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Learning Disorder Confers Setting-Specific Treatment Resistance for Children with ADHD, Predominantly Inattentive Presentation

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Abstract

Objective: Attention-Deficit/Hyperactivity Disorder-Predominantly Inattentive Presentation (ADHD-I) and Specific Learning Disorder (SLD) are commonly co-occurring conditions. Despite the considerable diagnostic overlap, the effect of SLD comorbidity on outcomes of behavioral interventions for ADHD-I remains critically understudied.

Method: The current study examines the effect of reading or math SLD comorbidity in 35 children with comorbid ADHD-I+SLD and 39 children with ADHD-I only following a behavioral treatment integrated across home and school (Child Life and Attention Skills [CLAS]). Pre- and post- treatment outcome measures included teacher-rated inattention, organizational deficits, and study skills; and parent-rated inattention, organizational deficits, and homework problems.

Results: A similar pattern emerged across all teacher-rated measures: children with ADHD-I and comorbid ADHD-I+SLD did not differ significantly at baseline, but between-group differences were evident following the CLAS intervention. Specifically, children with ADHD-I and comorbid ADHD-I+SLD improved on teacher-rated measures following the CLAS intervention, but children with ADHD-I only experienced greater improvement relative to those with a comorbid SLD. No significant interactions were observed on parent-rated measures—all children improved following the CLAS intervention on parent-rated measures, regardless of SLD Status.

Conclusions: The current results reveal that children with ADHD-I+SLD comorbidity benefit significantly from multimodal behavioral interventions, although improvements in the school setting are attenuated significantly. A treatment-resistant fraction of inattention was identified only in the SLD group, implying that this fraction is related to SLD and becomes apparent only when behavioral intervention for ADHD is administered.

Attention-Deficit/Hyperactivity Disorder (ADHD) and Specific Learning Disorders (SLDs) are two of the most prevalent disorders in childhood, affecting approximately 7% and 9% of children worldwide, respectively (Altarac & Saroha, 2007; Thomas, Sanders, Doust, Beller, & Glasziou, 2015). ADHD and SLD are also commonly co-occurring—children with

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ADHD are almost five times more likely to be diagnosed with an SLD relative to their typically developing peers (DuPaul, Gormley, & Laracy, 2013), and recent estimates suggest that approximately 45% of children with ADHD meet criteria for an SLD (DuPaul et al., 2013).

Comorbidity of any two disorders may be worse than the sum of its parts. For example, children with ADHD and Conduct Disorder, compared to children with only one of these disorders, have been found to have an earlier age of symptom onset, greater persistence of problem behaviors, worse academic problems, and increased severity of ADHD and conduct symptoms (Loeber & Keenan, 1994). An additive effect may explain some findings, but simple addition cannot explain the synergistic effect that comorbid ADHD has on the severity of Conduct Disorder symptomatology, and *vice versa*. In a related vein, both inattention and learning difficulties are often more severe for children with ADHD and SLD than for children diagnosed with only one disorder (McNamara, Willoughby, Chalmers, & YLC-CURA, 2005; Purvis & Tannock, 2000; Wei, Yu, & Shaver, 2014). Comorbid ADHD/SLD is also associated with greater educational, neurocognitive, and social impairments relative to children with only ADHD, including more severe executive functioning deficits, higher rates of grade-retention, increased likelihood of placement in special education classes, greater use of in-school tutoring services, and poorer social skills (Bental & Tirosh, 2007; Seidman, Biederman, Monuteaux, Doyle, & Faraone, 2001; Wei et al., 2014; Willcutt et al., 2010, 2007; Willcutt, Pennington, Olson, Chhabildas, & Hulslander, 2005). The greater symptom load associated with comorbidity is difficult to explain solely on the basis of additive effects of ADHD and SLD.

The question thus arises: if having an accompanying condition such as SLD confers more impairment than ADHD alone, will ADHD interventions prove less effective for children with ADHD/SLD comorbidity as a result of the inattentive sequela related to SLD? This question must be framed in the context of specific effects of treatment, because the best information will come from using a treatment that is known to preferentially reduce ADHD rather than SLD. If treatment targeted at one domain reduced impairments related to ADHD and SLD, we would not be able to distinguish the improvement of ADHD proper from the improvement in inattention that overflows from SLD. Recent evidence, however, suggests that treatments targeted toward one disorder do not substantially affect the other. Tamm and colleagues (2017) examined the effectiveness of intensive reading instruction, ADHD treatment (behavioral parent training and medication management administered concomitantly), and combined treatment (reading instruction, parent training, and medication) for children with comorbid ADHD and Reading Disorder. Children assigned to the ADHD and Combined treatment conditions improved in parent- and teacher-reported ADHD symptoms, whereas those receiving reading instruction did not. In addition, children assigned to the Reading Instruction and Combined conditions showed improvement on standardized reading measures, whereas children receiving BPT/Medication therapy did not show significant reading gains. Furthermore, there was no added benefit to combined vs. mono-domain therapy. Thus, Tamm et al. (2017) demonstrated specific effects of treatments designed for each diagnosis.

One of the most difficult differential decisions in child psychopathology, for children with weaknesses in both attention and learning, is ascertaining how symptoms and impairment might be attributable to each disorder. On the continuum of learning problems, even mild difficulty with reading or math may manifest as inattention, particularly when the child is engaged in academic endeavors and when the effort demanded requires additional attentional resources for those with already-reduced attention spans, sapping energy and motivation. Therefore, during academic tasks children with ADHD/SLD comorbidity may appear inattentive phenotypically partially because they lose focus, engage in off-task behaviors, and become frustrated because of the arduous nature of learning-related tasks (Pennington, Groisser, & Welsh, 1993). This fraction of the total inattention symptomatology (the part emanating from SLD) may be relatively intractable; that is, treatments that are effective for primary inattention may be considerably less effective for inattention that is secondary to learning difficulties, particularly in settings requiring increased learning demands (e.g., school, homework completion). Such an interpretation is consistent with evidence that children with ADHD and SLD are poorer responders to psychostimulant medications than those with ADHD alone (Grizenko, Bhat, Schwartz, Ter-Stepanian, & Joober, 2006).

Indeed, recent evidence suggests that deficits in learning adversely affect response to behavioral interventions. Breaux and colleagues (2018) examined predictors of treatment response among middle school adolescents with ADHD who received either a contingency-management or skill-based intervention for homework problems. Across a range of predictors examined, baseline math and reading achievement scores were the most consistent predictors of parent and teacher-rated treatment response. Those with low- to below-average academic achievement (i.e., reading or math achievement standard scores <95) were less likely to have reductions in homework problems and improved homework completion following treatment. However, findings from the Multimodal Treatment study for ADHD (MTA) did not support these results, as youth with a comorbid SLD did not differ on treatment-related improvement in homework problems (Langberg et al., 2010). Importantly, whether comorbid SLD moderates or predicts treatment-related improvements in inattention and other related impairments (e.g., organizational and study skills) has not been examined, but warrants scrutiny given the potential synergistic effect of SLD comorbidity on ADHD-related sequelae.

