	Improvement	No Improvement
Sumner et al., 2009	Study sample: $N = 56$ children $n = 20$ ADHD $n = 36$ ADHD + RD Age: 10–16 years Country: United States Inclusion criteria: Diagnosis of ADHD by *DSM-IV* criteria, requirement to meet *Kiddie Schedule for Affective Disorders and Schizophrenia for School-Aged Children-Present and Lifetime, Behavioral Disorders Supplement* module criteria for ADHD, and ADHD symptom severity score at least 1.5 standard deviations above age and gender norms for at least 1 of the diagnostic subtypes (inattentive or hyperactive/impulsive) or the total score for the combined subtype as assessed by the *ADHD Rating Scale–IV-Parent Version: Investigator Administered and Scored* (ADHDRS-IV) Method: Children with ADHD or ADHD and dyslexia received atomoxetine for 16 weeks	Intervention: Nonrandomized open-label pilot study of atomoxetine at doses ranging from 1.0 to 1.4 mg/kg once daily for 16 weeks Comparison: Baseline	*ADHD Rating Scale-IV* *Kaufman Test of Educational Achievement* (K-TEA) *Working Memory Test Battery for Children* (WMTB-C) *Life Participation Scale for ADHD-Child Version* (LPS-C)	Significant Treatment effects for both groups: ADHDRS-IV total score, inattention and hyperactivity/impulsivity subscores ($p < .001$) LPS-C ($p < .05$) K-TEA reading decoding, reading comprehension, reading composite, and spelling measures (all p values $< .05$) Significant Treatment effects for ADHD group: WMTB-C component and standard scores for central executive function ($p \leq .032$) Listening recall mean score ($p = .02$) PL nonword list recall subtest after 8 weeks of treatment ($p < .04$) Significant Treatment effects for ADHD + RD group: Phonological loop standard score ($p = .03$) PL nonword list recall subtest ($p = .004$)	No significant improvements in the ADHD reading decoding standard score ($p = .08$) and the ADHD+RD spelling standard scores ($p = .14$)

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Table 4. (continued)

Authors, Year	Study Sample and Method	Intervention or Treatment	Outcomes	Improvement	No Improvement
Nutritional supplement treatments in RD with ADHD					
Richardson & Puri, 2002	Study sample: $N = 41$ children RD + ADHD-related symptoms 22 received HUFA supplementation (18 M, 4 F) 19 received placebo (17 M, 2 F) Age: 8–12 years, $M = 10.25$ years Country: United Kingdom Inclusion criteria: general ability within the normal range, reading achievements > 2 *SD*s below expected level, scores above the general population average for age on three parent rating scales designed to assess ADHD-related symptoms Method: Dyslexic children received HUFA supplementation vs. placebo in a randomized double-blind placebo-controlled trial	Intervention: HUFA supplement, 8 capsules daily for 12 weeks Comparison: Placebo—olive oil, 8 capsules daily for 12 weeks	*Conners's Parent Rating Scale* Anxious/shy Cognitive problems Hyperactivity Opposition Perfectionism Psychosomatic Social problems *Conners's* ADHD Index *Conners's* Restless-Impulsive *Conners's* Emotional Lability *Conners's* Global Total *DSM* Inattention *DSM* Hyperactivity-Impulsive *DSM* Global Total	HUFA treatment: Anxious/shy ($z = 2.34, p = .02$) Cognitive problems ($z = 2.29, p = .02$) Psychosomatic ($z = 2.51, p = .01$) *DSM* Inattention ($z = 2.59, p = .01$) *DSM* Global Total ($z = 2.45, p = .01$) *DSM* Hyperactive-Impulsive ($z = 1.97, p = .05$) *Conners's* Global Total ($z = 1.95, p = .05$) HUFA treatment vs. placebo: Cognitive problems ($z = 2.45, p = .01$) Anxious/shy ($z = 2.02, p = .04$) *Conners's* Global Total ($z = 2.25, p = .02$) Effect size: Treatment effect size (mean change/baseline *SD*) for each group was more favorable for HUFA treatment than placebo: Psychosomatic = 0.72 Cognitive problems = 0.60 Anxiety = 0.54 Hyperactivity = 0.41 Perfectionism = 0.24 Opposition = 0.11 Social problems = 0.07 *DSM* attention = 0.61 *DSM* total = 0.58 Restless-Impulsive = 0.54 *Conners's* total = 0.50 Emotional liability = 0.34 *DSM* hyperactivity = 0.31 *Conners's* Index = 0.26	HUFA treatment (data not shown): Hyperactivity Opposition Perfectionism Social problems *Conners's* ADHD Index *Conners's* Restless-Impulsive ($z = 1.68, p = .09$) *Conners's* Emotional Liability ($z = 1.77, p = .08$) Placebo: No improvement on any scale

