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Comorbid Learning Disorders in Girls with ADHD: Longitudinal Course and Functional Outcomes in Young Adulthood

By

Jenna Rebecca Rinsky

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requirements for the degree of

Doctor of Philosophy

in

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Committee in charge:

Professor Stephen P. Hinshaw, Chair
Professor Sheri L. Johnson
Professor Anne Cunningham

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Abstract

Comorbid Learning Disorders in Girls with ADHD:
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Jenna Rebecca Rinsky

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Professor Stephen P. Hinshaw, Chair

There is an increased prevalence of learning disorders (LD) in children with attention-deficit/ hyperactivity disorder (ADHD) as compared to normative rates. Yet little is known about the developmental course or consequences of these co-occurring disorders as affected children reach young adulthood, particularly in females. It is critical to obtain a more complete understanding of the phenotype of co-occurring ADHD/LD in females, as well as to clarify the differential impact of reading and math disorders on outcomes in girls with ADHD. The goals of this study were to understand the differential and interactive effects of childhood ADHD and LD in females on key academic, behavioral, emotional, and social outcomes in young adulthood and to examine the course, developmental changes, and outcomes associated with persistence versus remittance of these disorders. The study has three main aims: (1) to determine whether girls with childhood-defined ADHD + LD have more significant negative outcomes in young adulthood than girls with ADHD only, LD only, or comparison girls, (2) to investigate the course of ADHD and LD in girls who were diagnosed with either or both disorders as children, and (3) to examine functional outcomes in those whose ADHD and/or LD symptoms persist versus those whose symptoms remit. The present study utilizes data from a longitudinal study of girls with and without ADHD, the largest known sample of childhood-diagnosed girls with ADHD and ethnicity matched comparison girls. Data were first collected at baseline (Wave 1), when the girls were 6-12 years old. Overall, the results indicate that childhood ADHD symptoms have the most significant implications for a variety of negative social, emotional, behavior, and academic young adult functional outcomes. Childhood learning disorders have some specific predictive value for young adult outcomes: childhood reading disorder (RD) status predicted likelihood of suicide attempt at young adulthood and childhood mathematics disorder (MD) status predicted social functioning at the young adult follow-up. Girls with childhood ADHD + RD and ADHD + MD demonstrated similar functioning in young adulthood to those girls who had a childhood diagnosis of ADHD alone. At follow-up, young adult ADHD status again predicted a wide range of negative functional outcomes, while young adult RD diagnosis specifically predicted concurrent internalizing disorders, frequency of self-harm behavior, and school problems. ADHD and RD diagnoses showed interactive effects for social functioning and school problems; simple main effects analysis revealed that ADHD and RD diagnoses were predictive of poorer outcomes in the absence of the other disorder. MD diagnosis at young adulthood was predictive

of poor social functioning and school problems. Most girls with ADHD and a concurrent learning disorder lost one or both diagnoses by young adulthood, and the course of ADHD did not appear to be affected by the presence of an LD at baseline or persistence vs. remittance of an LD into adulthood. Remittance of symptoms from childhood to young adulthood influenced functional outcomes. Remittance of ADHD by young adult follow-up was associated with improvements in self-esteem, psychopathology, frequency of self-harm behavior, and school problems. With remittance of MD by young adulthood, there was a reduction in suicide attempts. The results indicate that childhood ADHD symptoms have significant implications for a variety of negative social, emotional, behavior, and academic functional outcomes, but childhood learning disorders have more limited predictive value for young adult outcomes. Moreover, remission of ADHD symptoms was linked to better functional outcomes across a range of emotional, behavioral, and academic measures, emphasizing the importance of targeting early symptoms and related impairments.

Comorbid Learning Disorders in Girls with ADHD: Longitudinal Course and Functional Outcomes in Young Adulthood

There is considerable evidence that Attention-Deficit/Hyperactivity Disorder (ADHD) and learning disorders (LD) co-occur at a significantly higher rate than would be expected by chance, both in clinical (e.g., Mayes & Calhoun, 2006; Willcutt & Pennington, 2000b) and community (e.g., Carroll, Maughan, Goodman, & Meltzer, 2005; Pastor & Reuben, 2008) samples. ADHD is a neurodevelopmental disorder characterized by difficulty with sustaining and shifting attention, resisting distraction, inhibiting inappropriate behavior, and regulating activity level in accordance with situational demands. Learning disorders are defined by significant underachievement in particular academic areas (reading, mathematics, or writing), which is unexpected based on a person's age and development (e.g., American Psychiatric Association, 2000). Reading Disorder (RD), characterized by difficulties in single word reading, reading fluency, and comprehension, is commonly linked to ADHD (e.g., Willcutt & Betjemann, 2007; Willcutt et al., 2010a). There is emerging evidence that significant difficulties with development of number concepts and math calculation may also be prevalent in children with ADHD, which may signal a co-occurring Mathematics Disorder (MD) (Aster & Shalev, 2007; Karande et al., 2007; Mayes & Calhoun, 2006; Polderman et al., 2011). In children with ADHD, 15-45% are thought to have co-occurring RD and 31-60% are thought to have MD as a co-occurring disorder (Hechtman et al., 2005; Mayes & Calhoun, 2006; Sexton et al., 2011; Willcutt & Pennington, 2000b). Of course, these estimates are based largely on clinical samples; the true comorbidity in the population at large is indeterminate, though probably lower (but still substantial). Often studied as disorders of childhood, very little is known about developmental trajectories associated with ADHD and learning disorders into adulthood.

Most of the literature examining overlap between ADHD and LDs has focused on the relationship of ADHD to RD, with the relation between ADHD and MD largely neglected. However, evidence to date indicates that ADHD, RD, and MD likely share a common underlying pathophysiological pathway that increases susceptibility to all three disorders (Willcutt et al., 2010b). Behavioral genetic studies of the co-occurrence of RD and ADHD both within individuals and within families (Friedman et al., 2003; Gayán et al., 2005; Willcutt et al., 2007; Willcutt et al., 2010b) indicate that there are specific genes that confer risk for both ADHD and RD. In particular, there is evidence of a common genetic link between the inattention symptom dimension and low reading achievement that is independent from any genetic association with intelligence (Plaoyelis, Rijsdijk, Wood, Asherson, & Kuntsi, 2010). Several cognitive mechanisms have been posited to account for this association; converging evidence suggests that deficits in verbal working memory, processing speed, and speech and language impairment may be key risk factors for having both disorders (Bental & Tirosh, 2007; Purvis & Tannock, 2000; Shanahan et al, 2006; Sundheim et al., 2004; Willcutt, Sonuga-Barke, Nigg, & Sergeant, 2008; Willcutt et al., 2010a). Although genetic and neuropsychological studies of the co-occurrence of MD and ADHD are generally lacking, there is emerging evidence that specific genes may confer risk for MD and there has been some progress on identifying candidate cognitive mechanisms that may underlie the disorder (Willcutt et al., 2010b). In particular, deficits in verbal and visual working memory, processing speed, attentional functions, language, and visual imagery are present in MD and may be candidate etiological mechanisms leading to the development of MD (von Aster & Shalev, 2007; Willcutt et al., 2010b).

Several common environmental factors are also known to put a child at risk for developing an LD and/or ADHD, including prenatal substance exposure and perinatal complications, environmental deprivation, and early stress-related emotional dysregulation and anxiety (Banarjee, Middleton, & Faraone, 2007; Shalev, 2004). Research on underlying mechanisms and etiological risk factors for the development of co-occurring LD and ADHD is ongoing. Still, there is a dearth of knowledge about (1) the ways in which these childhood disorders affect adult academic, emotional, behavioral and social functioning separately and together; (2) the ways in which these disorders develop, interact, change, and/or improve as children become adults; and (3) the differential consequences of childhood vs. concurrent LD and ADHD symptoms for adult functioning.

ADHD and LD are more prevalent and co-occur more often in males than in females (Sexton et al., 2011; Yoshimasu et al., 2010). As a result, the literature on the co-occurrence of these disorders has been primarily male-referenced, with generalizability to females unknown. Research on female populations with co-occurring ADHD and LD is particularly salient given growing concern that girls with these conditions may be underdiagnosed as well as evidence that psychosocial outcomes may differ for females and males diagnosed with attentional and learning problems (Hinshaw & Blachman, 2005; Hinshaw et al., 2012; Nijmeijer et al., 2008; Willcutt & Pennington, 2000a; Willcutt & Pennington, 2000b).

It should be noted at the outset that there is disagreement within the field as to how an LD should be defined. Lack of consensus as to how to assess the clinical diagnosis of LD is an important limitation of the extant research. Many investigators have subscribed to a discrepancy model, which classifies an LD as a significant discrepancy between observed achievement and that expected as predicted by an intelligence quotient (IQ). Currently, this model is still used to establish clinical and educational criteria for LD (Fletcher et al., 1994). However, there is evidence that low achievement per se—independent of any discrepancy from IQ—is an equally valid method of classifying LD (Fletcher, Francis, Rourke, Shaywitz, & Shaywitz, 1992; Fletcher et al., 1994; Hinshaw, 2002). Poor readers with and without the discrepancy have been observed to have similar underlying deficits in phonological processing and both respond to similar types of treatment (Fletcher, Shaywitz, & Shaywitz, 1999). Further, children of lower socioeconomic status are less likely to be diagnosed with an LD by discrepancy criteria, given that measures of IQ are strongly related to socioeconomic status and decline with age in children who have RD (Fisher & DeFries, 2002). Such issues highlight the importance of considering other strategies for making an accurate diagnosis. An important strength of this dissertation is that I utilize both discrepancy-based and low-achievement definitions of LD, in order to capture a wider range of children with learning disability than in many previous studies and to avoid contaminating the ADHD-only and control groups with children who may have a LD.

The Relationships between ADHD and LD and Functional Outcomes

Negative adolescent and adult outcomes have been linked to both the symptoms of ADHD (Biederman et al., 1999; Hinshaw, Owens, Sami, & Fargeon, 2006; Hinshaw et al., 2012) and the underlying executive function (EF) deficits such youth often display (Rinsky & Hinshaw, 2011; Miller, Nevado-Montenegro, & Hinshaw, 2012). EF is defined as a group of high-level cognitive processes necessary for complex cognition and effortful behavior (Banich, 2009; Carpenter, Just, & Reichle, 2000). Although the search for causal mechanisms contributing to elevated risk for negative outcomes in children with learning disorders has proved more elusive, some children with learning disorders may have auxiliary EF and other neuropsychological

deficits, in addition to basic disruptions in processes underlying specific kinds of learning, such as reading or math (de Jong et al., 2009; McGrath et al., 2010; Willcutt et al., 2010b). These neuropsychological/executive deficits, by themselves, have been shown to lead to low achievement, poor social functioning, and higher rates of both internalizing and externalizing psychopathology in children, adolescents, and adults (Dawson, Shear, & Strakowski, 2012; Miller & Hinshaw, 2010; Miller, Nevado-Montenegro, & Hinshaw, 2012; Rinsky & Hinshaw, 2011).