No study to date has examined varying responses to behavioral intervention outcomes among children with ADHD-Predominantly Inattentive Presentation (ADHD-I). Extrapolating conclusions regarding treatment response from children with clear hyperactivity and impulsivity to children with ADHD-I is questionable, given that ADHD-I is uniquely associated with different attention and neurocognitive profiles, psychopathological correlates (e.g., less oppositionality and greater sluggish cognitive tempo, substance use), and social skills deficits than is the Combined presentation (Bauermeister et al., 2005; Huang-Pollock, Mikami, Pfiffner, & McBurnett, 2007; McBurnett, Pfiffner, & Frick, 2001; Milich, Balentine, & Lynam, 2001; Sobanski et al., 2008). Furthermore, at least one longitudinal study indicates that academic impairments for youth with ADHD-I presentation are more profound and persistent than those found in other presentations of the disorder (Massetti et al., 2008). Given the unique impairments and academic difficulties faced by children with ADHD-I, it is especially important to examine the impact of SLD in this presentation of ADHD.

Most behavioral interventions for ADHD target problematic behaviors typically associated with ADHD-Combined Presentation. That is, most behavioral interventions emphasize reducing hyperactivity, impulsivity, and defiance that are either absent in or less relevant to children with ADHD-I. To our knowledge, only one validated behavioral treatment exists currently for children with ADHD-I: The Child Life and Attention Skills program (CLAS, Pfiffner et al., 2014). CLAS is a multicomponent intervention that combines behavioral parent training, child skills training, and classroom consultation strategies tailored to address the cross-setting challenges specific to children with ADHD-I. In a randomized, controlled trial, our team (Pfiffner et al., 2014) found that CLAS was associated with significant improvements in teacher-rated attention, social skills, organization, and global functioning, as well as parent-rated organizational skills, relative to parent training alone and to treatment as usual. CLAS also demonstrated superior results relative to treatment as usual on parent-rated attention, social skills, and global functioning. Whether SLD comorbidity affects response to CLAS among children with ADHD-I, however, remains unknown.

In sum, no study to date has examined whether the presence of SLD predicts differential response to behavioral intervention for treatments designed specifically for ADHD-I. Herein, the effect of SLD comorbidity was assessed across several outcome domains (e.g., ADHD symptoms, organizational deficits, study skills, and homework problems) using both parent and teacher informants. We hypothesized a significant interaction between treatment and comorbid SLD status, such that children with ADHD-I (without SLD) would exhibit greater treatment-related improvements on multiple domains, including inattention severity, relative to those with ADHD-I/SLD. The hypothesized interaction is based on the greater symptom severity, educational impairments, and cognitive challenges among children with comorbid ADHD/SLD, compared to those with only ADHD (whose inattention is less likely to be secondary to learning-related difficulties; Bental & Tirosh, 2007; Seidman et al., 2001; Willcutt et al., 2010; Willcutt, Pennington, et al., 2005). This fraction of the symptom profile emanating from learning difficulties is hypothesized to be less responsive when treated with interventions targeting ADHD singly, such as CLAS. It is also based on contemporary etiological models of ADHD/SLD comorbidity suggesting that children with comorbid ADHD/SLD evince more severe and/or numerous neurocognitive (DuPaul et al., 2013; Purvis & Tannock, 2000; Willcutt et al., 2007; Willcutt, Pennington, et al., 2005) and neural morphology (Hynd, Semrud-Clikeman, Lorys, Novey, & Eliopulos, 1990; Jagger-Rickels, Kibby, & Constance, 2018; Kibby, Kroese, Krebbs, Hill, & Hynd, 2009) deficits than those with an ADHD monodiagnosis, features that are not directly addressed through the CLAS (ADHD-focused) intervention.

Method

Participants

The current study comprises a secondary analysis of a larger, randomized, controlled clinical trial (Pfiffner et al., 2014). Briefly, participants aged 7–11 with a diagnosis of ADHD-I were randomly assigned to one of three treatment conditions: Child Life and Attention Skills

(CLAS) program, Behavioral Parent Training only (BPT), and Treatment as Usual (TAU). We examine the CLAS group (n = 74; age M = 9.21, SD = 1.10) exclusively herein. First, CLAS demonstrated superior results relative to BPT alone and TAU in previous studies (Pfiffner et al., 2014). Second, it was the only intervention associated with improvements across all of the outcome domains assessed (e.g., inattention, organizational skills, social skills, and overall functioning)—and it is unlikely to find moderation effects in the absence of treatment effects barring any suppression effects (Hayes, 2017). Third, it was the only intervention that improved performance in the school setting, which is particularly relevant for children with learning disabilities.

Participants were recruited at two treatment sites: University of California, San Francisco and University of California, Berkeley. Children were recruited or referred from school personnel including principals, school mental health professionals, and learning specialists, pediatricians, and child psychiatrists and psychologists. In addition, recruitment flyers were posted in online parent networks and professional organizations. Across 4 years (2009–2012), six cohorts of children participated, with a mean number of 12 children in each cohort (range = 10 to 15).

To be considered for inclusion, children met the following criteria: (a) primary DSM-IV diagnosis of ADHD-I, as confirmed by the KSADS-PL clinical interview (see below), (b) aged 7–11 (grades 2–5), (c) attending school full time in a regular classroom, (d) Full Scale IQ > 80, as confirmed on the WISC-IV (Wechsler, 2003), (e) living with at least one parent for one year prior to study recruitment, (f) family schedule that permitted participation in CLAS groups, and (g) school proximity within 45 minutes of either treatment site to allow study personnel to conduct teacher consultation meetings. Children were excluded if they were planning to initiate or change medication (stimulant or otherwise) in the near-term. Children taking non-stimulant psychoactive medications were also excluded because of the difficulties of withholding medication to confirm ADHD-I symptoms among raters potentially unfamiliar with children's behavior while not taking medications (i.e., classroom teachers), as required to confirm cross-setting impairment required for diagnosis. Children with pervasive developmental disorders or other neurological illnesses were also excluded.

Demographic data for the participants in this study (i.e., children receiving CLAS, n = 74) are as follows: Mean child age was 9.21 years (range 7–11) with 18% in the second grade, 21% in third grade, 21% in fourth grade, and 14% in fifth grade. Boys comprised 51.4% of the sample. 55.4% were Caucasian, 12.2% were Latinx, 9.5% were Asian American, 5.4% were African American, and 17.6% identified as mixed-race. Total household income was below $50,000 for 12.2% of families, $50,000-$100,000 for 31.1%; $100,000-$150,000 for 24.3%, and more than $150,000 for 27.0% of families. Income data was missing from 5.4% of families. 84.9% of parents reported graduating from college and 9.5% of children were living in single-parent homes. Note that only 6.8% of children were taking medication for ADHD.