Note: RD = reading disorder; ADHD = attention-deficit/hyperactivity disorder; GORT-3 = *Gray Oral Reading Tests–Third Edition*; WJ-R = *Woodcock–Johnson–Revised*; *DSM* = *Diagnostic and Statistical Manual of Mental Disorders*; CBCL = *Child Behavior Checklist*; WISC-R = *Wechsler Intelligence Scale for Children–Revised*; PIAT = *Peabody Individual Achievement Test*; WRMT = *Woodcock Reading Mastery Test*; pts = patients; M = male; F = female; LD = learning disability; WISC-III = *Wechsler Intelligence Scale for Children–III*; DISC-P = *Diagnostic Interview Schedule for Children for Parents*; ODD = oppositional-defiant disorder; CD = conduct disorder; SNAP = Swanson, Nolan and Pelham Questionnaire; SSRS = *Social Skills Rating System*; MASC = *Multidimensional Anxiety Scale for Children*; WIAT = *Wechsler Individual Achievement Test*; SEM = Standard Error of the Mean; WRAT-3 = *Wide Range Achievement Test–3*; DBD = Disruptive Behavior Disorder Rating Scale; PL = Phonological Loop; HUFA = highly unsaturated fatty acid.

practices for intensive behavior treatment and monthly medication management resulted in the greatest gains in academic functioning as compared with single treatments and community care (Jensen, 2001).

In summary, although phonological awareness training has been well validated for the treatment of RD, few studies have evaluated educational and behavioral interventions in samples with co-occurring RD and ADHD. Problems with attention and behavior have been shown to undermine the effects of intervention programs. Additional research in children with comorbid RD and ADHD is needed to identify effective behavioral and educational interventions to be used in combination with medication management that enhance attention while addressing reading skills deficits.

Methylphenidate in co-occurring RD and ADHD. Methylphenidate (MPH) is the most frequently studied pharmacological treatment for co-occurring RD and ADHD (Bental & Tirosh, 2008; Dykman et al., 1980; Forness et al., 1991; Forness et al., 1992; Grizenko et al., 2006; Keulers et al., 2007; Shafritz et al., 2004), though only two studies identified in this review evaluated effects separately for those with pure ADHD and RD, respectively, and those with co-occurring RD and ADHD (Bental & Tirosh, 2008; Keulers et al., 2007). One of the primary treatment approaches for ADHD (American Academy of Pediatrics, 2001), MPH has been shown to improve behavioral symptoms of impulsivity and hyperactivity as well as cognitive attention skills and academic performance in children with ADHD (Balthazor, Wagner, & Pelham, 1991; Barkley, Grodzinsky, & DuPaul, 1992; Carison & Bunner, 1993; Hood, Baird, Rankin, & Isaacs, 2005; Jacobvitz, Sroufe, Stewart, & Leffert, 1990; Mehta, Goodyer, & Sahakian, 2004; E. Richardson, Kupietz, Winsberg, Maitinsky, & Mendell, 1988; Spencer et al., 1996; Swanson et al., 1993). This evidence, in particular the finding that MPH resulted in improvements in word and nonword decoding in ADHD (Richardson et al., 1988), led to the suggestion that MPH be indicated for co-occurring ADHD and RD and, potentially, for pure RD (Fletcher et al., 1999; Smart, Sanson, & Prior, 1996). However, early studies evaluating the effects of MPH on reading performance in children with RD did not generally support the use of the drug in ameliorating reading performance, though it was shown to improve visual-motor processes and some math outcomes (Gittelman, Klein, & Feingold, 1983; Gittelman-Klein & Klein, 1976). In parallel, other research in children with ADHD has suggested that MPH may not enhance reading outcomes. Forness et al. (1991; Forness et al., 1992) failed to find significant treatment effects in groups composed of boys with ADHD (with and without LD) unless conduct disorder was present. Improvement was seen only for time to complete reading comprehension, which was significantly greater in boys with ADHD, conduct disorder, and LD as compared to those with ADHD without these co-occurring disorders (Forness et al., 1991).