Children diagnosed with ADHD and LD have been shown to be at elevated risk for academic, social, behavioral, and emotional difficulties as compared to children who have either disorder alone (see Sexton et al., 2011 for a review). Some evidence suggests that problems with memory, attention, and other neuropsychological/executive functions may be more severe than in children with both ADHD and LD than in those children who have either disorder alone (Seidman, Biederman, Monuteaux, Doyle, & Faraone, 2001). In addition, many symptoms are common to both ADHD and LD, including inattention, low frustration tolerance, low morale, and poor self-esteem (American Psychiatric Association, 2000; Jensen, Martin, & Cantwell, 1997). It is possible that ADHD and LD contribute unique risk for negative outcomes, and so the co-occurrence of ADHD and LD may lead to intensified symptoms, cognitive deficits, and difficulties in functioning (Beitchman & Young, 1997; Van de Voorde, Roeyers, Verte, & Wiersema, 2010). Alternatively, given that the symptoms and neuropsychological deficits strongly linked to negative outcomes are core features of ADHD (Miller, Gelfand, & Hinshaw, 2010) yet are inconclusively linked to learning disorders independent of ADHD (e.g., Klorman et al., 1999), it may be that the addition of a learning disorder does not contribute significant additional risk for certain poor academic, social, emotional, and behavioral outcomes as children mature into adolescence and young adulthood. Understanding the outcomes specific to each disorder, and to overlapping ADHD and LD, is critical. Such knowledge could allow clinicians to identify which children are most in need of treatment and to target the problems most likely to lead to long-term negative outcomes. A strength of the present study is that I am able to examine the implications of both childhood ADHD/LD and concurrent (young adult) diagnostic status for young adult functional outcomes.

Academic functioning problems are among the most pervasive and prominent features of both ADHD and LD (DuPaul et al., 2004; Loe & Feldman, 2007; Sundheim et al., 2004). Children with ADHD are more likely to receive poor grades, be retained in grade, use a higher number of special services, and be suspended or expelled; ultimately, they are less likely to graduate from high school and less likely to enroll in and complete college (Barbaresi, Katusic, Colligan, Weaver, & Jacobsen, 2007; Hinshaw et al., 2006; Loe & Feldman; Mannuzza et al., 1997; see review in Barkley et al., 2006). Similarly, children with RD tend to perform poorly in school and are at risk for adverse educational outcomes, given that reading is a foundational skill for other subjects (Lyon, 1998). They are ultimately more likely to drop out of school, independently of comorbid psychiatric conditions (Daniel et al., 2006; McGee, Prior, Williams, Smart, & Sanson, 2002) and often reach a lower level of educational and occupational attainment than their peers (Boetsch, Green, & Pennington, 1996). Research on the impact of MD on academic functioning and ultimate educational attainment is lacking. Nevertheless, emerging evidence suggests that having an LD in conjunction with ADHD is associated with significantly greater difficulties in academic performance and achievement than are associated with either disorder alone, including weaker academic skills, lower grades, higher rates of grade retention, and higher rates of placement in special classes (Faraone et al., 2001; Willcutt & Pennington,

2000a; Willcutt et al., 2007). Yet extremely few longitudinal studies (Faraone et al., 2001; Willcutt et al., 2007) have examined academic and educational outcomes in children with co-occurring LD and ADHD, and only one has prospectively examined young adult outcomes in children who had co-occurring RD and ADHD (Willcutt et al., 2007). Furthermore, and crucially, none of these studies focused on females, and no studies to my knowledge have examined academic and educational outcomes in children with co-occurring MD and ADHD. Such research is crucial for understanding prognosis and identifying targets for intervention.

Beyond academic outcomes, there is widespread evidence of the significant impact of both LD and ADHD on important social outcomes and psychopathology. Considerable research illustrates the profoundly negative effect of childhood ADHD symptoms on social functioning, both concurrently (e.g., Greene et al., 2001; Nijmeijer et al., 2008) and longitudinally (e.g., Bagwell, Molina, Pelham, & Hoza, 2001; Wahlstedt, Thorell, & Bohlin, 2008). Children with ADHD have more difficulty making and keeping friends, experience frequent conflicts with agemates, and are more likely to be rejected by peers (Blachman & Hinshaw, 2002; Nijmeijer et al., 2008). The majority of adolescents and adults with ADHD have the same types of social impairment present in childhood (Bagwell et al; 2001; Stein et al., 2011). Childhood ADHD also confers risk for a wide range of later behavioral and emotional problems, and persistence of the disorder into adolescence and adulthood is associated with high rates of comorbidity with substance abuse, mood and anxiety disorders, and oppositional-defiant and conduct disorders (Biederman et al., 1993; Biederman et al., 2006; Rapport, Scalan, & Denney, 1999). In addition, the diagnosis of ADHD in childhood predicts increased risk for suicidal ideation and self-harm behavior in adolescence and young adulthood, particularly in females, as does continued presence of the disorder at adolescence and young adulthood (Hinshaw et al., 2012; Hurtig, Taanila, Moilanen, Nordstrom, & Ebeling, 2012; Impey & Heun, 2012).

Similarly, children with RD or MD may be hampered in their social/emotional development (Bender & Wall, 1994). As adults, they frequently struggle with developing and maintaining interpersonal relationships and may be prone to increased levels of depression, anxiety, and disruptive behavior disorders (Beitchman & Young, 1997; Bender & Wall, 1994; Cantwell & Baker, 1991; Prior et al., 1999; Shalev et al., 1995; Stein, Blum, & Barbaresi, 2011). The presence of RD also appears to confer risk for suicidal ideation, suicide attempts, and self-harm behavior in this population (Daniel et al., 2006; Sourander et al., 2006; Wilson, Deri Armstrong, Furrie, & Walcot, 2009), particularly in females (Wilson et al., 2009). Evidence is lacking for MD.

There are few studies of social outcomes or psychopathology in children with co-occurring ADHD and LD. For example, in a four-year follow-up study of children (aged 6-17 at baseline) who had ADHD + LD or ADHD alone, Faraone and colleagues (2001) found that ADHD was associated with significantly higher rates of psychiatric comorbidity and social dysfunction; the presence of LD did not significantly affect these difficulties at either baseline or follow-up. However, in a different follow-up study of social outcomes in young adults who were diagnosed with ADHD + RD as children, Willcutt et al. (2007) found that the ADHD + RD group was most impaired on several measures of social functioning, as compared to children who had either of these disorders in isolation.

In terms of psychopathology, studies are mixed as to whether depression and anxiety are significantly associated with RD after controlling for the effect of inattentiveness (Arnold et al., 2005; Carroll et al., 2005; Goldston et al., 2007; Willcutt & Pennington, 2000a). One study of co-occurring RD and ADHD in children found that RD was not significantly associated with

symptoms of aggression, delinquency, oppositional defiant disorders (ODD), or conduct disorder (CD) after controlling for the significant relation between RD and ADHD (Willcutt & Pennington, 2000a). In a follow-up study of that sample at late adolescence/young adulthood (Willcutt et al., 2007b), rates of comorbid depression, anxiety, and externalizing disorders were similarly elevated in the ADHD only and ADHD + RD groups as compared to controls. However, RD did seem to confer risk for psychopathology in itself; the RD-only group had elevated rates of depression and adolescent-onset CD. Thus, evidence is equivocal as to whether the co-occurrence of LD and ADHD is associated with increased risk for poor social functioning and psychopathology beyond that associated with ADHD in isolation, with long-term evidence specific to MD nearly absent.

The impact of gender on developmental outcomes also requires clarification. In the Willcutt & Pennington (2000a) study of children with ADHD + RD, RD remained significantly associated with elevated depressive symptoms and somatic complaints in girls but not boys after symptoms of ADHD were controlled. In adults, one study found that ADHD + LD does not confer increased risk for psychopathology as compared to ADHD alone, but females with ADHD + LD displayed more cognitive depression than females with ADHD only and males with ADHD + LD (McGillivray & Baker, 2009). However, another study found that boys with ADHD + LD are more susceptible to depression and anxiety than girls with ADHD + LD, whereas both groups had equal rates of disruptive behavior disorders (Livingston, Dykman, & Ackerman, 1990). Thus, research into the social, behavioral, and emotional characteristics of young adults with ADHD + LD, particularly females, remains equivocal.

Diagnostic Stability of ADHD + LD in Young Adulthood

There are very few studies examining the relationship between LD improvement and ADHD symptom improvement. Both attention and reading problems are highly stable over time and likely to persist at least into adolescence and often into adulthood (Faraone et al., 2000; McGee et al., 2002). Similarly, MD has been shown to persist at least into adolescence in almost half of affected individuals, with a higher risk of chronicity for those with concomitant attentional problems (Shalev, Manor, & Gross-Tsur, 2006). In the one study to examine the longitudinal course of co-occurring ADHD and LD, Willcutt and colleagues (2007) followed twin pairs from early to late adolescence and found that the group with co-occurring RD and ADHD had more stable reading deficits than the group with RD alone; yet the longitudinal stability of ADHD was not significantly different in probands with and without RD. However, knowledge is still lacking with respect to the longitudinal course of ADHD and LD from childhood to adulthood, particularly in females. As noted, data are quite limited with respect to whether the developmental course of these disorders is linked—in other words, whether change and/or improvement in symptomotology of one disorder affects the course of the other disorder as a child ages.

Symptom Improvement and Functional Outcomes

There are extremely few studies examining the relation between improvement in ADHD/LD symptoms across development and functional outcomes. Do associated/comorbid problems resolve as symptoms remit, resulting in a relatively good prognosis, or are the real risks of the disorder not so much continuation of symptoms but rather the long term consequences of poor psychosocial and adaptive functioning in childhood? Longitudinal studies of children diagnosed with LD demonstrate that behavioral problems may be intensified by the persistence

of the disorder into adolescence and adulthood and by the presence of symptoms of inattentiveness (Auerbach et al., 2008; Bender & Wall, 1994). Thus, psychosocial outcomes may improve for children whose symptoms remit. In fact, one study found that children whose reading skills increased as a result of audiobook training had improved school motivation and performance and reduced emotional/behavioral disorders (Milani, Lorusso, & Molteni, 2010).

In terms of ADHD, one study found that young adults whose ADHD remitted or partially remitted were less likely to experience depression and anxiety or display antisocial behavior as compared to those whose ADHD persisted into adulthood, even though difficulties with interpersonal relationships remained (Young & Gudjonsson, 2008). Treatment studies in children (Buitelaar & Medori, 2010: Karpenko, Owens, Evangelista, & Dodds, 2009) and adults (Buitelaar et al., 2011) with ADHD suggest that reduction in symptoms may be associated with improvement in psychosocial functioning, although this effect may be mediated by symptoms of hyperactivity/impulsivity as compared to the inattention dimension (Buitelaar et al., 2011)—and the latter appears most related to LDs (Willcutt et al., 2010). Overall, the impact of changes in symptom profiles of ADHD and LD on functional impairment, particularly in the understudied population of females, is unclear.

Summary

Overall, there is a dearth of research on ADHD with females, particularly as it co-occurs with LD. Moreover, knowledge with respect to the course and prognostic implications of ADHD with co-occurring LD is quite limited, particularly in young adulthood and especially with females. Furthermore, very few studies have examined the impact of developmental changes in symptom profiles or continuance of symptoms over time on functional outcomes. An increased understanding of the longitudinal course and consequences of ADHD and LD, using a prospective design with a female sample, has crucial implications for intervention and treatment for this clearly impaired and understudied group

Specific Aims and Hypotheses

The broad goals of this study are to understand the stability of co-occurring childhood ADHD and LD in females and the associations of these disorders, separately and together, with important young adult functional outcomes. The present investigation has three main aims.

First, I aim to determine whether girls with childhood-diagnosed, co-occurring ADHD and LD (LD is defined as either RD or MD) exhibit functional impairments in key domains of academic, social, emotional, and behavioral outcomes in young adulthood, as compared to girls with ADHD only, LD only, and age- and ethnicity-matched comparison girls. I then examine whether young adult-defined, co-occurring ADHD and LD is associated with functional impairments in the same key outcome domains, as compared to those young women who have ADHD only, LD only, and neither disorder. I expect that the group with childhood-defined ADHD + LD (again, including girls with both MD and RD), as well as the groups with childhood-defined ADHD + MD alone and ADHD + RD alone, will be more impaired than the ADHD only, LD only (as well as MD alone and RD alone) and comparison groups at the 10-year follow-up (young adulthood), in terms of social functioning, self-esteem, level of psychopathology, behavioral indicators of distress such as non-suicidal self-injury (NSSI) and suicide attempts, and academic functioning. This hypothesis is based on literature suggesting that co-occurring childhood ADHD and LD often lead to significant academic and psychosocial

deficits (see Sexton et al., 2011 for a review), although the majority of these studies consist mostly of men. In addition, having ADHD + LD during childhood may place people developmentally and cognitively behind their peers (Young & Gudjonsson, 2008).