Procedure

A detailed description of participant screening, flow, attrition, diagnostic procedures, treatment fidelity, and therapist qualifications are provided elsewhere (Pfiffner et al., 2014).

In short, participant screening was conducted using a successive, three-wave approach. First, telephone screening calls were conducted with parents and teachers to assess initial eligibility regarding demographics and medication status. Next, those meeting initial screening criteria were invited to complete rating scale packets containing the parent- and teacher- versions of the Child Symptom Inventory (CSI-IV, Gadow & Sprafkin, 2002) and the Impairment Rating Scale (IRS, Fabiano et al., 2006). Third, children who met the following criteria were invited for a full diagnostic assessment: (a) at least five symptoms rated as occurring “often” or “very often” by parents or teachers on the CSI, with each informant endorsing at least two symptoms; (b) five or fewer hyperactive/impulsive symptoms endorsed as occurring “often” or “very often” by parents and teachers on the CSI; and (c), at least one area of functioning rated as ≥ 3 on the IRS by both parent and teacher, thereby indicating evidence of impairment across settings. Diagnostic status was ascertained using clinical interviews that consisted of detailed questions regarding children’s developmental, medical, clinical, and school history, as well as the Kiddie Schedule for Affective Disorders and Schizophrenia (K-SADS-PL; Kaufman, Birmaher, Brent, Rao, & Ryan, 1996). The K-SADS is a semi-structured interview that assesses the presence and impairment of psychopathology including ADHD, oppositional defiant disorder, conduct disorder, anxiety disorders, mood disorders, and psychosis based on DSM-IV criteria. Its psychometric properties are well-established (cf., Kaufman et al., 1996).

To be considered for study entry, children were required to meet full DSM-IV criteria for ADHD-I based on K-SADS interview—viz., six or more inattention symptoms and fewer than six hyperactive/impulsive symptoms. Parents also completed a battery of questionnaires, and children were administered the WISC-IV (Wechsler, 2003), select subtests from the Woodcock Johnson Test of Achievement-III (Woodcock, Mather, McGrew, & Schrank, 2001), and a questionnaire battery.

Study procedures were approved by the Committee on Human Research at UCSF and UCB. All participating parents and children provided their informed written consent and assent, respectively. Families were compensated for measure completion at post-treatment ($50). Teachers were also compensated for competing measures at baseline ($50) and post-treatment ($75) and provided a total of $100 for their participation in teacher consultation meetings. Treatment was provided to participants at no cost. Immediately following treatment, laboratory visits were scheduled with families and rating scales were sent to teachers to collect post-treatment ratings.

Intervention

Child Life and Attention Skills (CLAS) consists of three, empirically supported behavioral interventions adapted for children with ADHD-I: behavioral parent training, child skills training, and daily report card with teacher consultation. For a detailed description of CLAS intervention skills and modules, see Pfiffner et al., 2014. The size of each CLAS group ranged between 6 and 8 families.

Parent component.—The parent training consisted of ten 90-minute weekday groups, along with up to six 30-minute individual family meetings (parent, child, and therapist). The curriculum was adapted from extant parent training programs (Barkley, 1997; Forehand & McMahon, 1981) and modified to include modules targeting challenges specific to ADHD-I. Parent stress management skills were also included.

Child component.—The child skill component consisted of ten 90-minute weekday groups that ran concurrently with the parent group sessions. Modules were adapted from a social skills program for children with ADHD (Pfiffner & McBurnett, 1997) and focused on building independence, organization, emotion regulation, assertiveness, and social skills. Parents reinforced skills using a token economy outside of the child group to encourage generalization of the skills across contexts.

Teacher component.—Teachers were taught evidence-based classroom management strategies to scaffold and support attention and use of the child skills in the classroom (DuPaul, Weyandt, & Janusis, 2011; Fabiano et al., 2010; Pfiffner et al., 2011). Teachers also implemented a customized, school-home daily report card whereby teachers rated students three times daily on up to four personalized treatment goals. Up to five meetings were conducted with teachers, parents, children, and study personnel to discuss daily report card goals, classroom accommodations, and the skills taught within the child component to encourage generalization of group skills across contexts.

Measures

Specific Learning Disorder.—The presence of a Specific Learning Disorder (SLD) status was assessed *a posteriori* and did not affect participant inclusion or exclusion. Children were considered to have a suspected SLD if they received a standard score ≤ 85 (i.e., 16th percentile) on any of the following subtests of the Woodcock Johnson Test of Educational Achievement-III (Woodcock et al., 2001): Passage Comprehension, Reading Fluency, Calculation, or Math Fluency. The psychometric properties of this test are well-established, including concurrent validity with other measures of academic achievement (Woodcock et al., 2001)[1].

Although SLD definitions vary widely in the literature wherein delineation scores range from 80 to 90 (cf. Brueggemann, Kamphaus, & Dombrowski, 2008 for a review), a cut-off score of 85 was chosen as it indicates the presence of a basic skill deficit that may require intervention, reliably identifies students with poor school performance and functional impairments (Brueggemann et al., 2008), and is associated with the lowest rates of reading growth following intervention (Vellutino, Scanlon, & Reid Lyon, 2000). In addition, the ‘low achievement model’ (i.e., below average academic achievement) was chosen over alternative models of SLD definition, such as the ‘IQ-achievement discrepancy model,’ as the latter is associated with limited reliability, questionable validity, poor sensitivity and positive predictive power, and limited incremental validity over the low-achievement definition (Brueggemann et al., 2008; Dombrowski, Kamphaus, & Reynolds, 2004; DuPaul et al., 2013). Both fluency and ability subtests were considered, consistent with the current conceptualization of SLD within the DSM-5 (American Psychiatric Association, 2013),

[1]It is important to recognize that SLD diagnosis is usually conferred following full psychoeducational or neuropsychological evaluation, and that the presence of significant academic achievement deficits indicates a *suspected* but not *confirmed* SLD diagnosis.

which recognizes an uneven profile of abilities wherein deficits can be observed in accurate and fluent calculation/reading, either independently or concomitantly. Based on this definition, 47.3% (n = 35) met criteria for an SLD. Specifically, 41.9% (n = 31) met criteria for a disability in math, 13.5% (n = 10) met criteria for a disability in reading, and 8.1% (n = 6) met criteria for a learning disability in both reading and math.

