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Slow Sluggish Cognitive Tempo Symptoms are Associated with Poorer Academic Performance in Children with ADHD

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Abstract

Sluggish cognitive tempo (SCT) symptoms may confer risk for academic impairment in attention-deficit/hyperactivity disorder (ADHD). We investigated SCT in relation to academic performance and impairment in 252 children (ages 6–12, 67% boys) with ADHD. Parents and teachers completed SCT and academic impairment ratings, and achievement in reading, math, and spelling was assessed. Simultaneous regressions controlling for IQ, ADHD, and comorbidities were conducted. Total SCT predicted parent-rated impairments in writing, mathematics, and overall school but not reading. Parent-rated SCT Slow predicted poorer reading and spelling, but not math achievement. Teacher-rated SCT Slow predicted poorer spelling and math, but not reading achievement. Parent-rated SCT Slow predicted greater academic impairment ratings across all domains, whereas teacher-rated SCT Slow predicted greater impairment in writing only. Age and gender did not moderate these relationships with the exception of math impairment; SCT slow predicted math impairment for younger but not older children. Parent and teacher SCT Sleepy and Daydreamy ratings were not significant predictors. SCT Slow appears to be uniquely related to academic problems in ADHD, and may be important to assess and potentially target in intervention. More work is needed to better understand the nature of SCT Slow symptoms in relation to inattention and amotivation.

Keywords

learning difficulties; school children; apathy/disinterest; slowed behavior/thinking

1. Introduction

Sluggish cognitive tempo (SCT) refers to a pattern of behavior characterized by inconsistent alertness (e.g., daydreaming, absent-mindedness) and slowed behavior/thinking (e.g., drowsy, slow to respond) (Bernad, Servera, Grases, Collado, & Burns, 2014; Carlson & Mann, 2002; Garner, Marceaux, Mrug, Patterson, & Hodgens, 2010; Jacobson, et al., 2012). Some studies have treated SCT as a unidimensional construct while others have found

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support for separate SCT dimensions of slowed thinking/sleepiness, daydreaming/inconsistent alertness, and/or low initiative/motivation (Becker, 2013). Attention-deficit/hyperactivity disorder (ADHD) and SCT frequently co-occur. In a nationally representative sample of 1,800 children ages 6 to 17, 39% of those who met criteria for ADHD also displayed elevated levels of SCT; conversely, 59% of children with elevated SCT also had ADHD (Barkley, 2013). SCT symptoms are associated with significant impairment in the internalizing and social domains, even after controlling for ADHD (Becker & Langberg, 2013; Bernad, et al., 2014; Carlson & Mann, 2002). There is also emerging evidence that SCT symptoms are associated with academic outcomes in children with ADHD. The majority of studies examining these associations have used either 1) parent and/or teacher ratings of academic impairment or 2) child performance on standardized measures of academic achievement in reading, math, and/or spelling, but rarely both. Examining both is critical to gather a full picture of a child's academic functioning. Direct norm-referenced achievement measures provide the most precise assessment of academic skills in comparison with same aged peers, while parent and teacher ratings provide a measure of impairment caused by academic difficulties.

1.1 SCT and academic impairment ratings

Several studies investigating the relation between SCT and parent or teacher ratings of academic impairment in children with ADHD have found a positive association. SCT-slowness ratings were positively associated with parent-rated learning problems (Fenollar Cortés, Servera, Becker, & Burns, 2014). Similarly, after controlling for inattention, SCT-low initiation/persistence ratings were positively associated with greater teacher-rated academic impairment (Jacobson, et al., 2012; Langberg, Becker, & Dvorsky, 2014). Another study found SCT to be associated with parent- and teacher-rated organizational problems (McBurnett, et al., 2014). Further, children with ADHD-Inattentive Type who also had high SCT scores were rated by parents as having significantly more homework problems than those with low SCT scores (Marshall, Evans, Eiraldi, Becker, & Power, 2014).