I also expect that the group with young adult-defined ADHD + LD (which includes young women with both MD and RD), as well as the groups with young adult-defined ADHD + MD alone and ADHD + RD alone, will be more impaired than the ADHD only, LD only (as well as MD alone and RD alone) and comparison groups in terms of key markers of young adult functioning, including social functioning, self-esteem, level of psychopathology, behavioral indicators of distress (NSSI and suicide attempts), and academic functioning. This hypothesis is based on literature suggesting that the presence of ADHD and LD influences functioning in young adulthood (Hinshaw et al., 2012; Stein et al., 2011), given that these disorders have been present for many years by young adulthood, thus compounding their effect on outcomes.

Second, I aim to examine the course of ADHD and LD in girls who were diagnosed with either or both disorders as children. I expect that the majority of girls who qualified for ADHD and an LD (RD or MD) in childhood will retain both diagnoses as young adults. I predict that ADHD may be more persistent in those girls who were diagnosed with ADHD + LD as children than those girls who had ADHD without an LD as children, given some evidence that these disorders may be mutually reinforcing and more resistant to treatment when they co-occur (Auerbach et al., 2008; Rabiner & Malone, 2004). Further, I expect that those girls whose LD symptoms persist into young adulthood will be more likely to continue to qualify for an ADHD diagnosis than those girls whose symptoms have remitted.

Finally, I aim to determine whether remission versus persistence of ADHD and/or LD symptoms in young adulthood is associated with better academic, behavioral, emotional, and social outcomes. As noted previously, there is some evidence from treatment studies of ADHD that improvement in symptoms leads to more successful functional outcomes, yet the only study, to my knowledge, to examine ADHD symptom improvement over time concluded that psychological and social functioning in young adulthood may be more linked to childhood symptomotology than is academic functioning (Young & Gudjonsson, 2008). I thus predict that those girls whose ADHD symptoms have remitted will display less impairment in academic and educational functioning than those whose symptoms have persisted. Yet, based on Young and Gudjonsson (2008), I predict that level of psychopathology may improve somewhat in those whose symptoms have remitted but that social functioning and self-esteem will remain similar to those whose symptoms have persisted. In addition, although exploratory in nature, I predict that those young adults diagnosed with ADHD + LD in childhood whose LD symptoms have remitted will have more successful functional outcomes in academic and possibly social, emotional, and behavioral areas, than those ADHD girls who still qualify for LD.

Method

Overview of Procedure

The present study utilizes data from a longitudinal study of the behavioral, cognitive, social, emotional, and family functioning of girls with ADHD and a matched comparison sample. This study has followed the largest known sample of childhood-diagnosed girls with ADHD and ethnicity matched comparison girls. Data were first collected at baseline (Wave 1), when the girls were 6-12 years old and attended research summer camps where multi-domain evaluation of key areas of childhood and family functioning was conducted (see Hinshaw, 2002, for detail about screening, diagnostic, and assessment strategies).

At the recently completed 10-year follow up, the participants were invited to take part in extensive individual and family evaluation, in order to evaluate levels of symptomatology and adjustment/impairment in key functional outcomes. Again, multi-method, multi-informant, and multi-domain procedures were employed. All assessments received full approval from the Committee for the Protection of Human Subjects at the University of California, Berkeley.

Participants

At initial assessment, the participants consisted of 228 girls, 140 with rigorously diagnosed ADHD and 88 matched comparison girls. The sample was 53% Caucasian, 27% African-American, 11% Latina, and 9% Asian-American, and family incomes ranged from public assistance to upper-middle class (see Hinshaw, 2002). Comparison girls were screened to match the ADHD sample at a group level with respect to age and ethnicity. Participants with an IQ lower than 70, overt neurological damage, psychosis, or pervasive developmental disorder were excluded. Three girls (all in the ADHD group) were missing the data necessary to evaluate LD status; thus, a total of 225 girls (137 with ADHD) were included in the analyses at baseline. All participated in the summer research programs and were followed prospectively into young adulthood, with re-assessment conducted approximately 10 years after the initial evaluations. At the 10-year follow-up, 216 girls were evaluated, a 95% retention rate, due to diligent efforts to track and evaluate participants across the country as well as the use of social media to track several participants. However, 3 girls were missing the data necessary to evaluate either ADHD or LD status; thus, a total of 213 girls (84 meeting current diagnostic criteria for ADHD) were included in the analyses at 10-year follow-up. The age range at initial assessment was 6-12 years (M = 9.1 yr); at 10-year follow up, the girls were between 17-23 years of age (M = 20 yr).

Diagnostic Procedures

Assessment for ADHD

The main diagnostic measure is the Diagnostic Interview Schedule for Children, 4th Edition (DISC-IV; Shaffer, Fisher, Lucas, Dulcan, & Schwab-Stone, 2000). At initial assessment, the child and parent versions were utilized, whereas, at 10-year follow-up, the young adult and parent versions were used, called the DISC-YA. It includes ADHD modules, typically absent in standard adult psychiatric structured interviews. In addition, the Swanson, Nolan, and Pelham (SNAP; Swanson, 1992) rating scale was used at both baseline and 10-year follow-up, yielding dimensional counts of ADHD symptoms**.**

Assessment for RD and MD

Academic achievement at baseline was assessed with the Wechsler Individual Achievement Test (WIAT; Wechsler, 1992).The WIAT is a psychometrically sound assessment, with both internal consistency and test-retest reliability estimates at above .85 for most composite scores (Wechsler, 1992). At young adult follow-up, the majority of the young adults were given the WIAT-II (Weschler, 2001) in order to use more current measures, although a small portion (21) of the young adults were given the WIAT, first edition (Weschler, 1992) before the switch to the current test was made. Scores on the WIAT and WIAT-II tests are considered to be equivalent and are analyzed as one group. Test-retest reliability estimates for the WIAT-II range from .85-.92 for the subtests used (Weschler, 2001). For both the WIAT and WIAT- II, the Basic Reading and Math Reasoning composite scores were used as indexes of reading and math achievement, respectively, at both baseline and 10-year follow up.

To indicate intelligence at baseline, I utilized the Full Scale IQ (FSIQ) score from the Wechsler Intelligence Scale for Children – Third Edition (WISC-III, Wechsler, 1991). At the 10-year follow-up, intelligence was estimated using the Wechsler Abbreviated Scale of Intelligence (WASI; The Psychological Corporation, 1999), which yields an estimate of FSIQ. The WASI has been validated in adult standardization (The Psychological Corporation, 1999) and clinical samples (Ryan et al., 2003), and correlates highly with the Wechsler Adult Intelligence Scale – Third Edition (WAIS-III; Wechsler, 1997; Zhu, Tulsky, & Leyva, 1999).

Participants with ADHD and LD were separated into ADHD + RD and ADHD + MD groups, via two definitions of LD, as discussed. First, individuals were categorized with LD if there was significant discrepancy between ability and achievement, which is the current legal (Federal Register, 1977a, b) gold standard. In order define "significant discrepancy," the magnitude of which is not usually specified, I used the procedure recommended by Reynolds (1984) and others (Frick et al., 1991) to define math and reading disorders separately. Full-scale IQ and achievement scores were initially converted to the *z* scores z_{IQ} and z_A respectively. The expected achievement score for math or reading, z_{EA}, was then estimated by the regression equation $z_{EA} = r_{IQA} \, x \, z_{IQ}$, where r_{IQA} is the correlation between the IQ and achievement tests. Values from the comparison sample were used. Then, the discrepancy score is $z_{EA} - z_A$, and its standard deviation is $(1\text{-}r^2_{IQA})^{1/2}$. I included in the LD group any participant who had a value greater than 1.65 on the standardized discrepancy score: $(Z_{EA} - Z_A)/(1\text{-}r^2_{IQA})^{1/2}$. It is important to note that the percentage of girls with RD and MD will not equal the percentage of girls with LD due to co-occurrence of MD and RD in some girls. At baseline, 12% of the ADHD sample had an LD (15 girls/11% with RD; 8 girls/6% with MD), while at follow-up, 18% of the ADHD sample had an LD (8 girls/10% with RD; 9 girls/11% with MD), using the discrepancy classification. Correspondingly, at baseline, 7% of the non-ADHD (comparison) sample had an LD (5 girls/6% with RD; 6 girls/7% with MD), while at follow-up, 8% of the comparison sample had an LD (7 girls/5% with RD; 3 girls/2% with MD).

Second, regarding low-achievement definitions of LD, I reclassified any remaining participants with a score of 85 or lower on the WIAT Basic Reading or Math Reasoning composites as having an LD, while retaining the regression-based classification for the other participants. This procedure reclassified 17% of the ADHD sample at baseline who had not previously been considered to have LD (9 girls with RD; 22 girls with MD) and 20% of the ADHD sample at follow-up (6 girls with RD; 17 girls with MD). Correspondingly, this procedure reclassified 6% of the comparison sample at baseline who had not been previously considered to have an LD (2 girls with RD; 4 girls with MD) and 16% of the comparison sample at follow-up (7 girls with RD; 23 girls with MD). Together, the combined discrepancy-based and low-achievement definitions resulted in an LD classification for 28% of the ADHD sample at baseline (18% with RD; 22% with MD) and 38% of the ADHD sample at follow-up (17% with RD; 31% with MD). For comparison participants, the corresponding percentages were 13% at baseline (8% with RD; 11% with MD) and 23% at follow-up (11% with RD; 20% with MD). All analyses below reflect the sample of ADHD and comparison participants classified for learning disorders on the basis of the combined selection procedures.

Young Adult Follow-Up Measures

The following measures of academic, social, emotional, and behavioral functioning at the 10-year follow-up were chosen because they reflected the outcomes of interest and because, as often as possible, they included multi-method and multi-information assessment methods.

Measures of Academic Functioning

Family Information Packet (FIP). Primary caregivers of participants completed a detailed questionnaire that assesses academic functioning and interventions or other services that the participant has received since baseline. Relevant data collected included whether the student had failed a grade, repeated a grade, or withdrawn from school, whether there had been a significant drop in grades, and whether there had been any suspensions and/or expulsions. Additionally, the FIP included questions on whether special school-support services had been utilized, including placement in a special day class or special education boarding school, the use of tutoring to supplement regular education, speech or occupational therapy, individual or group mental health counseling at school, and other special services provided at school.

A multi-measure composite to assess secondary school academic functioning ("School Problems") was created from the variables described above. Participants received one point for each of the following: failing a grade, repeating a grade, or withdrawing from school; receiving any suspensions or expulsions during secondary school; or receiving a significant drop in grades during secondary school. Participants received one point for using 1-2 special school-support services and two points for using three or more different school support services, in order to appropriately account for the range of school support services being utilized. Points were summarized in order to create a School Problems variable.

Measures of Emotional and Behavioral Functioning: Internalizing and Externalizing Symptoms

Diagnostic Interview Schedule for Children – 4th edition (DISC-IV; Shaffer, Fisher, Lucas, Dulcan, & Schwab-Stone, 2000; Young Adult version). As previously noted, this well-validated, highly structured diagnostic interview was administered separately to parents and young adults. It provides both categorical diagnoses and symptom counts for the major disorders in the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., *DSM-IV;* American Psychiatric Association, 2000). I utilized both parent and young adult reports in order to obtain data from multiple informants and considered disorders present within the preceding year (rather than lifetime diagnoses, which would be problematic for a longitudinal investigation).