Outcome Measures

Inattention.—Parent- and teacher-rated symptom count[2] from the Inattention scale of Child Symptom Inventory (CSI, Gadow & Sprafkin, 2002) was used to assess ADHD-related inattention symptomatology and had good internal consistency in the present sample (αs = .77-.82). The CSI measures inattention consistent with ADHD DSM-IV criteria on a 4 point scale (0 = never to 3 = very often). Inattention symptoms were considered present if they were rated as occurring ‘often’ or ‘very often.’ The Inattention scale of the CSI has normative data, acceptable test-retest reliability, and predictive validity for a categorical diagnosis of ADHD (Gadow & Sprafkin, 2002).

Organizational deficits.—Parents and teachers completed respective versions of the Children’s Organizational Skills Scale (COSS, Abikoff & Gallagher, 2003). Age-corrected T-scores of the COSS Total composite score served as the dependent variable to assess children’s deficits in organization, planning, and time management skills and had good internal consistency in the present sample (α = .91 to .97). The parent and teacher versions have adequate psychometric properties including high test-retest reliability (rs = .94 to .99, and .88 to .93, respectively), and evidence of structural, convergent, and discriminant validity (Abikoff & Gallagher, 2003). Items are rated on a 4-point scale from 1 (hardly ever/never) to 4 (just about all the time) and assess the extent to which children have difficulties with planning tasks effectively; engaging in organizational behaviors such as list creation, routines, and reminders; and managing materials and supplies necessary for task completion.

Study skills.—Teacher-rated, age-corrected decile scores on the Study Skills subscale of the Academic Competence Evaluation Scale (ACES, DiPerna & Elliott, 2001) served as the dependent variable to measure children’s study skills and had adequate internal consistency in the present sample (α = .88 to .90). The ACES has excellent psychometric properties including test-retest reliability (r = .96) and evidence of predictive and concurrent validity (DiPerna & Elliott, 2001). Items are rated on a 5-point scale ranging from 1 (never) to 5 (almost always); they assess the extent to which students are able to prepare for and manage tests and class assignments, with higher scores indicating greater functioning in study skills.

Homework problems.—Average parent-rated scores on the Homework Problems Checklist (HPC, Anesko, Schoiock, Ramirez, & Levine, 1987) served as the dependent variable to measure children’s challenges with managing and completing homework and showed high internal consistency in the present sample (α = .89 to .91). The HPC has adequate psychometric properties, including test-retest reliability and predictive validity

[2]Alternative summary scores, such as symptom severity scores, were also analyzed but did not change the pattern or interpretation of results.

with children's academic performance (Anesko et al., 1987). Items are rated on a 4-point scale ranging from 1 (never) to 4 (very often) and assess difficulties with the management of homework materials, knowledge and organization of homework tasks, homework completion, and homework independence.

Data Analytic Plan

All statistical analyses were performed using SPSS (Version 25; IBM Corp., 2017). Preliminary analyses involved investigation of missing data and assessment of baseline characteristics by SLD Status (see Table 1). We analyzed outcomes in the four domains that were the primary focus of our investigation: inattention, organizational deficits, study skills, and homework problems. For measures that included both parent and teacher ratings (i.e., inattention and organization deficits), separate analyses were performed for each rater. Primary analyses involved mixed-model ANOVAs examining within (pre-treatment, post-treatment) and between (ADHD-I, ADHD-I+SLD) group comparisons. Analyses were initially completed without covariates. We then performed follow-up ANCOVAs adjusting for the following pre-treatment variables: child's age, gender, race, medication status, and ODD symptoms, as well as education level of the primary parent. However, each of these covariates were either non-significant or did not change the pattern of interpretation of results when included within the analyses. Simple mixed-model ANOVAs without covariates are therefore presented. Consistent with recommendations (Dennis et al., 2009; Miller & Chapman, 2001), participant's Full Scale IQ (FSIQ) score was not examined as a covariate. That is, current etiological models of ADHD (Barkley, 1997; Castellanos & Tannock, 2002; Rapport et al., 2008; Sagvolden, Johansen, Aase, & Russell, 2005; Sonuga-Barke, Bitsakou, & Thompson, 2010; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005), as indicated in the most recent version of the *DSM* (American Psychiatric Association, 2013), conceptualize the core symptoms and related impairments of the disorder as secondary to underlying neurocognitive deficits. Therefore, cognitive deficits (e.g., working memory, processing speed) which contribute to FSIQ (a) are considered inherent to ADHD, (b) do not represent systematic error, and (c) violate the assumptions of a covariate (cf. Dennis et al., 2009; Miller & Chapman, 2001 for a review)

In order to control for Type 1 error, a Benjamini-Hochberg false discovery rate (FDR, Benjamini & Hochberg, 1995) was applied within domain. The FDR exerts more powerful control over wrongly rejecting the null compared to procedures that control the familywise error rate (e.g., the Bonferroni correction). Specifically, using this method, each *p*-value below the *a priori* family-wise alpha level of .05 (i) is ranked in ascending order, i through M, where M is the rank of the largest (least significant) *p*-value. These *p*-values are then compared to an adjusted alpha level of $i(\alpha)/M$, until one of the *p*-values (k) is larger than the adjusted alpha level. In this case, k and all *p*-values ranked after k are considered nonsignificant. For all pairwise comparisons, Hedges' g effect size metrics are provided. Hedges' g estimates are Cohen's d estimates corrected for the upward bias associated with smaller sample sizes. Interpretation of Hedges' g estimates are consistent with traditional effect size conventions (i.e., 0.2 = small; 0.5 = moderate; 0.8 = large)

Results

Preliminary Analyses

Very few data were missing at pre-treatment (5 data points, 0.4%) or post-treatment (7 data points, 0.9%), so none were imputed. Most of the missing data at post-treatment were related to attrition (Pfiffner et al., 2014), as one family dropped from treatment prior to the post-treatment assessment. All outcome variables were screened for univariate outliers as reflected by scores exceeding 3.5 standard deviations from the mean in either direction (Tabachnick & Fidell, 2007). None were identified. As seen in Table 1, participants did not differ significantly on pre-treatment variables based on SLD Status.

Inattention

Treatment-related effects on teacher-rated inattention symptoms were analyzed in a 2 (SLD Status: ADHD-I, ADHD-I+SLD) X 2 (Time: Baseline, Post-Treatment) mixed model ANOVA; see Figure 1a. Means comparisons are shown in Table 2. As expected, a significant main effect of Time ($F[1, 72] = 99.81$, $p < .001$) was observed, indicating significant, large magnitude improvement on teacher-rated inattention following CLAS ($g = 1.33$). A significant main effect of SLD Status ($F[1, 72] = 4.58$, $p = .036$), and an SLD Status X Time interaction ($F[1, 72] = 13.05$, $p = .001$), were also observed. Follow-up pairwise comparisons using the Benjamini-Hochberg FDR correction indicate that children with ADHD-I and comorbid ADHD-I+SLD did not differ significantly at baseline, but large-magnitude between-group differences were evident following the CLAS intervention ($g = 0.80$). Further inspection indicates that children with ADHD-I and comorbid ADHD-I +SLD improved on teacher-rated inattention following the CLAS intervention; however, children with only ADHD-I experienced greater improvement in teacher-rated inattention following intervention ($g = 2.08$) relative to those with a comorbid SLD ($g = .80$).