More recent data suggest some improvement in reading for those with ADHD and those with ADHD and RD following treatment with MPH (Bental & Tirosh, 2008; Jensen, 2001; Keulers et al., 2007; Tannock et al., 2000). The MTA clinical trial evaluated various treatment modalities in children with ADHD ($n = 579$; ages 7–9 years)—an unspecified number of whom also had diagnoses of RD and other LDs. Both combined treatment (MPH and behavioral intervention) and MPH medication management alone led to clinically and statistically significant improvements in the core symptoms of ADHD as compared to behavior treatment alone and standard community care, with medium effect sizes generally ranging from .5 to .6. In addition, combination therapy was shown to be superior to behavioral therapy alone for reading outcomes (Jensen, 2001). Unfortunately, analyses were not conducted separately to allow for comparisons between those with co-occurring ADHD and RD versus those with ADHD only. In a follow-up analysis in this ADHD sample (Hechtman et al., 2005), combination therapy was shown to reduce the risks of other conditions but did not markedly affect rates of LD in reading (combination therapy group, 12% at baseline and 9% at 14 months; behavioral therapy alone, 16% and 13%, respectively; all group differences nonsignificant).

Keulers et al. (2007) evaluated the effects of MPH in children with ADHD and co-occurring RD in an unblinded clinical trial. Reading performance was compared at pretest and posttest session among three groups, including the experimental group (children aged 9–12 with ADHD and dyslexia treated with MPH) and two comparison groups: (a) children with ADHD who were also treated with MPH and (b) children with dyslexia who had not been treated with MPH. When compared to both comparison groups, the co-occurring RD and ADHD group showed a trend for greater improvement in reading, although scores remained below average. In addition to some evidence of reading-related gains, significant improvements were made in sustained attention and automation in both the co-occurring RD and ADHD group and ADHD comparison group, with medium effect sizes of .56 and .52, respectively. Tannock et al. (2000) investigated the effect of MPH in an ADHD sample, 25% of which included participants with comorbid RD and ADHD, and found improvements in rapid naming in tests of color naming with an effect size of .10, though effects for the co-occurring group were not reported separately. Similarly, Bental and Tirosh (2008) also found significant treatment benefits for MPH on cognitive attention functions in a sample of 25 boys with ADHD (aged 8–12) in a placebo-controlled crossover trial with randomized sequence. Improvements were seen in rapid naming of digits, strategy and set shift (a core executive domain deficit of ADHD), and decoding accuracy of words and nonwords.

Support for the efficacy of MPH outcomes in children with ADHD and RD in relation to other clinical outcomes has been less pronounced as compared to the efficacy reported in children with ADHD alone. Grizenko et al. (2006) evaluated therapeutic response to MPH based on behavior and clinical outcomes in children with ADHD with and without LD and further explored responses for those with ADHD and RD + mathematics disability (MD), ADHD and RD only, and ADHD and MD only. In this study, therapeutic response was determined by the clinical research team based on overall degree of improvement as assessed using all available ecological and laboratory measures of symptoms and behavior. The results showed that therapeutic response was significantly lower among those with LD (55%) as compared to those with ADHD alone (75%). Additional analyses to explore whether the association between LD and therapeutic response to MPH was at least partially specific to MD or RD demonstrated that 59% of children with ADHD and RD showed improvement—a response rate that was not significantly different from that of children with ADHD without RD (68%). This result is consistent with previous findings suggesting that children with ADHD and RD respond similarly to MPH as children with ADHD only on specific tasks such as selective and sustained attention rather than on more global assessments such as therapeutic response (Dykman & Ackerman, 1991; Dykman et al., 1980). Shafritz et al. (2004) investigated the effects of MPH on selective and divided attention using behavioral tasks and functional MRI in a randomized, double-blind, placebo-controlled pharmacological study of adolescents with ADHD (n = 15), RD (n = 8), or ADHD and RD (n = 4) and 14 healthy controls and found no effects of the medication in any of the groups.

In summary, data on the treatment benefits of MPH confirm that it is effective in treating the core symptoms of ADHD. Although findings in relation to reading outcomes have been mixed, some evidence suggests that MPH may lead to some improvements in cognitive attention functions implicated in reading (Bental & Tirosh, 2008; Tannock et al., 2000) and other reading achievement outcomes (Jensen, 2001), though it has not been shown to reduce the risk of developing RD (Hechtman et al., 2005). Less is known about the effects of MPH in samples of children with pure RD, but available data do not support positive effects on reading (Gittelman et al., 1983; Gittelman-Klein & Klein, 1976). Studies evaluating the effects of MPH in co-occurring RD and ADHD samples suggest that overall therapeutic response may be similar to that found in ADHD samples and that children with both disorders may show greater improvements in reading as compared to those with either disorder alone (Grizenko et al., 2006). However, children with co-occurring RD and ADHD in this study continued to demonstrate below-average reading, indicating that treatment with MPH alone is not sufficient in fully remediating the reading difficulties of children with both disorders.