Adult Behavior Checklist and Adult Self Report (ABCL and ASR; Achenbach & Rescorla, 2005). The ABCL is a parent-report form that includes normed scales for adaptive functioning, empirically based syndromes, and DSM-oriented scales, while the ASR is the self-report version of this form. These measures contain broadband factors of Externalizing (Aggressive Behavior and Rule-Breaking Behavior scales) and Internalizing (Withdrawn, Somatic Problems, and Anxious/Depressed Behavior scales). Both scales have excellent internal consistency and test-retest reliability as well as validity. It is important to consider both adult self-report and collateral report when making a diagnosis (Achenbach, 2006; Meyer et al., 2001).

For young adult to be characterized as having an internalizing disorder, she had to meet criteria for one or more of the following disorders on the DISC-IV (generalized anxiety disorder (GAD), obsessive-compulsive disorder (OCD), social phobia, panic disorder, depression, and/or dysthymia) *or* have a score greater than or equal to 65 on the Internalizing factor of the ABCL or ASR. To be diagnosed with an externalizing disorder (other than ADHD), she had to meet criteria for oppositional-defiant disorder (ODD) or conduct disorder (CD) on the DISC-IV, *or* have a score greater than or equal to 65 on the Externalizing factor of the ABCL or ASR (see Rinsky & Hinshaw, 2011).

Measure of Self-Injury

Self-Injury Questionnaire (SIQ). I assessed the variety and frequency of non-suicidal self-injury (NSSI) using a modification of Claes, Vendereycken, and Vertommen's (2001) SIQ. Reliability and validity data for the measure are provided by Vanderlinden and Vendereycken (1997), within samples with eating disorders. On this questionnaire, participants were asked whether in the past year, they had deliberately injured themselves (e.g., scratched or cut their skin with objects, burned themselves, hit themselves hard, pulled hair out) and how often they engaged in these behaviors (1 = only once; 6 = a couple of times a day). I averaged the frequency counts for seven types of NSSI in order to create an NSSI frequency variable.

Measures of Suicide Attempts

Barkley Suicide Questionnaire (Barkley, 2006). This self-report scale contains three questions: "Have you ever considered suicide?"; "Have you ever attempted suicide?"; and "Have you ever been hospitalized for an attempt?" Endorsement of any item was followed up with a frequency question. I analyzed only the dichotomous suicide attempts question.

Family Information Packet (FIP). The FIP also inquired about suicide attempts. There was one case where the FIP reported an attempt but the Barkley scale did not; this individual was added to the count of attempted suicide. The FIP covered the years since participants were last evaluated and contained information from participants and/or their parents.

Measures of Self-Esteem

Rosenberg Self-Esteem Questionnaire (Rosenberg, 1965). Young adults' self-esteem was measured by the Rosenberg Self-Esteem Questionnaire, a 10-item self-report scale with items such as "I feel that I have a number of good qualities" and "I feel that I do not have much to be proud of." The response metric ranged from strongly agree to strongly disagree; higher scores indicate better self-esteem. Internal consistency and test-retest reliability are in accordance with standards in the field; reported Cronbach's alphas range from .77 (Dobson, Goudy, Keith, & Powers, 1979) to .88; one-week test-retest reliability was .82 (Fleming & Courtney, 1984).

Self-Perception Profile for Adolescents – Global Self-Worth Subscale (Harter, 1988). On this scale, participants indicated the extent to which they agreed or disagreed with statements reflecting perceived competence across several domains (scholastic, behavioral/conduct, social athletic, close friends, job, romantic relationships, physical appearance, and self-worth). I utilized the Global Self-Worth subscale. As reported by Harter (1982), internal consistencies of the subscales range from .75-.84, with test-retest reliabilities ranging from .69-.80.

These two measures of self-esteem were z-scored and averaged to form a multi-measure composite of self-esteem.

Measure of Social Functioning

Adult Behavior Checklist and Youth Self-Report: Friends Adaptive Functioning Scale (ABCL; Achenbach & Rescorla, 2005). The *Friends* adaptive functioning scale of the ABCL and ASR, tapping the strength of relationships between the participant and her friends, was utilized as a measure of social functioning. The *z*-scored parent and young adult reports were averaged.

Self-Perception Profile for Adolescents – Social Acceptance Subscale (Harter, 1988). The Social Acceptance subscale of the Self-Perception Profile for Adolescents (described above) was utilized as an additional measure of social functioning. This subscale assesses a young adult's perceived competence in social interaction.

The mean of the ABCL/ASR composite was summed with the *z*-scored Social Acceptance Subscale of the Harter; the average of these formed a multi-method, multi-informant composite measure of social functioning.

Covariates

To determine whether having an LD in addition to ADHD provides greater prediction to young adult criterion measures than having ADHD alone, an LD alone, or neither of these disorders, two key covariates were utilized for Aims1-2. First, I controlled for baseline socioeconomic status (SES), measured as family income, given the association between SES and clinical outcomes (Cadoret & Stewart, 1991). Maternal education was also included as a covariate, given that this measure has been shown to be strongly correlated with children's academic functioning (Rosenzweig & Wolpin, 1994). I did not control for follow-up diagnostic status when predicting outcomes from baseline diagnostic status (and vice versa) due to high collinearity between diagnostic status at baseline and follow-up.

Data Analytic Plan

Data were analyzed using SPSS version 20. In order to better understand the additive impact of LD on ADHD, three analyses were conducted for each aim: (1) analysis of the group with ADHD + LD (spanning MD and RD) as compared to groups with LD only, ADHD only, and neither disorder; (2) analysis of the group with ADHD + RD only as compared to groups with RD only, ADHD only, and neither disorder; and (3) analysis of the group with ADHD + MD only as compared to groups with MD only, ADHD only, and neither disorder.

Aim 1: The first analyses involved parametric group comparisons. I first examined whether girls with ADHD + LD at baseline, as compared to girls with ADHD alone, LD alone and comparison girls, had more significant negative outcomes at 10-year follow-up. I conducted an initial MANOVA analysis across all 7 outcomes for alpha protection (self-esteem, social functioning, internalizing disorders, externalizing disorders, self-injury behavior, suicide attempts, and school problems). For significant MANOVAs, separate two-way ANOVAs (ADHD status x LD/RD/MD status) were then conducted for each functional outcome measured with a continuous variable. Significant interaction effects within the ANOVAs were followed up with simple main effects analyses for each group contrast. I report effect sizes as eta squared for ANOVAs, in order to identify the percent of variance explained by each independent variable. Logistic regression analyses were conducted for categorical outcomes, decomposing significant findings into a series of 2 X 2 chi-square tests for group comparisons. Here, effect sizes were calculated as odds ratios. The same procedures were used to examine whether girls with ADHD + LD at *follow-up,* as compared to girls with ADHD alone, LD alone and girls with neither disorder at follow-up, had more negative concurrent functioning. Because this study involves the first examination of functional outcomes in females with ADHD + LD, alpha was set to .05 for primary analyses. This liberal interpretation was chosen to ensure that new and potentially meaningful findings were not excluded.

Next, I considered performing covariate analyses to ensure that prediction of outcome variables from diagnostic status would withstand control of important covariates (see Rinsky & Hinshaw, 2011). The covariates of maternal education and family income were evaluated to determine whether assumptions were met to conduct (a) analyses of covariance for those variables with significant MANOVAs and ANOVAs and (b) hierarchical logistic regressions for categorical variables with a significant logistic regression. That is, I first examined whether

family income was correlated with both independent and dependent variables. Maternal income did not correlate with any of the dependent variables and was no longer considered for any covariate analyses. Family income correlated with the independent variables of baseline learning disorder and baseline math disorder and only the dependent variable of school problems. Next, for those independent variables correlated with family income, I examined slopes to ensure that the values of the covariate did not vary over the different levels of the independent variables. I discovered that the values of the covariate did not vary over the levels of baseline learning disorder (p = .052) but did vary over the levels of baseline math disorder (p = .047). As a result, covariate analyses were warranted only in the event that baseline learning disorder predicted follow-up school problems.

Aim 2: Next, to examine patterns of persistence and remittance in those girls who were diagnosed with ADHD and/or LD as children, I examined the proportion of participants who were classified as ADHD + LD, ADHD only, LD only, or neither, at baseline and again at the ten-year follow-up. In order to assess whether ADHD was more persistent in those girls who were also diagnosed with LD as children, as compared to those girls with ADHD only, I then conducted chi-square analyses, via 2 (ADHD remitted vs. ADHD persisted at follow-up) X 2 (ADHD +LD vs. ADHD only at baseline) chi-square tests. To assess ADHD status in young adult females whose LD symptoms had persisted into young adulthood versus those whose symptoms had remitted, I conducted chi-square analyses, via 2 (ADHD remitted, ADHD persisted) X 2 (LD remitted, LD persisted) chi-square tests. Effect sizes were calculated as odds ratios. I performed hierarchical logistic regressions for each categorical variable with a significant chi-square test, controlling for maternal education and family income at baseline.

Aim 3: To examine whether remittance versus persistence of ADHD and/or LD symptoms into young adulthood is associated with better outcomes, I utilized t-tests for functional outcomes measured by continuous variables and 2 X 2 chi-square tests for functional categorical outcomes, as these statistical tests can be robust even with small sample sizes. These statistical tests were chosen because the analyses were exploratory and power was limited. Separate tests were conducted for ADHD remitted vs. persisted in those girls diagnosed with ADHD + LD at baseline and for LD remitted vs. persisted in those girls diagnosed with ADHD + LD at baseline.

Results

Aim 1a

Prediction from baseline diagnostic status. Table 1 provides mean raw scores and standard deviations for all outcome measures at follow-up by diagnostic status at baseline; Table 2 shows the results of significance tests for all outcome measures at follow-up by diagnostic status at baseline.

Prediction from baseline ADHD and overall LD (RD or MD) status. The omnibus MANOVA across all 7 dependent variables was highly significant for ADHD status ($F_{7, 171}$ = 3.94, p = .001, Pillai's trace = 0.14), but not for LD status ($F_{7, 171}$ = 1.06, p = .39, Pillai's trace = 0.04) or for the ADHD x LD status interaction ($F_{7, 171}$ = .57, p = .78, Pillai's trace = 0.02). Even though the omnibus MANOVA did not attain significance for the main effect of LD status and the ADHD x LD status interaction, I computed univariate tests for heuristic purposes (especially given the *a priori* hypotheses), as per Huberty and Morris (1989).

Starting with Self-Esteem, the two-way ANOVA revealed non-significant effects for both main effects (baseline ADHD status and LD status) and their interaction (ADHD x LD). For the

Social Functioning variable at follow-up, there was a significant effect of baseline ADHD status (*df:* 1, 207), but no main effect of baseline LD status or baseline ADHD x LD interaction. The baseline ADHD group had significantly worse social functioning at follow-up than the non-ADHD group, with a small to medium effect size.

In terms of psychopathology, the two-way ANOVA indicated that baseline ADHD status had a significant effect on Internalizing disorders at follow-up (*df* = 1, 209); the baseline ADHD group was significantly more likely to have an internalizing disorder at follow-up than the group without ADHD at baseline, with a medium effect size. Neither the main effect of baseline LD status nor the baseline ADHD x LD interaction was significant. Similarly, for the Externalizing variable at follow-up, there was a main effect of baseline ADHD status (*df* = 1, 209), but no main effect of baseline LD status and no significant interaction. Girls with ADHD at baseline were significantly more likely to have an externalizing disorder at follow-up than those girls without ADHD, with a medium effect size.