However, not all studies have found a significant association between SCT and academic impairment in children with ADHD. For instance, Marshall et al. (2014) did not find SCT to affect teacher-rated classroom performance. Similarly, Carlson and Mann (Carlson & Mann, 2002) did not find that elevated SCT symptoms negatively impacted teacher-rated academic functioning, and SCT was not found to predict parent- or teacher-reported homework problems or academic impairment above and beyond ADHD severity (Becker & Langberg, 2013). McBurnett et al. (McBurnett, et al., 2014) also did not find SCT to be associated with parent-rated homework problems when controlling for ADHD severity.

1.2 SCT and academic achievement

Results from studies investigating SCT in relation to child performance on standardized measures of academic achievement have also been mixed. In a community sample of twins that was over-selected for children with ADHD and learning disabilities, both parent- and teacher-rated SCT were associated with lower reading achievement, and teacher-rated SCT was also correlated with lower math achievement (Hartman, Willcutt, Rhee, & Pennington, 2004). Similarly, SCT has been associated with poorer academic achievement (standardized

measures of word reading, reading comprehension, mathematics, and written language) above and beyond ADHD symptom severity (Willcutt, et al., 2014).

In contrast, no significant association was found between SCT and standardized measures of reading, spelling, and math achievement in two samples of children with ADHD (Langberg, et al., 2014; Marshall, et al., 2014). Another study showed that inattention was more strongly associated than SCT with standardized measures of reading and math in children at-risk for ADHD (Bauermeister, Barkley, Bauermeister, Martinez, & McBurnett, 2012).

1.3 Importance of assessing SCT multi-dimensionally

It is unclear why discrepant findings have been reported for SCT and ratings or objective measures of academics. One possibility is the use of different measures of SCT. Some studies (Bauermeister, et al., 2012; Becker & Langberg, 2013; Carlson & Mann, 2002; Marshall, et al., 2014) used a small set of 4–5 SCT items pulled from the *Child Behavior Checklist* or *Teacher's Report Form* (Achenbach, 1991) which was not designed to specifically assess SCT, whereas other studies (Fenollar Cortés, et al., 2014; Langberg, et al., 2014; McBurnett, et al., 2014; Willcutt, et al., 2014) used scales specifically designed to assess SCT. Even studies using SCT-specific measures differ in the content and number of items they use to measure the SCT construct, and the nature and number of resulting dimensions. In fact, it is unclear if SCT is best considered as a unidimensional or multidimensional construct (Becker, Luebbe, & Joyce, 2015). In studies examining SCT multidimensionally, support for separate dimensions of slowed thinking/sleepiness, daydreaming/inconsistent alertness, and/or low initiative/motivation have generally been found (Becker, et al., 2016). Certain aspects of SCT may be more strongly associated with academic functioning than others. For example, Jacobson et al. (2014) and Langberg et al. (2014) found the slow/low initiation aspects of SCT to account for the largest proportion of variance in teacher ratings of academic impairment, compared to SCT items assessing daydreaming, sleepiness, or sluggishness. Likewise, parent report of learning problems was associated with SCT slow symptoms but not SCT inconsistent alertness symptoms (Fenollar Cortés, et al., 2014).

Although emerging research suggests that certain aspects of SCT may be more strongly associated with academic functioning than others, more research is needed to test this hypothesis. None of the three studies that have directly tested this possibility examined SCT in relation to objective academic achievement scores (Fenollar Cortés, et al., 2014; Jacobson, et al., 2012; Langberg, et al., 2014). In addition, although Langberg et al. (Langberg, et al., 2014) included young adolescents diagnosed with ADHD, Fenollar Cortes et al. (Fenollar Cortés, et al., 2014) included children whose parents reported a prior diagnosis of ADHD (i.e., diagnoses not established by the investigators) and Jacobson et al. (Jacobson, et al., 2012) recruited their sample from an outpatient neuropsychology clinic (i.e., not all children had elevated ADHD symptoms).