Importantly, comparisons of these outcomes must also take into account age ranges, other conditions, IQ, and the range of impairments in phonological processing and attention or control deficits—all of which vary considerably across studies. Additional research with comparisons between specific co-occurring RD and ADHD groups and pure subgroups is needed to better understand the extent of treatment benefits on different outcomes as well as the mechanism underlying improvements.

Atomoxetine in co-occurring RD and ADHD. Two recent studies evaluated the effects of atomoxetine for the treatment of co-occurring RD and ADHD (de Jong, Van De Voorde, Roeyers, Raymaekers, Allen, et al., 2009; Sumner et al., 2009). Atomoxetine hydrochloride (hereafter referred to as atomoxetine) is a nonstimulant, selective norepinephrine reuptake inhibitor that has demonstrated efficacy in the treatment of ADHD across age, gender, and subtypes of ADHD. Given the overlap in executive functioning deficits common to ADHD and RD, atomoxetine was hypothesized to provide therapeutic benefits in individuals with both disorders.

In a randomized placebo-controlled crossover study in the Netherlands and Belgium, de Jong, Van De Voorde, Roeyers, Raymaekers, Allen, et al. (2009) evaluated the effect of atomoxetine on visuospatial working memory, inhibition, and lexical decision in children aged 8 to 12 with ADHD (n = 15), RD (n = 21), or RD and ADHD (n = 20) and normal controls (n = 26). Visuospatial working memory improved after treatment with atomoxetine in children with ADHD and RD compared to placebo as well as in children with ADHD and RD alone (verbal working memory was not measured in this study). There was a marginally significant positive effect on inhibition in the ADHD and RD group. The effect sizes for atomoxetine on visuospatial working memory and speed of processing were small (.13 and .23, respectively). No treatment benefits were detected for atomoxetine on lexical decision or executive functioning in children with ADHD and RD. As expected, atomoxetine decreased ADHD symptoms. One caveat to the findings is that results may have been confounded by age and IQ. However, IQ was lower in children with ADHD in this study, and given that procedures to assess RD can take 2–3 years, children with ADHD and RD were older than the children with ADHD alone; thus, both of these variables were considered by the study authors to be crucial to represent the true variance of the groups.

Sumner et al. (2009) investigated the effects of atomoxetine in an open-label trial of children aged 10–16 in the United States with ADHD (n = 20) and ADHD and RD (n = 36). Importantly, the primary study hypothesis was that atomoxetine would improve symptoms of ADHD in individuals with both ADHD and RD. A secondary objective was to evaluate to what extent changes in reading performance resulting from treatment correlated with change in ADHD symptoms and working memory function and to what extent certain skills related to reading correlated with changes in overall reading performance. Consistent with the primary hypothesis, atomoxetine decreased ADHD symptoms in both groups. Both groups experienced gains in academic reading, and the ADHD and RD group, which had lower mean baseline scores for academic reading, achieved greater numerical gains than the ADHD group. Improvements in ADHD symptoms were weakly correlated with performance on academic and cognitive measures, suggesting that the improvements in reading found in the ADHD and RD group were not merely reflective of improvements in inattentive symptoms. On tests of neurocognitive function, the ADHD group exhibited more notable improvement in central executive function, whereas the ADHD and RD group exhibited more notable improvement in phonological loop—despite comparable scores in these domains at baseline. Thus, the authors concluded that atomoxetine may differentially affect brain symptoms in individuals with ADHD and RD and ADHD alone.

Nutritional supplement treatments in co-occurring RD and ADHD. Nonpharmacological supplements such as piracetam and ginkgo biloba are believed to enhance cognitive skills including memory and concentration (Giurgea & Salama, 1977; Mahadevan & Park, 2008). Although data on the effects of these medications in children with co-occurring RD and ADHD are not available, some research has been conducted in RD-only samples. A number of studies evaluated the effects of piracetam in children with RD in the late 1980s and produced mixed results. Although some studies demonstrated improvements in reading speed (Di Ianni et al., 1985; Tallal, 1980), reading ability (Tallal, Chase, Russell, & Schmitt, 1986; Wilsher et al., 1987), and single word reading (Helfgott, Rudel, & Kairam, 1986), Ackerman, Dykman, Holloway, Paal, and Gocio (1991) did not find any significant effects on reading.