In terms of behavioral indicators of distress, the two-way ANOVA indicated that baseline ADHD status had a significant effect on the frequency of self-harm behaviors at follow-up (*df* = 1, 193), but that baseline LD status did not. The baseline ADHD group displayed a higher frequency of self-harm behaviors at follow-up as compared to the baseline non-ADHD group, with a small to medium effect size. There was no significant interaction between the effects of baseline ADHD and LD status on the frequency of self-harm behaviors at follow-up. Examination of the Suicide Attempts outcome variable at follow-up revealed a main effect of baseline ADHD status (*df* = 1) but no significant main effect of LD status. Girls with ADHD at baseline were 4.16 times more likely to make a suicide attempt at follow-up than girls without ADHD at baseline. There was no significant interaction between the effects of baseline ADHD status and baseline LD status on follow-up suicide attempts.

Regarding the School Problems variable, the two-way ANOVA revealed a highly significant effect of baseline ADHD status on school functioning at follow-up (*df* = 1, 197), but a non-significant effect of baseline LD status on school functioning at follow-up. The ADHD group displayed a larger number of school problems than the non-ADHD group, with medium effect size. There was no significant interaction between the effects of baseline ADHD and LD status on the number of school problems at follow-up.

Prediction from baseline ADHD and RD status. The omnibus MANOVA across all 7 dependent variables at follow-up was highly significant for ADHD status at baseline ($F_{7, 171}$ = 2.97, p = .006, Pillai's trace = 0.11), but not for RD status at baseline ($F_{7, 171}$ = 1.64, p = .13, Pillai's trace = .06) or for the baseline ADHD x RD status interaction ($F_{7, 171}$ = 1.77, p = .10, Pillai's trace = 0.07). For brevity and clarify, I highlight here only those findings that are discrepant from the overall LD prediction.

For the Social Functioning variable at follow-up, the effect of the interaction between ADHD and RD status at baseline on social functioning at follow-up was significant (*df* = 1, 207). Simple main effects analysis showed a weak trend for girls with reading disorder and ADHD to have somewhat poorer social functioning than girls with ADHD only (p = .10). However, it appeared that the strong main effect of ADHD might have driven this interaction.

Examination of the Suicide Attempts outcome variable at follow-up revealed a significant main effect of RD status (*df* = 1). While the main effect for overall LD prediction was not significant, here the main effect for RD status was clearly significant. Girls who were diagnosed

with RD at baseline were 12.5 times more likely to make a suicide attempt by follow-up than girls who did not have RD at baseline.

Regarding the School Problems variable, the two-way ANOVA revealed a non-significant effect of baseline ADHD status on school functioning at follow-up (*df* = 1, 197); the effect was clearly significant when examining ADHD as a predictor variable in calculations including the overall LD effect.

Prediction from baseline ADHD and MD status. The omnibus MANOVA across all 7 dependent variables was highly significant for baseline ADHD status ($F_{7, 171} = 4.40$, $p = .000$, Pillai's trace = 0.15), but not for baseline MD status ($F_{7, 171} = 0.99$, $p = .44$, Pillai's trace = 0.04). The baseline ADHD x MD status interaction was not significant ($F_{7, 171} = 0.58$, $p = .77$, Pillai's trace = 0.02). Again, I highlight here only those findings that are discrepant from the overall LD prediction.

For the Social Functioning variable at follow-up, there was a significant effect of baseline MD status (*df* = 1, 207). While the main effect for overall LD prediction was not significant, here the main effect for MD status was clearly significant. The baseline MD group had significantly worse social functioning than the baseline non-MD group, with a small effect size.

Aim 1b

Prediction from follow-up diagnostic status. Table 3 provides mean raw scores and standard deviations for all outcome measures at follow-up by concurrent (i.e., follow-up) diagnostic status; Table 4 shows the results of significance tests for all outcome measures at follow-up by follow-up diagnostic status.

Prediction from follow-up ADHD and overall LD (RD or MD) status. The omnibus MANOVA across all 7 dependent variables was highly significant for ADHD status ($F_{7, 172} = 13.42$ $p = .000$, Pillai's trace = 0.35), as well as for LD status ($F_{7, 172} = 3.43$, $p = .002$, Pillai's trace = .12), but not for the ADHD x LD status interaction ($F_{7, 172} = .38$, $p = .91$, Pillai's trace = .02). As before, even though the omnibus MANOVA did not attain significance for the ADHD x LD status interaction, I computed univariate tests for heuristic purposes (especially given the *a priori* hypotheses), as per Huberty and Morris (1989).

Starting with the Self-Esteem outcome variable, the two-way ANOVA revealed a significant effect for follow-up ADHD status (*df* = 1, 206), but no main effect of follow-up LD status and no significant interaction. The follow-up ADHD group had significantly worse self-esteem than the non-ADHD group, with a medium effect size. For the Social Functioning variable at follow-up, there was a significant effect of follow-up LD status (*df* = 1, 208) but a non-significant effect of follow-up ADHD status and a non-significant ADHD x LD status interaction. The follow-up LD group had significantly worse social functioning than the non-LD group, with a small to medium effect size.

In terms of psychopathology, the two-way ANOVA indicated that follow-up ADHD status had a highly significant effect on Internalizing disorders (*df* = 1, 210); the group with ADHD at follow-up was significantly more likely to have an internalizing disorder than the group without ADHD at follow-up, with a large effect size. The main effect of follow-up LD status was also significant (*df* = 1, 210). The group with LD at follow-up was significantly more likely to have an internalizing disorder than the group without LD at follow-up, with a small effect size. The interaction effect of ADHD x LD at follow-up on internalizing disorders was not significant. For the Externalizing variable, there was a main effect only of follow-up ADHD

status (*df* = 1, 210); there was no main effect of follow-up LD status and no significant follow-up ADHD X LD interaction. Examination of the main effect of follow-up ADHD status revealed that girls with ADHD at follow-up were significantly more likely to have an externalizing disorder than those girls without ADHD, with a very large effect size.

As for behavioral indicators of distress, the two-way ANOVA indicated that follow-up ADHD status had a significant effect on the frequency of self-harm behaviors at follow-up (*df* = 1, 194), but follow-up LD status did not. The ADHD group at follow-up displayed a higher frequency of self-harm behaviors than did the non-ADHD group, with a medium to large effect size. There was no significant interaction between the effects of follow-up ADHD and LD status on the frequency of self-harm behaviors at follow-up. The Suicide Attempts outcome variable at follow-up revealed a main effect of follow-up ADHD status (*df* = 1). Girls with ADHD at follow-up were 3.39 times more likely to make a suicide attempt by follow-up than girls without ADHD at follow-up. The main effect of LD status at follow-up was non-significant, as was the ADHD x LD interaction effect on suicide attempts by follow-up.

With regard to the School Problems variable, the two-way ANOVA revealed a significant effect of ADHD status on school functioning (*df* = 1, 197) and a significant effect of LD status on school functioning (*df* = 1, 197). The ADHD group at follow-up displayed a larger number of school problems than the non-ADHD group at follow-up, with medium to large effect size. The LD group at follow-up displayed a larger number of school problems than the non-LD group at follow-up, with a medium effect size. There was no significant interaction between the effects of follow-up ADHD and LD status on the number of school problems at follow-up.

Prediction from follow-up ADHD and RD status. The omnibus MANOVA across all 7 dependent variables was highly significant for ADHD status ($F_{7, 172} = 7.12$, $p = .000$, Pillai's trace = 0.23), as well as for RD status ($F_{7, 172} = 3.30$, $p = .003$, Pillai's trace = 0.12), but not for the ADHD x RD status interaction ($F_{7, 172} = 1.16$, $p = .33$, Pillai's trace = 0.05). I highlight here only those findings that are discrepant from the overall LD prediction at follow-up.

For the Social Functioning variable at follow-up, the main effect of RD status at follow-up was non-significant; the main effect of follow-up LD status had been significant. However, here, the effect of the interaction between ADHD and RD status at follow-up on social functioning at follow-up was significant (*df* = 1, 208). Simple main effects analysis showed that, within the non-ADHD group, girls with reading disorder had poorer social functioning than girls with no reading disorder ($p = .01$). Simple main effects analysis also showed that, within the group without a reading disorder, girls with ADHD had poorer social functioning than those without ADHD ($p = .004$).

In terms of behavioral indicators of distress, the two-way ANOVA indicated that, in contrast to follow-up LD status, follow-up RD status had a significant effect on the frequency of self-harm behaviors at follow-up (*df* = 1, 194). Surprisingly, the non-RD group demonstrated a higher frequency of self-harm behaviors than the RD group at follow-up, with a small effect size. For the Suicide Attempts outcome variable at follow-up, it should be noted that the ADHD x RD status interaction effect on suicide attempts could not be examined in the logistic regression because one of the cell sizes was 0.

With regard to the School Problems variable, the interaction between the effects of follow-up ADHD and RD status on the number of school problems at follow-up was significant (*df* = 1, 197), in addition to the main effects. Simple main effects analysis showed that, within the non-ADHD group, girls with reading disorder had a larger number of school problems than

girls with no reading disorder (p = .000). In addition, within the group without a reading disorder, girls with ADHD had a larger number of school problems than those without ADHD (p = .000).

Prediction from follow-up ADHD and MD status. The omnibus MANOVA across all 7 dependent variables was highly significant for ADHD status ($F_{7, 172}$ = 12.86, p = .000, Pillai's trace = 0.34), non-significant for MD status ($F_{7, 172}$ = 1.93, p = .067, Pillai's trace = 0.07), and non-significant for the ADHD x MD status interaction ($F_{7, 172}$ = 0.75, p = .63, Pillai's trace = 0.03). As before, I highlight here only those findings that are discrepant from the overall LD prediction at follow-up.

The two-way ANOVA indicated that there was no main effect of follow-up MD status on internalizing disorders at follow-up. There had been a significant effect of overall LD prediction on internalizing disorders.

Aim 2

Table 5 provides data on the diagnostic status of participants across time. Overall, from examination of Table 5, it can be seen that both ADHD and LD were likely to remit by young adulthood, whether initially diagnosed individually (e.g., ADHD or LD only) or concurrently (ADHD + LD). The impact of having an LD on ADHD persistence was examined in order to better understand the relationships between these two disorders. Table 6 provides data on the impact of learning disorders at baseline and follow-up on the persistence of ADHD at follow-up. The persistence of ADHD into young adulthood did not differ by LD status at baseline (df = 1). Similarly, the persistence of ADHD at follow-up in those who had ADHD + LD at baseline did not differ by persistence or remittance of the LD at young adulthood (df = 1).

From a qualitative perspective, further analyses of Table 5 reveals the following patterns with respect to persistence/remittance of ADHD, overall LD, and RD/MD separately over time. Under half of those initially diagnosed with ADHD + LD at baseline maintained this status at follow-up (38%). A minority of the girls diagnosed with LD only at baseline maintained their diagnosis by follow-up (20%); one girl maintained the LD diagnosis and gained an additional ADHD diagnosis (10%) by follow-up. Similarly, under half of girls classified as ADHD only at baseline maintained this classification at follow-up (43.5%). Fifteen girls gained an LD diagnosis by follow-up in addition to maintaining an ADHD diagnosis into young adulthood (17.5%).

Under a quarter of those girls initially diagnosed with ADHD + RD at baseline maintained this status at follow-up (21.5%). None of the girls diagnosed with RD only maintained this classification by follow-up; however, one girl maintained the RD diagnosis and gained an additional ADHD diagnosis (16.5%) by follow-up. Only about half of the girls diagnosed as ADHD only at baseline maintained this classification at follow-up (51%). Eight girls obtained an RD diagnosis by follow-up in addition to maintaining an ADHD diagnosis into young adult follow-up (8%).

ADHD + MD appeared to be somewhat more persistent than ADHD + RD; 35.5% of those initially diagnosed with ADHD + MD at baseline maintained this status at follow-up. A minority of the girls diagnosed with MD only at baseline maintained their diagnosis into follow-up (22%); no girls maintained the MD diagnosis and gained an additional ADHD diagnosis. Under half of the girls with ADHD and no MD at baseline retained an ADHD diagnosis at follow-up (44.5%). Fourteen girls obtained an MD diagnosis by young adulthood in addition to maintaining an ADHD diagnosis into young adulthood (14%).