Given the mixed findings in extant studies reviewed above, we tentatively hypothesized that a total SCT score would be significantly correlated with parent and teacher ratings of academic impairment but not academic achievement test scores. In considering specific SCT dimensions, we hypothesized that SCT symptoms characterized by slow and apathetic

behaviors would predict lower academic achievement scores and higher ratings of academic impairment.

2. Methods

2.1 Subjects

Families with children ages 6 to 12 were recruited for an ongoing study through the standard clinical intake flow at an outpatient clinic specializing in pediatric ADHD. Participants who contributed data for the current analyses were 252 children (168 boys; *M* age=8.64, *SD*=1.61; *M* IQ=100.4, *SD*=14.5). Of the 252 children, 42.1% met criteria for ADHD Combined Type, 44.4% for ADHD Inattentive Type, 10% for ADHD Hyperactive/Impulsive Type, and 9.5% for ADHD Not Otherwise Specified. Approximately three-quarters (*n*=192) were non-Hispanic White, and the remaining participants were African American (*n*=47) Hispanic (*n*=8), Asian (*n*=3), or Native American (*n*=1). With regards to socioeconomic status, 26.5% reported an income ≤$30,000, 16.7% reported an annual income between $30,001-$50,000, 13.1% reported an income between $50,001-$70,000, 38.8% reported an income >$70,000, and 4.8% declined to answer. The majority of children (90%) were not on psychotropic medications. Of those children on medication, the vast majority were taking medications to manage ADHD including methylphenidate (*n*=8), dextroamphetamine (*n*=3), atomoxetine (*n*=3), or a combination of stimulant and/or non-stimulant medications (*n*=10), with the remaining children (*n*=2) taking antidepressants or mood stabilizers.

In terms of comorbid *DSM-IV-TR* (American Psychiatric Association, 2000) psychiatric disorders, 68 participants met current criteria for Oppositional Defiant Disorder (ODD), 3 participants met criteria for Conduct Disorder (CD), two participants met criteria for Major Depressive Disorder, and 32 participants met criteria for at least one anxiety disorder.

2.2 Procedures

All procedures were in accordance with Institutional Review Board standards. After obtaining informed consent from the parent and assent from the child, parents were administered the *Kiddie Schedule for Affective Disorders and Schizophrenia for School-Age Children* (K-SADS) (J. Kaufman, et al., 1997) and completed ratings. Concurrently, the child was administered IQ and academic testing. Teacher ratings were obtained by mail for a subsample of participants (*n*=174); collection of teacher ratings was discontinued partway through the study from which this convenience sample was derived.

2.3 Measures

2.3.1 Diagnosis.—The K-SADS (J. Kaufman, et al., 1997) is a semi-structured diagnostic interview with good reliability and validity. The disruptive behavior disorder, mood disorder, and anxiety disorder modules were administered for the current period. The K-SADS was administered by individuals with Master's or doctoral degrees in clinical psychology. All interviewers were trained by experienced interviewers, including scoring a previously recorded interview, observation of interviews, and being observed before interviewing independently. In addition, one interview per interviewer was randomly

selected to be scored by another interviewer. We achieved 100% reliability between interviewers on this reliability check.

2.3.2 IQ.—The *Kaufman Brief Intelligence Tests-2* (K-BIT) (A. S. Kaufman & Kaufman, 2004), a brief culturally-sensitive standardized assessment, was used to estimate verbal, non-verbal, and overall intelligence.

2.3.3 ADHD.—Inattentive and hyperactive-impulsive symptoms were assessed using the *Vanderbilt ADHD Diagnostic Parent Rating Scale* (VADPRS) and *Teacher Rating Scale* (VADTRS) (Wolraich et al., 2003), a DSM-IV-based scale with strong psychometric properties (Wolraich et al., 2003). Parents or teachers rate how frequently each symptom occurs on a 4-point scale (0=*never*, 3=*very often*). Average scores for the nine Inattention and nine Hyperactivity/Impulsivity items were calculated (αs = .88 and .90, respectively for parents; αs = .93 and .94, respectively for teachers). This is the standard approach for scoring the Vanderbilt scales, and provides meaningful information; for example, an average of 2.0 for the inattention score for the sample suggests that on average the sample "often" exhibits inattentive symptoms.