A similar mixed model ANOVA was analyzed to assess CLAS treatment-related effects on parent-rated inattention. As expected, there was a significant main effect of Time ($F[1, 73] = 112.57$, $p < .001$) indicating significant, large-magnitude improvement in parent-rated inattention following CLAS ($g = 1.52$). Neither the main effect of SLD Status ($F[1, 73] = 0.27$, $p = .60$) nor the SLD Status X Time interaction ($F[1, 73] = 0.24$, $p = .63$) was significant.

Organizational Deficits

A mixed model ANOVA was analyzed to assess CLAS treatment-related effects on teacher-rated organizational deficits, as depicted in Figure 1b. As expected, a significant main effect of Time ($F[1, 72] = 72.82$, $p < .001$) was observed, indicating significant, large-magnitude improvement on teacher-rated organizational deficits following CLAS ($g = 0.83$). A significant SLD Status X Time interaction ($F[1, 72] = 3.95$, $p = .05$) was also observed. However, the main effect of SLD Status ($F[1, 72] = 3.24$, $p = .076$) was not significant. Follow-up pairwise comparisons using the Benjamini-Hochberg FDR correction indicate that children with ADHD-I and comorbid ADHD-I+SLD did not differ significantly on teacher-rated organizational deficits at baseline, but moderate-magnitude between-group differences were evident following the CLAS intervention ($g = 0.59$). Further inspection indicates that children with ADHD-I and comorbid ADHD-I+SLD improved on teacher-rated organizational deficits following the CLAS intervention, but children with only ADHD-I experienced greater improvement in teacher-rated organizational deficits following intervention (g = 1.19) relative to those with a comorbid SLD (g = 0.62).

For parent-rated organizational deficits, the mixed model ANOVA was significant for a main effect of Time ($F[1, 72] = 94.14$, $p < .001$), indicating significant, large-magnitude improvement in parent-rated organizational deficits following CLAS (g = 1.14). Neither the main effect of SLD Status ($F[1, 72] = 1.48$, $p = .23$) nor the SLD Status X Time interaction ($F[1, 72] = .56$, $p = .46$) was significant.

Study Skills

As shown in Figure 1c, a significant main effect of Time ($F[1, 71] = 32.64$, $p < .001$) was observed, indicating significant, moderate to large-magnitude improvement on teacher-rated Study Skills following CLAS (g = 0.61). A significant SLD Status X Time interaction ($F[1, 71] = 4.12$, $p = .046$) was also observed. However, the main effect of SLD Status ($F[1, 71] = 3.43$, $p = .07$) was not significant. Follow-up pairwise comparisons using the Benjamini-Hochberg FDR correction indicate that children with ADHD-I and comorbid ADHD-I+SLD did not differ significantly on teacher-rated study skills at baseline, but medium-magnitude between-group differences were evident following the CLAS intervention (g = 0.56). Further inspection indicates that children with ADHD-I and comorbid ADHD-I+SLD improved on teacher-rated study skills following the CLAS intervention; however, children with only ADHD-I experienced greater improvement in teacher-rated study skills following intervention (g = 0.89) relative to those with a comorbid SLD (g = 0.37).

Homework Problems

For parent-rated homework problems, the mixed model ANOVA was significant for a main effect of Time ($F[1, 72] = 183.44$, $p < .001$), indicating significant, large-magnitude improvement in parent-rated homework problems following CLAS (g = 1.45). As shown in Figure 1d, The main effect of SLD Status was also significant ($F[1, 72] = 4.73$, $p = .03$), indicating that children with comorbid ADHD-I+SLD experienced significantly more homework management and completion challenges relative to those with an ADHD-I monodiagnosis. However, the SLD Status X Time interaction failed to reach significance ($F[1, 72] = 0.05$, $p = .84$).

Post-Hoc Analyses: Symptom Normalization

The above analyses indicate that larger treatment effects were observed within the school setting for children with ADHD-I relative to those with ADHD-I+SLD. In a final set of analyses, we examine whether rates of symptom normalization varied as a function of SLD Status for significant models. Normalization was defined as evincing subclinical symptoms of inattention (i.e., 5 or fewer symptoms endorsed on the CSI-IV as occurring ‘often’ or ‘very often’), and minimal organization (i.e., T-score less than 65 indicating organizational skills within 1.5 standard deviations of the mean on the COSS), and study skills (i.e., decile scores 2 or below, as recommended; DiPerna & Elliott, 2001) deficits on post-treatment measures. Results revealed that children with ADHD-I were significantly more likely to experience symptom normalization on teacher-rated inattention (X^2= 7.14, *p*=.008, ADHD-I=87.2% normalized, ADHD-I+SLD = 60.0%), organizational deficits (X^2=4.03, *p*=.045, ADHD-I=89.7% normalized, ADHD-I+SLD = 71.4%), and study skills (X^2= 7.74, *p*=.005, ADHD-I=79.4% normalized, ADHD-I+SLD = 48.6%) relative to those with ADHD and an SLD.

Discussion

The current study is the first, to our knowledge, to empirically examine whether the presence of an SLD among school-aged children with ADHD-I differentially predicts response to a behavioral intervention targeted at ADHD-I-related impairment (i.e., CLAS). It extends the relatively limited prior literature addressing treatment recommendations for children with comorbid ADHD-I and SLD. The presence of academic deficits significantly moderated improvement in teacher-rated inattention, organizational deficits, and study skills, such that all children improved across the domains assessed, irrespective of SLD status, but children without a comorbid academic weaknesses evinced greater treatment-related improvement than those with a comorbid learning disorder. Children with ADHD-I were also more likely to experience symptom normalization relative to children with ADHD-I and an SLD on teacher-rated measures. We did not find evidence for such moderation with respect to parent-reported outcomes.