Aim 3

Table 7 provides data on the impact of remediation or persistence of ADHD and/or LD on outcome variables at follow-up, in the group diagnosed with ADHD + LD at baseline.

In terms of the Self-Esteem, there were significant effects for persistence vs. remittance of ADHD (*df* = 121) and MD (*df* = 30) and non-significant effects for persistence vs. remittance of overall LD or of RD. Girls whose ADHD persisted into young adulthood had worse self-esteem than girls whose ADHD remitted, with a small effect size. Surprisingly, girls whose MD persisted into young adulthood had higher self-esteem than girls whose ADHD remitted, but the effect size was quite small. For Social Functioning, there were no significant effects for persistence vs. remittance of ADHD or LD, of RD, or of MD.

Regarding the Internalizing outcome variable, there was a significant effect for persistence vs. remittance by follow-up of ADHD (*df* = 115), but no significant effects of LD, or of RD and MD when considered separately. Girls whose ADHD persisted into young adulthood were more likely to have an internalizing disorder than girls whose ADHD remitted, with a medium effect size. For the Externalizing outcome variable, persistence vs. remittance of ADHD by follow-up was again the only significant effect (*df* = 114); there were no significant effects of LD, or of RD and MD when considered separately. Those girls whose ADHD persisted into young adulthood had a higher rate of externalizing disorders than those girls whose ADHD remitted, with a large effect size.

In terms of Self-Harm, there was a significant effect for persistence vs. remittance by follow-up of ADHD (*df* = 115), with a higher frequency of self-harm behaviors in girls with persistent ADHD as compared to those girls whose ADHD remitted, with a medium effect size. There were no significant effects for persistence vs. remittance by follow-up of LD, or of RD and MD when considered separately. For the Suicide Attempts variable, the likelihood of a suicide attempt by follow-up differed by persistence or remittance of MD by young adulthood (*df* = 1), but not by persistence or remittance of ADHD, LD, or RD. The participants whose MD persisted into young adulthood had a higher rate of suicide attempts than those participants whose MD remitted by follow-up.

Finally, for School Problems, there was a significant effect for persistence vs. remittance of ADHD by follow-up (*df* = 118), but no significant effects of LD, or of RD and MD when considered separately. Those girls whose ADHD persisted into young adulthood had a larger number of school problems than those girls whose ADHD remitted, with a medium effect size.

Discussion

My key goals were to understand the differential and interactive effects of childhood ADHD and LD in females on key academic, behavioral, emotional, and social outcomes in young adulthood and to examine the course, developmental changes, and outcomes associated with persistence versus remittance of these disorders. First, I found that childhood ADHD status was predictive of significant difficulties with regard to important young adult outcomes, including social functioning, internalizing and externalizing disorders, frequency of self-harm behavior and likelihood of suicide attempt, and school problems. Overall, learning disorders in childhood were not predictive of these key outcomes, when examining the multivariate analyses.

However, in exploratory analyses, RD specifically predicted greater likelihood of suicide attempt and MD in particular predicted poorer social functioning at the young adult follow-up, as compared to participants without childhood RD and MD, respectively.

Second, when considering contemporaneous young adult diagnostic status, I found that both ADHD and LD diagnostic status were predictive of key functional outcomes. In particular, young adult ADHD status predicted self-esteem, internalizing and externalizing psychopathology, frequency of self-harm behavior, likelihood of suicide attempt, and difficulties in school functioning. Overall LD status at young adulthood predicted poor social functioning, internalizing psychopathology, and school problems. Young adult RD diagnosis specifically predicted internalizing disorders, frequency of self-harm behavior, and school problems. ADHD and RD diagnoses showed interactive effects for social functioning and school problems; simple main effects analysis revealed that ADHD and RD diagnoses were predictive of poorer outcomes in the absence of the other disorder. An MD diagnosis at young adulthood was predictive of poor social functioning and school problems.

Third, just over 40% of childhood-diagnosed girls lost their ADHD diagnosis by young adulthood, while just under 40% lost their LD diagnosis, 59% lost their RD diagnosis, and 43% lost their MD diagnosis by young adulthood. Most girls diagnosed with ADHD + LD in childhood lost one or both diagnoses by young adulthood. In those girls who had ADHD at baseline, neither presence of LD at baseline or persistence of LD into young adulthood affected the persistence of ADHD into adulthood.

Fourth, in those girls who were diagnosed with both ADHD and LD at baseline, remission versus persistence of ADHD from childhood to young adulthood was associated with improvements in self-esteem and reduction of internalizing and externalizing psychopathology, frequency of self-harm behavior, and school problems. In those girls whose MD remitted, as compared to those girls who still qualified for an ADHD + MD diagnosis at young adulthood, there was a reduced likelihood of suicide attempts.

The results are consistent with previous research indicating that childhood ADHD status confers significant risk for negative outcomes in adolescence and young adulthood (Biederman et al., 2012; Hinshaw et al., 2006; Hinshaw et al, 2012) and indicate that ADHD symptoms are more strongly linked to negative academic, emotional, and behavioral outcomes than are learning disorders. However, the findings indicate that particular learning disorders may confer risk for *specific* negative outcomes: childhood RD predicted likelihood of suicide attempt at young adulthood, while childhood MD predicted social functioning at the young adult follow-up. These results support emerging evidence that reading difficulties confer risk for suicidal ideation and behavior (Daniel et al., 2006) and that this risk may be particularly significant in females (Wilson et al., 1999). In addition, the results add to the literature on this topic by (1) providing prospective (rather than cross-sectional) data, (2) focusing on females, (3) extending outcome data into young adulthood, (4) indicating that different kinds of learning disorders have specific implications for outcomes in young adulthood, and (5) providing the first evidence, to my knowledge, of young adult outcomes in children diagnosed with mathematical disorder. It is worth noting that neither childhood RD or MD conferred significant risk for adverse academic outcomes at young adulthood; this could be the result of loss of LD diagnosis and/or educational intervention for significant numbers of girls diagnosed at childhood.

Evidence to date has been equivocal with respect to whether having an LD diagnosis confers significant additional risk for negative outcomes in children with ADHD. In the present study, there was no evidence of additional risk for negative young adult outcomes conferred by

having an LD diagnosis concomitant with ADHD in childhood. The results differ from those of Willcutt and colleagues (2007), who found that children with both ADHD and RD were more impaired on measures of social and academic functioning at the five-year follow-up than children who had either disorder in isolation. The present sample was entirely female, generally older, and of more homogenous age than the Willcutt et al. sample, which may account for the negative findings in this study with respect to social and academic impairment in the ADHD + RD group compared to the ADHD only group.

The present results indicate that ADHD is the primary predictor of negative outcomes in young adulthood in those girls diagnosed with co-occurring childhood ADHD and LD and suggest that the impairments associated with ADHD may have the more potent influence on the developmental trajectory**.** Negative adolescent and adult outcomes have been linked to symptom profiles in children with ADHD (Biederman et al., 1999; Hinshaw, Owens, Sami, & Fargeon, 2006; Hinshaw et al., 2012), as well as to underlying executive function (EF) deficits such as planning, working memory, and inhibition that make independent contributions to outcomes (Rinsky & Hinshaw, 2011; Miller, Nevado-Montenegro, & Hinshaw, 2012). There is evidence that some children with learning disorders may have auxiliary executive functioning and other neuropsychological deficits, in addition to basic disruptions in processes underlying specific kinds of learning, such as reading or math (de Jong et al., 2009; McGrath et al., 2010; Willcutt et al., 2010b). In those children with both ADHD and RD/MD, inattention and slow processing speed are thought to underlie patterns of comorbidity in both disorders and confer increased risk for other forms of psychopathology (Maughan, Rowe, Loeber, & Stouthamer-Loeber, 2003; Sundheim & Voeller, 2004; Willcutt et al., 2000a; Willcutt et al., 2010b). However, since the inattention symptoms and neuropsychological deficits strongly linked to negative outcomes are core features of ADHD (Miller, Gelfand, & Hinshaw, 2010; Sundheim & Voeller, 2004; Willcutt et al., 2010b), it may be that the addition of a learning disorder does not contribute significant additional risk for academic, social, emotional, and behavioral outcomes. Future research should examine the predictive utility of measures of attention and executive functioning for outcomes in children with learning disorders; it should also examine the associations between severity of symptoms and outcomes.

Current findings indicate that ADHD and learning disorders may have distinct impacts at different stages of development. Whereas ADHD alone appeared to have strong implications for academic, emotional, behavior, and social outcomes in young adulthood when predicting from childhood diagnostic status, both ADHD and LD diagnostic status during young adulthood had significant associations with respect to concurrent functional outcomes. It is possible that the risk conferred by having an LD increases as a child ages, as the impact on development may be more significant the longer that a disorder persists. Persistent executive functioning deficits, as well as the stressors directly associated with having a reading disorder (e.g., Maughan & Carroll, 2006), such as low academic achievement, low self-esteem, and poor motivation as a result of past failure, may underlie such risk. Future studies on the relative impact of ADHD and LD on outcomes at different stages of development, both cross-sectionally and longitudinally, will be needed to further explore this hypothesis.

Although ADHD diagnosis at young adulthood had broad predictive effects, parallel effects of learning disorders were more circumscribed. Young adult RD specifically predicted internalizing disorder, frequency of self-harm behavior, and school problems. RD diagnosis was additionally predictive of poor social functioning in the absence of ADHD. MD diagnosis at young adulthood predicted poor social functioning and school problems. The results are

consistent with research indicating that the presence of externalizing disorders in the ADHD + LD population is largely accounted for by ADHD symptoms (Maughan & Carroll, 2006; Willcutt et al., 2000a), while internalizing disorders and symptoms (including self-harm behavior) and academic problems may be directly impacted by the stressors and possible underlying language/communication difficulties associated with reading disorders (Arnold et al., 2005; Goldston et al., 2007; Maughan & Carroll, 2006; Sundheim & Voeller, 2004). Previous research has been largely male-referenced and focused on a child/adolescent population, since ADHD and LD are often considered to be disorders of childhood. The present research indicates that the disorders can cause disruptive effects even past high school age, provides the first results regarding functional implications of MD in young adulthood, and provides specific results for females. Future research should examine the specific predictors that lead to negative outcomes at particular developmental stages.

Girls with ADHD + LD did not present with significantly worse functional outcomes as compared to girls with ADHD only at young adulthood, suggesting that ADHD largely accounted for poor functional outcomes in those girls who had both disorders. The results parallel those obtained when predicting from diagnostic status in childhood. The findings indicate that the ADHD and ADHD + LD groups at young adulthood have similar risk for negative outcomes and that ADHD symptoms and associated executive functioning difficulties may be the most critical targets for intervention. The present results support those of McGillivray and colleagues (2009), who also failed to find differences in levels of psychopathology between adults with ADHD + LD and adults with ADHD only, extending findings to a female population.

It will be crucial to clarify whether and when having an LD in addition to ADHD leads to negative outcomes over and above those associated with ADHD in isolation. In a recent 4-year follow-up study of boys aged 6-17 at baseline with ADHD and LD, Faraone and colleagues (2001) found increased academic difficulties at follow-up in those boys with ADHD + LD as compared to ADHD alone. Willcutt and colleagues (2007) found evidence in their 5-year follow-up study of children aged 8-18 that those children initially diagnosed with ADHD + RD had more significant social and academic difficulties as compared to those with either disorder alone. In future studies, in order to clarify similarities and differences between the present findings and those of Willcutt et al and Faraone et al, the impact of LD and ADHD symptom on negative outcomes should be examined (1) at specific points in development with clearly circumscribed age ranges, (2) for specific genders, (3) for specific types of learning disorders (e.g., RD vs. MD), and (4) for particular levels of severity. It would also be helpful consider the impact of specific separate and overlapping symptoms of ADHD and LD on particular functional outcomes, both cross-sectionally and longitudinally.