2.3.4 Sluggish cognitive tempo.—We utilized the *Sluggish Cognitive Tempo Scale* (Penny, Waschbusch, Klein, Corkum, & Eskes, 2009), a 14-item measure that assesses the frequency sleepy, daydreaming, and slowed behaviors. Items are rated on a 4-point scale (0=*not at all*, 3=*very much*). An SCT Total Score was derived by averaging all 14 items. Adequate factor structure and reliability for the parent-report version of this scale which includes three factors: Slow (e.g., apathetic, lacks initiative), Sleepy (e.g., drowsy, appears sluggish), and Daydreamy (e.g., daydreams, gets lost in own thoughts) has been reported (Penny, et al., 2009). A similar factor structure was identified for the teacher-report version of this scale (Jacobson, et al., 2012). The number of items included in each factor varies slightly for parents and teachers (Jacobson, et al., 2012; Penny, et al., 2009) (see Table 1). For parents, Slow includes six items, Sleepy includes five items, and Daydreamy includes three items (Penny, et al., 2009). In the present study, αs = .82, .87, .87, and .88 for parent-rated Slow, Sleepy, Daydreamy, and SCT Total, respectively. For teachers Slow includes four items, Sleepy includes five items, and Daydreamy includes five items (Jacobson, et al., 2012). In the present study, αs = .87, .93, .87, and .92 for teacher-rated Slow, Sleepy, Daydreamy, and SCT Total, respectively. With regards to intercorrelations, the teacher and parent SCT Total scores correlated significantly with one another (r=.26, p<.01), as did the Slow (r=.27, p<.01), Sleepy (r=.17, p<.05) and Daydreamy (r=.32, p<.01) dimensions.

2.3.5 Academic impairment ratings.—The VADPRS and VADTRS (Wolraich, et al., 2003) include items assessing perceptions of child impairment in school functioning on a scale ranging from 1 (*excellent*) to 5 (*problematic*). Internal consistency and reliability is excellent (Wolraich, et al., 2003). Individual school-related academic impairment ratings (i.e., overall school performance, reading, writing, and mathematics from the VADPRS, and reading, mathematics, writing impairment from the VADTRS) were utilized.

2.3.6 Objective academic achievement.—Selected subtests of the *Wechsler Individual Achievement Test-Third Edition* (WIAT-III) (Wechsler, 2009) including Word Reading, Numerical Operations, and Spelling were administered to assess achievement.

2.4 Statistical analysis

Associations between all variables of interest were assessed with Pearson bivariate correlations (two-tailed) for parents and teachers respectively to inform the subsequent regression analyses. SCT dimensions that significantly correlated with academic achievement or impairment ($p<.05$) were retained for multivariate analyses conducted in Mplus Version 6.11 (Muthén & Muthén, 1998–2012). We controlled for IQ, inattention and hyperactivity/impulsivity mean scores from the VADPRS and VADTRS, and externalizing and internalizing disorders [ODD/CD diagnosis and Anxiety/Depressive diagnosis were each coded as 0 (no comorbidities) or 1 (an ODD or CD diagnosis, or any comorbid Anxiety or Depressive disorder)] given their previous associations with SCT. For the teacher and parent data separately, we regressed all the outcome measures on the predictors simultaneously in order to determine the unique associations of the predictors with the outcomes. This analysis simultaneously estimates the prediction of each of the dependent variables from the independent variables, taking into account the inter-correlations among both the independent variables and dependent variables. Notably, the bivariate associations between SCT, inattention, hyperactivity, comorbidities, and IQ did not exceed $r=.70$ and formal tests for multicollinearity (Variance Inflation Factor - all values<10, Tolerance - all values<.01) were within acceptable limits suggesting no significant redundancy among the predictors.