One possible explanation for the present findings is that the attentional challenges observed in the school setting for children with ADHD-I/SLD comorbidity are qualitatively different from those of children with an ADHD monodiagnosis, reflecting specific difficulties with reading and math rather than ADHD-related inattention, organizational deficits, and study skills challenges. That is, children with reading or math learning disabilities may appear inattentive phenotypically during academic tasks because they lose focus, engage in off-task behaviors, and become frustrated due to the arduous nature of learning tasks (Pennington, Groisser, & Welsh, 1993). Therefore, the attenuated response to behavioral intervention observed among children with ADHD/SLD comorbidity could be due to the fact that CLAS may not adequately target the proximal etiological mechanisms contributing to the fraction of inattentive symptoms that emanate from learning challenges. It is important to note that, consistent with a *DSM* diagnosis of ADHD-I, children in the present study displayed symptoms and impairments across multiple settings, including situations where learning demands are either minimized or less-relevant (e.g., at home, during social situations) as reported by both parents and teachers. Although learning challenges might exacerbate inattentive symptoms within classroom settings among children with comorbid ADHD/SLD, it is unlikely that learning-related inattention can explain the totality of impairments experienced by children with ADHD/SLD comorbidity given the separate, additive symptoms and impairment associated with each disorder.

The classroom supports provided by CLAS targeting ADHD-related impairments (e.g., school-home daily report card, behavioral classroom management interventions, promotion of child skills within the classroom such as organization, independence, time management, and following routines) may be necessary but not sufficient to address the cross-domain and unique challenges among children with dual ADHD/SLD deficits. That is, inattention among children with comorbid ADHD/SLD appears to emanate from two disparate underlying causes—one related to ADHD and amenable to behavioral interventions and another stemming from specific academic challenges. Children with comorbid ADHD/SLD are therefore likely to require intervention aimed at reducing *both* ADHD and SLD symptoms and related impairments. This account is supported by current etiological models of ADHD/SLD comorbidity (cf., DuPaul et al., 2013 for a review) wherein comorbidity is associated with either more severe or numerous neurocognitive and structural deficits relative to only one disorder. Specifically, ADHD and SLD are each linked to shared and unique neurocognitive deficits (DuPaul et al., 2013; Purvis & Tannock, 2000; Willcutt et al., 2007; Willcutt, Pennington, et al., 2005) and structural/morphological differences (Hynd et al., 1990; Jagger-Rickels et al., 2018; Kibby et al., 2009). Even more, ADHD/SLD comorbidity is associated with neurocognitive deficits in an additive fashion relative to those with only one disorder. This explanation is also consistent with recent evidence of neural morphology differences among children with ADHD/SLD comorbidity (e.g., right thalamus and left medial frontal cortical volume) that are absent in children with monodiagnoses (Jagger-Rickels et al., 2018). This, coupled with the observed differences in symptom normalization rates among children with comorbid SLD, underscores the need for adjunctive, SLD-specific intervention within this population to target the multiple underlying deficits absent in those with an ADHD-I monodiagnosis.

The presence of an SLD diagnosis did not significantly affect treatment response on parent-rated inattention and organizational deficits at baseline or post-treatment (i.e., a main effect). For parent-rated homework problems, all children exhibited large-magnitude improvements ($g = 1.45$) following intervention. Children with comorbid ADHD-I and SLD, however, showed greater parent-rated homework problems at baseline and post-treatment relative to those with an ADHD-I monodiagnosis (i.e., significant main effect of SLD status). Treatment response on parent-rated homework problems, however, did not significantly differ for the diagnostic subgroups following the CLAS intervention (i.e., non-significant interaction). This finding was surprising, particularly in light recent results from Breaux and colleagues (2018) that middle-school-aged adolescents with ADHD and low- to below-average academic performance predicted poor treatment response to contingency-management and skills-based homework interventions. However, the absence of treatment response differences is consistent with findings from the MTA study, in which SLD status neither moderated nor predicted improvements in parent-rated homework performance among elementary school-aged children (Langberg et al., 2010). It is possible that differences in age-related homework expectations (e.g., increased time spent completing homework, more long-term projects, and greater expectations for homework independence in middle school relative to elementary school) affect parent-rated impairment. The age-demographic differences among the studies, coupled with the homework focused intervention utilized in the Breaux and colleagues study relative to the MTA and CLAS interventions which target varied areas of impairment, may account for the discrepant findings.

Limitations and Future Directions

Several caveats warrant discussion despite multiple methodological strengths (e.g., multi-method/multi-informant ADHD diagnosis; intensive, multimodal intervention; and stringent SLD delineation scores). Although the sample size of the present study was sufficient to assess the questions of interest, the limited number of participants precluded consideration of the differential effects of individual learning disorders (i.e., specific learning disorder in reading relative to math). Future studies should examine whether results are consistent across learning disorder modalities and replicate the findings of the current study using larger and more diverse samples (e.g., larger range of socioeconomic levels and racial ethnicity/backgrounds, differing age ranges of participants) as well as samples with clinically confirmed SLD. In a related vein, the parents of study participants were highly educated (i.e., 85% of parents reported graduating from college), and therefore the generalizability of the present findings may be limited, particularly in light of potential relations between parental academic success and child school functioning. However, parent education level did not vary as a function of SLD status, and it is therefore unlikely that parent education level accounted for systematic variance in the attenuated treatment response observed within the school setting.

We also recognize that many clinical disorders, particularly ADHD-I and SLDs, exist on a continuum of normally distributed scores, and the use of a cut-off score artificially dichotomizes inattention and academic achievement abilities. However, our decision to operationalize ADHD-I and SLD as binary constructs is consistent with that of many school districts within the United States and abroad, wherein provision of intervention services is considered only following a diagnosis. Future studies should examine if findings are consistent across varying degrees of attention and learning challenges, particularly because the presentation of ADHD-I is heterogeneous and may include children with subthreshold combined presentation[3].

Despite the use of *a posteriori* procedures to identify cases of potential SLDs due to the absence of full a psychoeducational evaluation, the observed ADHD/SLD comorbidity rate (i.e., 47.3%) is nearly identical to that identified in extant literature (i.e., 45.1%; DuPaul et al., 2013). Rates of SLDs in reading also fell within the range of previously reported comorbidities, albeit within the lower portion of the reported range. However, the comorbidity rate for math SLD (i.e., 42%) is slightly higher than the range identified in extant literature, which primarily used DSM-IV diagnostic procedures. (i.e., 5–30%; DuPaul et al., 2013). This discrepancy likely reflects the current study's consideration of math fluency for SLD diagnosis, consistent with the DSM-5, which was absent in DSM-IV criteria used within extant studies. In addition, recent evidence suggests that mathematics deficits are more closely related to inattention rather than hyperactivity/impulsivity (Bauermeister et al., 2012; Garner et al., 2013; Pham, 2013) and the genetic overlap between specific academic weaknesses in math and ADHD is largely driven by inattention symptoms (Greven et al., 2014, Plourde et al., 2015, Willcutt et al., 2000). Therefore, children with

[3]Re-examination of the study models excluding participants with more than three symptoms of hyperactivity/impulsivity on the KSADS clinical interview (*n*=3) did not change the pattern or interpretation of findings.