Ginkgo biloba was evaluated in children with RD in one study identified in this review (Donfrancesco & Ferrante, 2007), a small open-label trial conducted in 15 children (ages 5–16 years), and results indicated significant improvements in reading skills following approximately 4 weeks of treatment with ginkgo biloba.

Preliminary evidence suggests a positive role for fatty acid supplementation on RD alone and RD with ADHD (Johnson et al., 2009; Lindmark & Clough, 2007; Richardson & Puri, 2002). In an open-label pilot study in children with RD alone, long-chain polyunsaturated fatty acid supplementation for 5 months resulted in improved reading speed and letter decoding (Lindmark & Clough, 2007). In another double-blind randomized control trial in children and adolescents with ADHD, omega 3/6 supplementation was not different from placebo for the overall group at the 6-month follow-up (Johnson et al., 2009). However, when the data were further analyzed according to diagnostic subgroups, a clinically meaningful response occurred more frequently in the subgroup of children with an associated co-occurring condition, including RD and/or disorder of written expression (p = .05) based on *DSM-IV* criteria (Johnson et al., 2009).

Deficiency in highly unsaturated fatty acid (HUFA) has previously been reported in children with ADHD alone (Mitchell, Aman, Turbott, & Manku, 1987; Stevens et al., 1995; Stevens, Zentall, & Burgess, 1996) as well as RD alone (Baker, 1985; Richardson, Cox, Sargentoni, & Puri, 1997; Richardson et al., 1999; Richardson & Ross, 2000; Stordy, 1995, 2000), leading to speculation that children with both disorders may benefit from this intervention. Richardson and Puri (2002) examined the effects of HUFA in a randomized double-blind placebo-controlled trial including 41 children (age M = 10 years) with specific learning difficulties (mainly dyslexia) and ADHD. Supplementation with HUFA for 12 weeks resulted in significant improvements in cognitive and behavioral problems compared to placebo. In sum, some support has been found for HUFA in relation to behavioral and reading outcomes in children with co-occurring RD and ADHD. Additional data from large clinical trials are needed to further examine the role of these supplements in the management of co-occurring RD and ADHD.

Impact of Co-occurring RD and ADHD on Psychosocial Functioning

Both RD and ADHD typically affect cognitive and academic outcomes, including early school experiences, educational attainment, and long-term achievement outcomes (Karande, Bhosrekar, Kulkarni, & Thakker, 2009; Loe & Feldman, 2007; Pastura, Mattos, & Araujo, 2009; Trampush, Miller, Newcorn, & Halperin, 2009) as well as behavioral, emotional, and psychosocial functioning (Carroll et al., 2005; Hinshaw, 1992; Karande et al., 2007; Wehmeier, Schacht, & Barkley, 2010). Longitudinal data suggest that there are dual pathways from early hyperactivity and inattentive behaviors to later inattention and reading problems and from early reading problems to poor academic outcomes (McGee, Prior, Willams, Smart, & Sanson, 2002). Furthermore, individuals with both RD and ADHD are at greater risk for lower grades and weaker academic skills than those with either disorder alone or neither disorder (Willcutt & Pennington, 2000b). However, less is known about the consequences of co-occurring RD and ADHD on children's emotional and psychosocial functioning. Information about the impact of co-occurring RD and ADHD on children's psychosocial adjustment is discussed in relation to behavioral problems, internalizing problems, and social functioning in the sections below.

Behavioral problems. The increased susceptibility of children with RD to developing other psychiatric disorders—most notably disruptive behavior disorders—has been well documented (Carroll et al., 2005; Hinshaw, 1992; Trzesniewski, Moffitt, Caspi, Taylor, & Maughan, 2006). Disruptive behavior disorders, also known as externalizing disorders, are marked by such features as impulsivity, defiance, inattention, and antisocial behavior and include clinical diagnoses such as oppositional-defiant disorder (ODD), conduct disorder (CD), and ADHD, which is sometimes classified as externalizing and sometimes referred to separately. The overlap between LDs and externalizing behaviors most often appears during the preschool years, with children who display the combination of attentional problems, aggression, and verbal or neuropsychological deficits prior to formal schooling at elevated risk for delinquency by adolescence (Hinshaw, 1992).