Findings revealed that both ADHD and MD were reasonably persistent over time, with over half of participants diagnosed with either disorder in childhood retaining the diagnosis into young adulthood. A key question with respect to ADHD is whether developmentally-adjusted adult criteria for the disorder would allow for truer rates of persistence of this condition (see Barkley et al., 2008). These results are in agreement with studies in males indicating that ADHD diagnoses are stable over time and likely to persist into adulthood (Biederman et al., 2006; Biederman et al., 2012; Klein et al., 2012) and provide the first known data on the stability of MD into young adulthood. In contrast to the high stability of MD in the current sample, over half of participants lost their childhood RD diagnosis at the young adult follow-up. While epidemiological data on the persistence of RD into young adulthood are generally lacking and complex to obtain (Gerber, 2012), it is likely that persistence is affected by level of severity at

initial diagnosis, as well as factors such as access to screening and appropriate educational support. In addition, the significantly greater public recognition of RD as compared to MD, research on effective treatments, and screening and services available to children with RD, may lead to increased remittance for children diagnosed with RD as compared to those with MD.

The persistence of ADHD in this female sample did not appear to be dependent on the presence of LD at baseline or the persistence of LD at young adulthood. The results indicate that LD does not influence the developmental course of ADHD in the all-female sample under investigation in this dissertation. These results are in agreement with those of Willcutt et al. (2007), who found that the longitudinal stability of ADHD was not significantly different in probands with and without RD in a five-year follow-up study of children who were 8-18 at baseline. However, it is possible that the longitudinal stability of ADHD may influence the course of RD (Willcutt et al., 2007), particularly given evidence that specific genetic influences may give rise to pathophysiologic pathways that confer risk for both disorders (Friedman et al., 2003; Gayán et al., 2005; Willcutt et al., 2007; Willcutt et al., 2010b). Future studies with larger samples of RD children should investigate the impact of change and/or improvement in ADHD symptomotology on the course of both RD and MD as a child ages.

Finally, the results of the current study indicate that, in the ADHD + LD group, remission of ADHD had a significant impact on several key functional outcomes across emotional, behavioral, and academic domains. Remission of MD led to decreased likelihood of suicide attempt only, whereas remission of RD did not appear to have an impact on functional outcomes. The results suggest that negative functional outcomes in young adulthood may be prevented or reduced by treating childhood ADHD symptoms. Given that childhood ADHD had a more significant impact on young adult functional outcomes than childhood LD, it follows that improvement in ADHD symptoms is likely to have a greater impact on the developmental trajectory of functional outcomes as compared to improvement in LD symptoms. The results are consistent with other research demonstrating that young adults whose ADHD remitted or partially remitted demonstrated improvements in psychopathology but not social functioning as compared to those whose ADHD persisted into adulthood (Young & Gudjonsson, 2008). It will be important to clarify the relative impact of severity of childhood symptoms, as well as subsequent improvement in both inattention and hyperactivity/impulsivity dimensions of ADHD on young adult outcomes. As well, it will be critical to assess the level of symptom reduction required in order to obtain measurable improvements in functional outcomes.

This study has several limitations. First, the data were gathered from a clinical sample and thus findings may not generalize to other populations. Furthermore, the sample size for the ADHD + LD and LD only groups was relatively small, limiting the statistical power for examining the differences between groups and the impact of persistence versus remittance of ADHD and LD on functional outcomes. It is also important to note that the design lacked balanced groups and random assignment to group, potentially limiting power to detect significant findings. However, (1) significant findings were interpretable, and (2) the groups do reflect the proportion of learning disorders likely to be found in a clinically-ascertained ADHD group of girls and a matched control sample, reflective of the socioeconomic and ethnic diversity of the San Francisco Bay Area. I note that the effects of baseline LD on young adult outcomes should be considered exploratory and interpreted with caution, given that the overall multivariate analysis of the overall impact of LD on functional outcomes was not significant. Another limitation of this study is that treatment effects were not taken into account when examining the longitudinal effects of childhood ADHD and LD; it is possible that (1) those girls with more

severe ADHD and/or LD were more likely to receive treatment and (2) that those girls who received intervention had more successful outcomes, which could interfere with predictive validity of childhood diagnostic status. Next, participants were not assessed for writing disorders, meaning that that girls with writing disorders, but not disorders relating to reading or mathematics, could have been incorrectly identified as ADHD only. Finally, the results in this study cannot be generalized to males with ADHD and/or LD.

Overall, the results indicate that ADHD symptoms have the most significant implications for a variety of negative social, emotional, behavior, and academic functional outcomes, with childhood learning disorders revealing more limited predictive power with respect to young adult outcomes. Girls with ADHD + RD and ADHD + MD at baseline demonstrated similar functioning in young adulthood to those girls with ADHD alone at baseline. At follow-up, young adult ADHD status again predicted a wide range of negative functional outcomes. RD status specifically predicted internalizing disorders, frequency of self-harm behavior, and school problems, as well as social functioning in the absence of ADHD. MD diagnosis at young adulthood was predictive of poor social functioning and school problems. Most girls with ADHD and a concurrent learning disorder lost one or both diagnoses by young adulthood, and the course of ADHD did not appear to be affected by the presence of an LD at baseline or persistence vs. remittance of an LD into adulthood. Remittance of symptoms from childhood to young adulthood did appear to impact functional outcomes, suggesting that targeting ADHD symptoms early is critical for improving social, emotional, behavioral, and academic functioning later in life. Remittance of ADHD by young adult follow-up was associated with improvements in self-esteem, rates of psychopathology, frequency of self-harm behavior, and school problems. With remittance of MD by young adulthood, there was a reduction in suicide attempts.

More research is needed regarding risk factors for negative functional outcomes in both males and females with ADHD and LD. Future research should evaluate potential mechanisms underlying change in symptoms and mediators that predict outcomes for both learning disorders and ADHD at clearly specified developmental periods. Future studies should also utilize larger sample sizes, ascertained through both clinical and community samples. Underlying language disorders, executive functioning, self-esteem, and social support are proposed mediators of the impact of ADHD and LD on functional outcomes; future studies should clarify the mediators that are shared by ADHD and LD as well as those that are unique to each disorder. Future research should also examine the risks associated with ADHD + LD, as compared to each disorder in isolation, and assess mechanisms responsible for changes in diagnosis and functioning from childhood through adolescence. Finally, future studies should include examination of the effects of writing disorders on outcomes, both concurrently and longitudinally.

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Table 1

Mean Raw Scores and Standard Deviations for W3 Outcome Measures by W1 Diagnostic Status

LD - Learning Disorder (Reading Disorder or Math Disorder)

	No ADHD or LD		LD only		ADHD only		ADHD + LD	
Dependent variable (DV)	*N*	M (SD)	*N*	M (SD)	*N*	M (SD)	*N*	M *(SD)*
Self-Esteem	75	.20 (.91)	10	.04 (.77)	88	-.17 (1.06)	36	-.03(.82)
Social Functioning	75	.30 (.71)	10	-.03 (1.22)	89	-.13 (.75)	37	-.35 (.83)
Internalizing	76	.16 (.37)	10	.30 (.48)	90	.51 (.50)	37	.51 (.51)
Externalizing	76	.13 (.34)	10	.20 (.42)	90	.54 (.50)	37	.51 (.51)
Self-Harm	69	.71 (1.59)	10	1.20 (1.99)	83	2.65 (4.71)	35	3.51 (5.19)
Suicide Attempts (%)	74	4.1%	10	20.0%	87	14.9%	36	28.6%
School Problems	70	.83 (1.15)	8	1.13 (1.46)	89	2.0 (1.45)	34	2.26 (1.44)

RD – Reading Disorder

	No ADHD or RD		RD only		ADHD only		ADHD + RD	
Dependent variable (DV)	*N*	M (SD)	*N*	M (SD)	*N*	M (SD)	*N*	*M (SD)*
Self-Esteem	79	.18 (.90)	6	.14 (.88)	101	-.13 (1.03)	23	-.15 (.82)
Social Functioning	79	.22 (.79)	6	.74 (.34)	103	-.14 (.76)	23	-.44 (.84)
Internalizing	80	.16 (.37)	6	.33 (.52)	104	.52 (.50)	23	.48 (.51)
Externalizing	80	.14 (.35)	6	.17 (.41)	104	.56 (.50)	23	.43 (.51)
Self-Harm	73	.67 (1.56)	6	2.00 (2.28)	96	2.59 (4.52)	22	4.27 (6.02)
Suicide Attempts (%)	78	3.8%	6	33.3%	101	14.9%	22	27.3%
School Problems	74	.80 (1.13)	4	2.00 (1.63)	100	2.07 (1.45)	23	2.09 (1.44)

MD – Math Disorder

	No ADHD or MD		MD only		ADHD only		ADHD + MD	
Dependent variable (DV)	*N*	M (SD)	*N*	M (SD)	*N*	M (SD)	*N*	*M (SD)*
Self-Esteem	76	.18 (.93)	9	.20 (.63)	97	-.17 (1.03)	27	.02 (.82)
Social Functioning	76	.30 (.70)	9	- .06 (1.29)	98	-.12 (.76)	28	-.46 (.78)
Internalizing	77	.17 (.38)	9	.22 (.44)	99	.52 (.50)	28	.50 (.51)
Externalizing	77	.14 (.35)	9	.11 (.33)	99	.55 (.50)	28	.50 (.51)
Self-Harm	70	.77 (1.66)	9	.78 (1.56)	92	2.73 (4.79)	26	3.54 (5.09)
Suicide Attempts (%)	75	5.3%	9	11.1%	96	16.7%	27	18.5%
School Problems	71	.87 (1.21)	7	.71 (.95)	98	2.01 (1.45)	25	2.32 (1.41)

Table 2

Significance Tests for W3 Outcome Measures by W1 Diagnostic Status

	ADHD Status			LD status			Interaction		
	F value or *Wald* X^2	p^a	ES[b]	*F* value or *Wald X*	p^a	ES[b]	*F* value or *Wald* X^2	p^a	ES[b]
Self-Esteem	1.40	.24	.01	.001	.97	.000	.65	.42	.003
Social Functioning	6.14	.01	.03	3.33	.07	.02	.15	.70	.001
Internalizing	10.10	.002	.05	.66	.42	.003	.61	.43	.003
Externalizing	17.42	.000	.08	.05	.83	.000	.33	.57	.001
Freq. of Self-Harm	7.66	.006	.04	.78	.38	.004	.06	.81	.000
Suicide Attempts	4.64	.03	4.16	3.25	.07	5.92	1.36	.24	.28
School Problems	16.27	.000	.08	.96	.33	.004	.003	.96	.000

	ADHD Status			RD status			Interaction		
	F value or *Wald* X^2	p^a	ES[b]	*F* value or *Wald X*	p^a	ES[b]	*F* value or *Wald* X^2	p^a	ES[b]
Self-Esteem	1.69	.20	.007	.02	.89	.000	.002	.97	.003
Social Functioning	17.14	.000	.07	.33	.57	.001	4.72	.03	.02
Internalizing	5.16	.02	.05	.35	.56	.003	.92	.34	.003
Externalizing	10.24	.002	.05	.19	.66	.001	.50	.48	.002
Freq. of Self-Harm	4.96	.03	.02	2.55	.11	.01	.04	.85	.000
Suicide Attempts	5.10	.02	4.36	5.82	.02	12.5	2.21	.14	.17
School Problems	3.23	.07	.02	2.60	.11	.01	2.45	.12	.01

	ADHD Status			MD status			Interaction		
	F value or *Wald* X^2	p^a	ES[b]	*F* value or *Wald X*	p^a	ES[b]	*F* value or *Wald* X^2	p^a	ES[b]
Self-Esteem	1.76	.19	.009	.29	.59	.001	.20	.66	.001
Social Functioning	6.58	.01	.03	4.71	.03	.02	.006	.94	.000
Internalizing	10.87	.001	.05	.04	.84	.000	.13	.72	.001
Externalizing	18.41	.000	.08	.18	.68	.001	.006	.94	.000
Freq. of Self-Harm	8.34	.004	.04	.25	.62	.001	.24	.62	.001
Suicide Attempts	4.73	.03	3.55	.46	.50	2.22	.26	.61	.51
School Problems	19.89	.000	.09	.06	.81	.000	.58	.45	.003

Note. ADHD status = whether or not ADHD diagnosed at baseline; LD status = whether or not a learning disorder (reading disorder or math disorder) was diagnosed at baseline; RD status = whether or not a reading disorder was diagnosed at baseline; MD status = whether or not a math disorder was diagnosed at baseline; N/A = not applicable (i.e., no ANCOVA because of lack of significance of ANOVA).