ADHD-I, of which our study sample was comprised exclusively, may be at a greater risk for SLDs in math relative to other presentations of the disorder and likely accounts for this observed discrepancy. Future studies should examine whether findings are consistent among samples using clinically-diagnosed SLD and differing ADHD presentations.

It might be argued that our measures of reading comprehension and fluency reflect inattention more than they indicate a true learning disability, due to their high correlation with inattention (Arrington et al., 2014; Plourde et al., 2015). Were that true, we would expect the SLD group to have higher inattention scores at baseline, and this was not the case. Conversely, it might be claimed that our measures of reading comprehension and fluency led to overidentification of learning disorder due to this correlation. The lack of baseline differences cast doubt on this critique, as well as the fact that our rate of comorbid learning disorder fell within the lower range of estimates identified in extant literature (DuPaul et al., 2013). Note that we do not deny the correlation, we simply assert that it does not threaten our findings. Future studies should examine whether outcomes are consistent when reading decoding measures are considered, although we hypothesize that findings will be consistent with our own.

The use of parent- and teacher-rated outcome measures may overestimate the magnitude of treatment-related improvements due to their active involvement in treatment (i.e., Hawthorne effects). Future studies may wish to utilize objective outcome measures (e.g., blinded, direct observations) in order to more accurately characterize the magnitude treatment attenuation among children with specific learning difficulties. Likewise, future investigations should also determine whether SLD affects treatment-related changes on a broader range of academic outcomes (e.g., grades, daily report cards, academic achievement tests).

Clinical Implications

Collectively, the present results indicate that CLAS is an effective intervention for children with ADHD-I regardless of SLD comorbidity status, as robust improvements were observed across home and school settings and within several domains of functioning including inattention symptoms, organization deficits, homework problems, and study skills. Additional intervention to address the underlying learning challenges among those with a comorbid SLD is warranted to produce maximal improvements. That is, multimodal treatment targeting ADHD-I (e.g., behavioral interventions) and SLD (e.g., direct instruction, tutoring) may be necessary to address the cross-domain challenges associated with ADHD-I/SLD comorbidity. Further study would be needed to evaluate the temporal sequencing of interventions to determine whether (a) ADHD and SLD intervention should occur concomitantly or (b) the symptoms and impairment related to one disorder require amelioration prior to initiating intervention for the comorbid condition.

Our findings are also important for informing diagnostic assessment, treatment planning, and intervention monitoring practices. Currently, full psychoeducational evaluations for ADHD are utilized with diminished frequency within clinical settings because (in part) of insurance reimbursement challenges, ever-increasing patient quotas, and long waitlists for services (Handler & DuPaul, 2005; Nelson et al., 2014). However, the present results suggest that psychoeducational testing for SLD may be a valuable component of ADHD assessment and treatment planning given high comorbidity rates and varying responses to treatment. Current medical guidelines state that testing is unnecessary for making the diagnosis of ADHD. While this may be technichally true for applying diagnostic criteria, it leaves unseen critical cognitive and academic features that influence treatment expectations. Poor academic achievement, or other sign of a learning disorder, will indicate the possibility that treatment gains may be limited within the school setting, and, based on these data, that only a fraction of the variance in teacher-rated inattention may respond to ADHD treatment.

Despite the increased parent-teacher communication that occurred during the CLAS intervention (i.e., as many as 5 parent-teacher conferences over a 10-week span), parents were not as perceptive to SLD-related effects on functioning relative to classroom teachers. This might be explained by the greater sensitivity on the part of teachers to inattention that is secondary to SLD which is more readily observed in the classroom, underscoring the importance of gathering diagnostic and treatment response data from children's classroom teachers both during assessment and while administering behavioral interventions for ADHD.

Conclusions

As advances continue toward developing effective and lasting interventions for children with ADHD, it is important to consider the synergistic effect of comorbid conditions on ADHD-related sequela, as well as intraindividual strengths and weaknesses when designing intervention plans to maximize treatment effectiveness. Although the current findings underscore the importance of academic achievement deficits in the context of a comprehensive intervention for ADHD-I, additional factors including neurocognitive profiles, comorbid internalizing symptoms, family and interpersonal dynamics, and sociocultural identities may also affect treatment response and should be taken into consideration to inform more tailored and precise interventions for the disorder.

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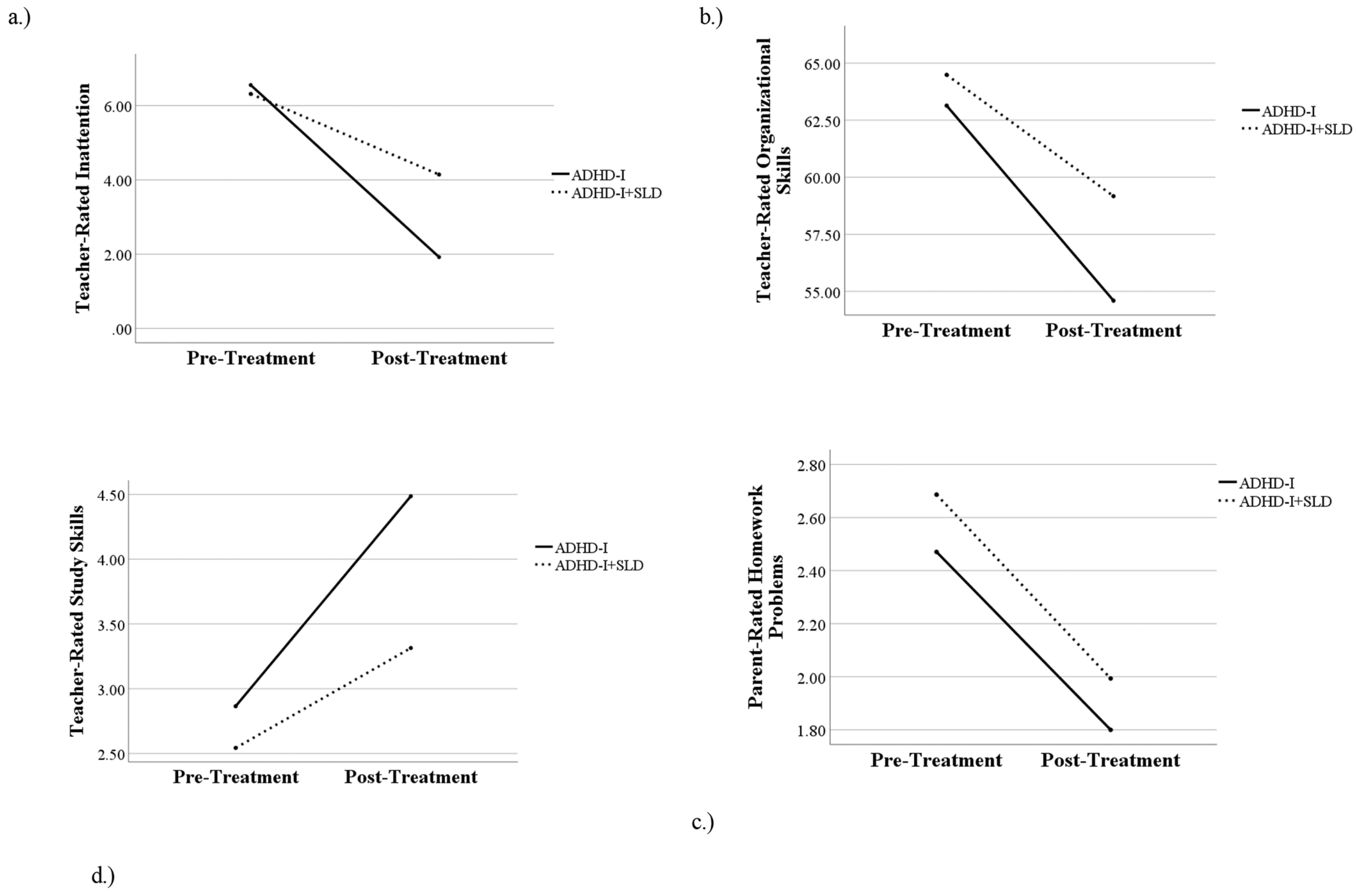