Although the relationship between ADHD and behavioral problems persists regardless of whether or not the child also has RD, the attentional aspects of ADHD appear to mediate the relationship between RD and problematic externalizing behaviors (Hinshaw, 1992; Morrison & Cosden, 1997; Willcutt & Pennington, 2000b). Willcutt and Pennington (2000b) found that reading difficulties were most strongly associated with the inattentive subtype of ADHD rather than the hyperactive subtype. In this study, analyses were conducted separately in boys and girls, and significant associations were found between reading problems and inattention for both groups, whereas an association between reading problems and hyperactivity-impulsivity was found for the boys only. Logistic regression analyses indicated that RD was not significantly associated with symptoms of aggression, delinquency, ODD, or CD after controlling for the significant relation between RD and ADHD (Willcutt & Pennington, 2000b).

In a follow-up 5-year longitudinal study of 8- to 18-year-old twin pairs, Willcutt, Betjemann, et al. (2007) evaluated the stability of co-occurring RD and ADHD and their relationship to internalizing and externalizing disorders as well as a range of education and functional outcomes. Results showed that the stability of RD was significantly higher if the individual also had ADHD at Time 1 (86%) than if he or she had RD alone at Time 1 (59%). By contrast, the stability of ADHD did not differ significantly for those with (64%) and without RD (60%).

Internalizing problems. In contrast to externalizing disorders, less research has examined the relationship of co-occurring RD and ADHD with internalizing problems, such as anxiety, depression, and low self-esteem. Anxiety is consistently higher among children with RD as compared to controls (Carroll et al., 2005; Willcutt & Pennington, 2000b). Carroll et al. (2005) found that both generalized anxiety and separation anxiety disorders were higher among 9- to 15-year-olds with RD and that associations between reading problems and anxiety disorders remained significant after controlling for inattention scores. Goldston et al. (2007) found that adolescents with poor reading skills had higher rates of ADHD, affective disorders, and anxiety disorders; however, only anxiety disorders remained significantly related to reading status after controlling for presence of ADHD.

Findings in relation to depression have been mixed, with some differences by gender. Depressive disorders were similar among those with and without RD in findings reported by Carroll et al. (2005). However, increasing levels in poor readers' own reports of depressed mood were attributable to associated inattentiveness. Arnold et al. (2005) also found that self-reports (but not parent reports) of depressed mood were higher in children with RD as compared to those without but found that co-occurring ADHD did not appear to account for these links. Results from Willcutt and Pennington's (2000a, 2000b) twin study demonstrate significantly higher rates of internalizing symptoms in children and adolescents with RD as compared to those without. Furthermore, among girls, RD remained significantly associated with elevated depressive symptoms and somatic complaints even when symptoms of ADHD were controlled (Willcutt & Pennington, 2000b).

Much of the research demonstrating the effects of RD on self-concept and self-esteem has involved qualitative research or semistructured interviewing—though only one study evaluating the impact of co-occurring RD and ADHD was identified in this review. In a sample of current and previous university students, Griffin and Pollak (2009) provided qualitative evidence suggesting that the way in which individuals interpret their diagnoses of RD and ADHD determines the impact on self-esteem. University students who viewed their diagnoses of RD and ADHD as deficits tended to report low academic self-esteem, confusion, and minimal optimism about their future. In contrast, students who viewed their diagnoses as a profile of differences rather than a deficit reported greater levels of academic self-esteem.

Social functioning. The social difficulties encountered by children with RD and ADHD have been well documented (Bauminger, Edelsztein, & Morash, 2005; Coleman, 2008; Kavale & Forness, 1996). Social cognition and friendship formation are likely to be particularly challenging for children with co-occurring RD and ADHD because they invoke cognitive processes such as attention, memory, and focus that may be underdeveloped in children with both disorders. However, research is needed to understand the impact of co-occurring RD and ADHD on children's social development.

Economic burden. In addition to the psychosocial consequences of RD and ADHD, these disorders are also associated with considerable economic burden. Cost methodology can take many forms but most commonly includes cost of illness (COI) and cost-effectiveness studies. Although COI studies purport to measure an illness's economic burden to society, inclusive of all parties who bear the costs (Tarricone, 2006), they do not account for all outcomes related to a disease (Byford, Torgerson, & Raftery, 2000). By contrast, cost-effectiveness studies consider outcomes of various therapies and medicines and include direct and indirect costs (Siegel, Weinstein, Russell, & Gold, 1996). Direct costs include health care costs such as hospital stays, medicines, and doctor visits as well as non–health care costs such as informal care, transportation to health appointments, and legal costs. In the case of RD and ADHD, direct costs to the educational system are also implicated. Indirect costs include effects on productivity, which may include the work time loss for parents of a dyslexic child as well as the lost productivity in adults with RD.