[a] Significance: Two-way ANOVA for continuous variables; logistic regression for categorical variables.

[b] Effect sizes: Eta squared (η^2) for ANOVA and odds ratio for dichotomous variables.

Table 3

Mean Raw Scores and Standard Deviations for W3 Outcome Measures by W3 Diagnostic Status

LD - Learning Disorder (Reading Disorder or Math Disorder)

	No ADHD or LD		LD only		ADHD only		ADHD + LD	
Dependent variable (DV)	*N*	M (SD)	*N*	M (SD)	*N*	M (SD)	*N*	M *(SD)*
Self-Esteem	98	.29 (.84)	30	.10 (.85)	51	-.46 (1.05)	31	-.32(.93)
Social Functioning	98	.21 (.76)	30	-.26 (.77)	52	-.09 (.83)	32	-.32 (.77)
Internalizing	99	.19 (.40)	30	.30 (.47)	53	.55 (.50)	32	.75 (.44)
Externalizing	99	.12 (.33)	30	.27 (.45)	53	.70 (.46)	32	.75 (.44)
Self-Harm	90	1.14 (2.68)	27	.52 (1.42)	49	3.71 (6.05)	32	3.63 (3.84)
Suicide Attempts (%)	96	8.3%	29	3.4%	51	23.5%	32	18.8%
School Problems	92	.93 (1.11)	28	1.79 (1.45)	51	2.10 (1.59)	30	2.60 (1.33)

RD – Reading Disorder

	No ADHD or RD		RD only		ADHD only		ADHD + RD	
Dependent variable (DV)	*N*	M (SD)	*N*	M (SD)	*N*	M (SD)	*N*	*M (SD)*
Self-Esteem	114	.27 (.84)	14	.03 (.92)	69	-.41 (1.00)	13	-.35 (1.08)
Social Functioning	114	.16 (.79)	14	-.42 (.50)	70	-.19 (.83)	14	-.12 (.72)
Internalizing	115	.18 (.39)	14	.50 (.52)	71	.59 (.50)	14	.79 (.43)
Externalizing	115	.14 (.35)	14	.29 (.47)	71	.70 (.46)	14	.79 (.43)
Self-Harm	104	1.11 (2.58)	13	.15 (.55)	67	4.06 (5.63)	14	1.86 (2.28)
Suicide Attempts (%)	112	8.0%	13	0%	69	21.7%	14	21.4%
School Problems	106	.97 (1.14)	14	2.36 (1.34)	68	2.24 (1.56)	13	2.54 (1.27)

MD – Math Disorder

	No ADHD or LD		LD only		ADHD only		ADHD + LD	
Dependent variable (DV)	*N*	M (SD)	*N*	M (SD)	*N*	M (SD)	*N*	*M (SD)*
Self-Esteem	102	.26 (.85)	26	.20 (.85)	57	-.44 (1.05)	25	-.31 (.90)
Social Functioning	102	.17 (.78)	26	-.18 (.78)	58	-.11 (.83)	26	-.33 (.78)
Internalizing	103	.21 (.41)	26	.23 (.43)	59	.56 (.50)	26	.77 (.43)
Externalizing	103	.14 (.34)	26	.23 (.43)	59	.71 (.46)	26	.73 (.45)
Self-Harm	94	1.10 (2.63)	23	.61 (1.53)	55	3.45 (5.79)	26	4.15 (4.00)
Suicide Attempts (%)	100	8.0%	25	4.0%	57	24.6%	26	15.4%
School Problems	96	1.01 (1.15)	24	1.63 (1.50)	57	2.19 (1.57)	24	2.50 (1.35)

Table 4

Significance Tests for W3 Outcome Measures by W3 Diagnostic Status

	ADHD Status			LD status			Interaction		
	F value or *Wald* X^2	p^a	ES[b]	*F* value or *Wald X*	p^a	ES[b]	*F* value or *Wald* X^2	p^a	ES[b]
Self-Esteem	17.11	.000	.08	.03	.86	.000	1.34	.25	.006
Social Functioning	2.28	.13	.01	8.51	.004	.04	.91	.34	.004
Internalizing	35.69	.000	.14	5.32	.02	.02	.49	.48	.002
Externalizing	75.14	.000	.26	2.60	.11	.009	.59	.45	.002
Freq. of Self-Harm	21.56	.000	.10	.34	.56	.002	.19	.66	.001
Suicide Attempts	6.06	.01	3.39	.75	.39	.39	.28	.60	1.91
School Problems	22.37	.000	.10	10.47	.001	.05	.70	.41	.003

	ADHD Status			RD status			Interaction		
	F value or *Wald* X^2	p^a	ES[b]	*F* value or *Wald X*	p^a	ES[b]	*F* value or *Wald* X^2	p^a	ES[b]
Self-Esteem	7.94	.005	.04	.25	.62	.001	.66	.42	.003
Social Functioning	.027	.87	.000	2.55	.11	.01	4.11	.04	.02
Internalizing	15.23	.000	.07	8.26	.004	.04	.48	.49	.002
Externalizing	42.58	.000	.17	1.95	.16	.008	.16	.69	.001
Freq. of Self-Harm	8.55	.004	.04	3.92	.05	.02	.62	.43	.003
Suicide Attempts	8.73	.003	3.66	.34	.56	.68	**	**	**
School Problems	6.98	.009	.03	9.53	.002	.04	3.92	.05	.02

	ADHD Status			MD status			Interaction		
	F value or *Wald* X^2	p^a	ES[b]	*F* value or *Wald X*	p^a	ES[b]	*F* value or *Wald* X^2	p^a	ES[b]
Self-Esteem	16.64	.000	.07	.07	.79	.000	.41	.52	.002
Social Functioning	2.89	.09	.01	5.04	.03	.02	.23	.63	.001
Internalizing	38.59	.000	.15	2.55	.11	.01	1.83	.18	.007
Externalizing	69.17	.000	.25	.77	.38	.003	.35	.56	.001
Freq. of Self-Harm	21.05	.000	.10	.03	.87	.000	.85	.36	.004
Suicide Attempts	7.56	.006	3.74	.46	.50	.48	.02	.90	1.17
School Problems	20.96	.000	.09	4.21	.04	.02	.47	.50	.002

Note. ADHD status = whether or not ADHD diagnosed at baseline; LD status = whether or not a learning disorder (reading disorder or math disorder) was diagnosed at baseline; RD status = whether or not a reading disorder was diagnosed at baseline; MD status = whether or not a math disorder was diagnosed at baseline; N/A = not applicable (i.e., no ANCOVA because of lack of significance of ANOVA).

[a] Significance: Two-way ANOVA for continuous variables; logistic regression for categorical variables.

[b] Effect sizes: (partial) eta squared (η^2) for ANOVA and odds ratio for dichotomous variables.

** The interaction could not be examined in the logistic regression because one of the cell sizes was 0.

Table 5

Attention-Deficit/Hyperactivity Disorder and Learning Disorder Status at Follow-Up Compared to Baseline Assessment Point

	Wave 1 Diagnosis							
	No ADHD/LD (*N* = 76)		LD, no ADHD (*N* = 10)		ADHD, no LD (*N* = 90)		ADHD + LD (*N* = 37)	
	n	%[a]	*n*	%[a]	*n*	%[a]	*n*	%[a]
Wave 3 Diagnosis								
No ADHD/LD	62	81.5	6	60	26	29	5	13.5
LD, no ADHD	5	6.5	2	20	10	11	13	35
ADHD, no LD	8	10.5	1	10	39	43.5	5	13.5
ADHD + LD	1	1.5	1	10	15	17.5	14	38

	Wave 1 Diagnosis							
	No ADHD/RD (*N* = 80)		RD, no ADHD (*N* = 6)		ADHD, no RD (*N* = 104)		ADHD + RD (*N* = 23)	
	n	%[a]	*n*	%[a]	*n*	%[a]	*n*	%[a]
Wave 3 Diagnosis								
No ADHD/RD	70	87.5	4	67	36	34.5	5	21.5
RD, no ADHD	1	1	0	0	7	6.5	6	26
ADHD, no RD	9	11.5	1	16.5	53	51	7	31
ADHD + RD	0	0	1	16.5	8	8	5	21.5

	Wave 1 Diagnosis							
	No ADHD/MD (*N* = 77)		MD, no ADHD (*N* = 9)		ADHD, no MD (*N* = 99)		ADHD + MD (*N* = 28)	
	n	%[a]	*n*	%[a]	*n*	%[a]	*n*	%[a]
Wave 3 Diagnosis								
No ADHD/MD	63	82	6	67	30	30.5	4	14.5
MD, no ADHD	4	5	2	22	11	11	9	32
ADHD, no MD	9	11.5	1	11	44	44.5	5	18
ADHD + MD	1	1.5	0	0	14	14	10	35.5

Note. ADHD = attention-deficit/hyperactivity disorder. LD = learning disorder (reading or math). RD = reading disorder. MD = math disorder.

[a] Percentages are of diagnostic group at Wave 1.

Table 6

Impact of Baseline LD and LD Persistence at Follow-Up on ADHD Persistence Into Follow-Up

	X^2	*p*	ES[a]
Baseline LD	.80	.37	.70
LD Persistence	.01	.92	1.08

Note: LD = Learning Disorder (Reading or Math Disorder); ADHD = Attention-Deficit/Hyperactivity Disorder

[a] Effect sizes: Odds ratio for dichotomous variables.

Table 7

Significance Tests for Persisters Versus Remitters for Each Outcome Variable

	ADHD			Learning Disorder			Mathematical Disorder			Reading Disorder		
	t or X^2	*p*	ES[a]	*t* or X^2	*p*	ES[a]	*t* or X^2	*p*	ES[a]	*t* or X^2	*p*	ES[a]
Outcome Variables												
Self-Esteem	-3.26	.001	.20	.69	.49	.21	2.36	.03	.08	-.61	.55	.24
Social Functioning	- .97	.33	.17	-.70	.49	.22	.18	.86	.06	-1.73	.09	.64
Internalizing	3.28	.001	.60	.57	.57	.18	- .71	.49	.24	1.21	.24	.46
Externalizing	6.68	.000	1.21	.97	.34	.30	1.00	.32	.34	.33	.74	.14
Freq. of Self-Harm	3.06	.003	.55	-1.11	.28	.37	-.68	.51	.24	-1.96	.06	.69
Suicide Attempts	2.36	.12	2.19	2.91	.09	.29	4.41	.04	.12	.02	.90	.90
School Problems	2.83	.005	.51	1.66	.11	.55	.37	.72	.13	1.11	.28	.43

Note. T-tests between persisters and remitters for each disorder were conducted for continuous outcome variables, whereas chi square tests were conducted for dichotomous variables.

[a] Effect sizes: Cohen's *d* for continuous variables and odds ratio for dichotomous variables.