Figure 1.

Graphs depicting Teacher-rated (a) CSI inattention symptom count, (b) COSS organizational skills deficits T-Score, and (c) ACES study skills decile score, and Parent-rated (d) Homework Problems Checklist mean score for children with ADHD-I (solid line) and comorbid ADHD-I+SLD (dashed line) before and after the CLAS intervention.

Table 1.

Sample and Demographic Variables of Children Receiving CLAS (n = 74)

Variable	ADHD-I (n = 39) *M*	ADHD-I (n = 39) *SD*	ADHD-I+SLD (n = 35) *M*	ADHD-I+SLD (n = 35) *SD*
Child Age (years)	8.98	1.09	9.47	1.07
Gender (% boys)	53.8%		48.6%	
KSADS IN symptoms, parent	7.56	1.10	7.42	1.04
KSADS HI symptoms parent	1.25	1.18	1.17	1.50
IRS-Parent	3.20	1.12	3.07	0.73
IRS-Teacher	3.02	1.06	3.17	0.97
On medication at randomization	7.7%		5.7%	
KSADS Comorbid ODD*	0%		6.8%	
KSADS Comorbid Mood Disorder	2.6%		1.4%	
KSADS Comorbid Anxiety Disorder	2.6%		5.4%	
FSIQ	104.92	9.98	102.26	12.06
WJ-III Passage Comprehension	100.38	8.07	96.29	10.96
WJ-III Reading Fluency*	105.95	14.94	93.71	13.03
WJ-III Math Fluency*	98.35	12.01	88.02	6.85
WJ-III Calculation*	106.62	11.47	98.51	11.09
Child Ethnicity				
Caucasian	56.4%		54.3%	
African American	2.6%		8.6%	
Hispanic/Latinx	10.3%		14.3%	
Asian/Pacific Islander	12.8%		5.7%	
Mixed/Other	17.9%		17.1%	

Note: FSIQ = Full-Scale IQ, HI= Hyperactivity and Impulsivity, IN = Inattention, IRS = Impairment Rating Scale (Fabiano et al., 2006), KSADS = Kiddie Schedule for Affective Disorders and Schizophrenia (Kaufman et al., 1996), ODD = Oppositional Defiant Disorder, WJ-III = Woodcock-Johnson Test of Educational Achievement-III (Woodcock et al., 2001)

* $p < 0.05$

Table 2.

Means and Standard Deviations

Outcome	ADHD-I (*n* = 39)		ADHD-I+SLD (*n* = 35)		SLD Status X Time Interaction	Pairwise Comparisons ES[a]		
	M	***SD***	***M***	***SD***	***F***	**ADHD-I vs ADHD-I+SLD**	**ADHD-I: Baseline vs Post**	**ADHD-I+SLD: Baseline vs Post**
Teacher-rated CSI inattention symptoms					13.05*		2.08† [1.53, 2.63]	0.80† [0.31, 1.29]
Baseline	6.56	1.96	6.31	2.22		−0.12 [−0.34, 0.58]		
Post-Treatment	1.92	2.43	4.14	3.08		0.80† [0.32, 1.27]		
Teacher-rated COSS organizational skills					3.95*		1.19† [0.71, 1.67]	0.62† [0.14, 1.10]
Baseline	63.11	7.40	64.49	8.20		0.18 [0.28, 0.63]		
Post-Treatment	54.59	6.73	59.17	8.65		0.59† [0.12, 1.05]		
Teacher-rated ACES study skills					4.12*		0.89† [0.42, 1.35]	0.37† [−0.10, 0.84]
Baseline	2.87	1.42	2.54	2.06		0.19 [−0.27, 0.64]		
Post-Treatment	4.49	2.12	3.31	2.04		0.56† [0.10, 1.03]		
Parent-rated CSI inattention symptoms					0.24		1.24 [0.75, 1.72]	1.73 [1.18, 2.28]
Baseline	6.00	2.34	6.40	1.94		0.18 [−0.27, 0.64]		
Post-Treatment	2.66	2.96	2.74	2.24		0.03 [−0.43, 0.49]		
Parent-rated COSS organizational skills					0.56		1.23 [0.75, 1.71]	1.07 [0.57, 1.57]
Baseline	62.34	8.31	63.43	7.18		0.14 [−0.32, 0.60]		
Post-Treatment	53.61	5.44	55.94	6.69		0.38 [−0.08, 0.84]		
Parent-rated HPC homework problems					0.05		1.59 [1.08, 2.10]	1.42 [0.90, 1.59]
Baseline	2.47	0.46	2.69	0.53		0.44 [−0.02, 0.90]		
Post-Treatment	1.80	0.37	1.99	0.44		0.46 [0.00, 0.93]		

Note: ACES = Academic Competence Evaluation Scale (DiPerna & Elliott, 2001); ADHD = attention-deficit/hyperactivity disorder; ADHD+SLD = attention-deficit/hyperactivity disorder with comorbid specific learning disorder; COSS = Child Organizational Skills Scale (Abikoff & Gallagher, 2003); CSI = Child Symptom Inventory (Gadow & Sprafkin, 2002); ES = Effect Size; HPC = Homework Problems Checklist (Anesko et al., 1987).

[a]Effect sizes: Standardized mean differences corrected for sample size bias (Hedges' *g*). Numbers within brackets represent 95% confidence interval of Hedges' *g* estimates.

*$p < 0.05$

†Significant after within-domain Benjamini-Hochberg false discovery rate correction following significant SLD Status X Time interaction.