In the present review, a search of relevant government, expert, and advocacy Web sites resulted in only a few cases of relevant data, all of which were related to the costs of ADHD alone—without respect to RD. Results from searches conducted in the peer-reviewed literature identified three articles as potentially containing relevant information on the economic burden of RD and RD with ADHD in this literature review.

Of these, two (Heath & Hogben, 2004; Nicolson & Fawcett, 1999) outlined the potential advantages of their methods and interventions from a cost–benefit perspective but contained no cost data. Thus, only one empirical study is described here (Nyden, Myren, & Gillberg, 2008). Nyden et al. (2008) followed one cohort of 60 boys in Sweden with neuropsychiatric disorders, including 20 with ADHD, 20 with reading and writing disorder (RD/WD), and 20 with Asperger syndrome or high-functioning autism (AS/HFA). Direct and indirect costs were assessed at 2 years and 9 years following randomization into two groups: (a) a special education clinical index group and (b) a follow-up without special education program clinical comparison group. A healthy comparison group of 60 children was also followed during this period but was not included in analyses of cost data. Parents of participating children completed a questionnaire, which assessed psychosocial functioning and resource utilization, including outpatient and inpatient care for the child, health care for parents in relation to the child's disorder, time lost from work for parents, hours of extra school assistance, and costs associated with state support to parents in relation to the child's diagnosis.

The average annual cost for the sample was 42,040 Swedish krona (SEK) per family (about US$5,196) at the time the study was conducted. About 78% of costs were indirect (i.e., costs in the home and at school and days off work for parents). There was considerable variability in costs reported, with 34% of families stating that they had no costs and others reporting costs as high as 588,000 SEK per year (about US$64,758). Data were not presented by child's diagnosis. In regression models, higher psychosocial function was related to lower costs. Although this study highlights cost data that may be useful in future studies evaluating the economic burden of co-occurring RD and ADHD, the absence of a healthy comparator group and lack of information about the relative contribution of each of the diagnoses (i.e., ADHD, RD/WD, and AS/HFA) limit the generalizability of the findings in relation to the patient population that is the focus of this review. Future research is needed to evaluate the direct and indirect costs associated with co-occurring RD and ADHD.

Discussion

This review examined the literature on co-occurring RD and ADHD to understand the epidemiology, effects of treatments and interventions, psychosocial impact, and economic burden associated with the overlap of these conditions. Research to date clearly indicates that these disorders co-occur more frequently than would be expected by chance (0.2%). Epidemiological evidence from general population samples is limited, with estimates ranging from 0.4% (Carroll et al., 2005) to 3.7% (Pastor & Reuben, 2008). Estimates from selected samples from twin and clinical studies ranged from 15% to 45% for RD in children selected for ADHD and from approximately 9% to 60% for ADHD in children selected for RD. Differences in the definitions of disorder—including presence defined by LD generally as opposed to RD specifically and varying methods of assessment—make it difficult to reconcile these estimates. Given the prevalence of these disorders alone and the substantial burden associated with them, the lack of epidemiological evidence represents a significant gap in the literature on the co-occurrence of RD and ADHD. Future research in population-representative samples is needed to better understand to what extent RD and ADHD overlap, and the choice of diagnostic measure of RD is crucial in evaluating the generalizability of results.

Although the causal pathways leading to co-occurrence between ADHD and RD have not been fully elucidated, the disorders share common features, such as core deficits in attention and response inhibition, processing speed, and working memory. The "multiple deficit model," which posits that common genetic and neuropsychological factors increase vulnerability to both disorders, has garnered support in the literature (Shanahan et al., 2006; Willcutt et al., 2003; Willcutt et al., 2005), though recent data also support the possibility that there may be separate developmental pathways for co-occurring RD and ADHD as compared to ADHD or RD alone (de Jong, et al., 2009). Findings on the shared deficits in co-occurring RD and ADHD have important implications for interventions and treatments. First, multiple domains of reading skill should be measured when conducting psychoeducational assessments. The attentional and processing problems evident in those with co-occurring RD and ADHD may be missed by assessments that do not assess reading rate and oral decoding as well as silent reading tasks (Ghelani et al., 2004). Furthermore, evidence of slower processing speed suggests the importance of extra time allotments—an accommodation that is commonly afforded to children with RD but not routinely provided for children with ADHD alone.

Treatment studies focusing on co-occurring RD and ADHD are sparse. In addition to suggesting future research directions, data from clinical trials and intervention studies focusing on either disorder alone have contributed to our understanding of which treatments may best address the needs of children with co-occurring RD and ADHD. Results from studies evaluating the effects of MPH in ADHD, RD, and co-occurring RD and ADHD samples, respectively, suggest that it may have a supplemental positive effect on reading performance via cognitive attention functions. However, a combination therapy for ADHD, which involved empirically validated behavioral intervention and MPH, did not reduce rates of RD at follow-up. Thus, multimodal, empirically validated therapies for ADHD alone do not confer sufficient benefits on the cognitive and academic problems of those with both RD and ADHD. Recent data suggest that atomoxetine may be a promising intervention for improving both ADHD symptoms and reading outcomes in children with RD and ADHD (de Jong, et al., 2009; Sumner et al., 2009). Importantly, the magnitude of reading improvement following treatment with atomoxetine was greater for children with RD and ADHD than those with ADHD alone in an open-label study, suggesting the need for further investigation in larger, placebo-controlled clinical trials to determine whether atomoxetine differentially affects individuals with both disorders.

Educational interventions emphasizing phonological awareness via frequent small-group or one-one-one tutoring have been shown to be effective in the prevention and remediation of RD (Alexander & Slinger-Constant, 2004; Snow et al., 1998). However, problems with attention and behavior have been associated with poor outcomes in both prevention and intervention programs (Alexander & Slinger-Constant, 2004; Rabiner & Malone, 2004), and little is known about the effects of educational interventions in children with RD and ADHD. Additional research is needed to identify effective behavioral or educational interventions that address the severe deficits in working memory, concentration, and attention (Rucklidge & Tannock, 2002; Tannock et al., 2000; Willcutt et al., 2005); processing speed and time processing (Ghelani et al., 2004; Rucklidge & Tannock, 2002; Shanahan et al., 2006; Tannock et al., 2000); and response inhibition (Purvis & Tannock, 2000; Willcutt et al., 2003) that hinder academic and psychosocial development in children who face the additive problems of both of these disorders. Research to uncover brain regions responsible for the co-occurrence in relation to evaluations of treatment may help to further establish a framework for new multimodal treatments. Although researchers have speculated that more intensive and frequent interventions specifically targeted to address both attention problems and reading difficulties may be needed for children with both RD and ADHD, it remains unclear to what extent children with co-occurring RD and ADHD benefit from tutoring versus small-group training and how frequent (e.g., 3 vs. 5 days per week or more often) and long these interventions need to be to provide effective remediation.

Taken together, these findings suggest that pharmacotherapy treatments for ADHD should be coupled with educational or behavioral interventions designed to address the unique cognitive deficits and behavioral problems of children with co-occurring RD and ADHD. Additional research that presents effect size data and includes comparisons between specific co-occurring and pure subgroups is needed to better understand the extent of the effects of various types of treatment benefits on different outcomes as well as the mechanism underlying improvements. A significant limitation to the extant literature—with respect to both epidemiological and clinical research—is the overwhelming reliance on the IQ–achievement discrepancy definition of RD presence, and future research is needed to evaluate outcomes based on alternative identification criteria. Finally, little is known about treatment preferences and satisfaction with intervention or treatment options for RD and ADHD, and research in this area could be used to inform the development of new interventions.

In addition to affecting school success, co-occurring RD and ADHD significantly affects children and adolescents' psychosocial development. Evidence suggests that the overlap between childhood antisocial behavior and LD is mediated chiefly through the co-occurrence of aggression with traits associated with ADHD, underscoring the importance of early intervention prior to adolescence, when the co-occurrence between delinquency and underachievement may already be well established (Hinshaw, 1992). Although the impact of both disorders on internalizing problems has been given less attention, data are mixed, with some studies suggesting that elevated rates of depression and anxiety problems in RD samples are mediated by symptoms of ADHD and others finding that symptoms of ADHD do not account for these links.

There is a dearth of data on the economic cost of co-occurring RD and ADHD, with only a single relevant study identified in this review, encouraging future research in this area.

Conclusion and Implications

In sum, the extant literature suggests that RD and ADHD commonly co-occur and result from shared genetic risk factors that increase susceptibility for both disorders. Although the overlap of these disorders is associated with considerable consequences for children's academic and psychosocial development, few studies have evaluated interventions or treatments targeted to both disorders, and differences between co-occurring and pure subgroups have not been adequately studied. Findings from this review underscore the importance of identifying effective multimodal treatments that address the common and unique neuropsychological deficits of both disorders through carefully planned clinical research.

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Note

1. Different analyses on the same study are described in Hechtman et al., 2005 and Jensen, 2001.

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