Missing data varied across measures with up to 3.6% of the sample missing at least one parent measure (SCT or VADPRS), and up to 32% of the sample missing at least one teacher measure (SCT or VADTRS). Tests of patterns of missingness suggested data were missing completely at random (Little's MCAR test: $\chi^2=156.7$, $df=140$, $p=.16$). Comparison of participants who did and did not have teacher data revealed that the groups did not differ significantly with regards to age, IQ, gender, race, income, or comorbidities (all ps>.10). Missing data for the simultaneous regressions was handled via maximum likelihood parameter estimation which is robust to non-normality (Enders, 2010; Graham, 2012; Muthén & Muthén, 1998–2012).

3. Results

3.1 Bivariate analyses

Bivariate correlations for parent ratings of SCT and impairment are reported in Table 2, and for teacher ratings of SCT and impairment in Table 3. Not surprisingly, Total SCT and SCT dimensions were strongly correlated (parent ratings rs=.72-.86; teacher ratings rs=.80-.86). SCT dimensions were moderately to strongly (parent ratings rs=.40-.50; teacher ratings rs=.45-.57) correlated with each other (see Tables 2–3). Given the high correlations (and item redundancy) between Total SCT and SCT dimensions, analyses were run separately for Total SCT and SCT dimensions. Of note, SCT, both as a unidimensional and multidimensional construct, has been shown to be strongly correlated with ADHD inattentive symptoms [see

(Becker, et al., 2016)]. In the present study, SCT and ADHD inattention were moderately to strongly associated as well (*r*s = .28-.63 for parent ratings; *r*s = .27-.72 for teacher ratings, all *p*s < .01). Across both parent and teacher ratings, Total SCT was strongly correlated with ADHD inattention. Of the SCT dimensions, parent and teacher Sleepy symptoms evidenced the smallest correlation with ADHD inattention, whereas parent and teacher SCT Slow symptoms evinced the largest correlations (see Tables 2–3). Nevertheless, the magnitude of the associations between the SCT dimensions and ADHD inattentive symptoms in our study are not so high as to indicate that they are redundant constructs and are in the range of what we would expect based on a recent meta-analysis (Becker et al., 2016).

3.1.1 Parent.—As shown in Table 2, parent ratings of Slow were significantly associated with lower Word Reading, Numerical Operations and Spelling achievement scores as well as with greater ratings of impairment in all academic subjects. Slow was also significantly, negatively correlated with IQ and positively correlated with ADHD symptoms and comorbid diagnosis with ODD/CD and Anxiety/Depression. Ratings of Sleepy were significantly, positively associated with ratings of overall school and mathematics impairment, inattention symptoms, and comorbid diagnosis with Anxiety/Depression. Parent ratings of Daydreamy were significantly also positively associated with mathematics impairment ratings and inattention symptoms.

3.1.2 Teacher.—As shown in Table 3, teacher ratings of Slow were significantly associated with lower Word Reading, Numerical Operations, and Spelling achievement as well as greater ratings of impairment in all academic domains. Teacher Slow was significantly, negatively associated with IQ and positively associated with ADHD symptoms. Similarly, teacher ratings of Sleepy were significantly positively associated with inattention symptoms. Teacher ratings of Daydreamy were significantly positively associated with mathematics and writing impairment ratings, inattention symptoms, and comorbid diagnosis with ODD/CD.

3.2 Simultaneous regression analyses

3.2.1 SCT total analyses

3.2.1.1. Parent model.: Total SCT was entered as a predictor of all parent reported impairment ratings based on bivariate correlations. Total SCT was a significant predictor of overall school [B (SE) = .30 (.13), *p*=.018; β (SE) = .16, *p*=.021], writing [B (SE) = .21 (.07), *p*=.0003; β (SE) = .21, *p*=.003], and mathematics [B (SE) = .39, *p* = .005; β (SE) =.18 (.07), *p* = .006] but not reading [B (SE) = .08, *p* = .625; β (SE) = .03, p = .624] ratings of impairment after controlling for ADHD symptoms, IQ, and comorbidities.

As an exploratory analysis, we examined age and gender as potential moderators of the relationship between Total SCT and academic impairment ratings. This involved including the interaction term between Total SCT and each moderator in separate analyses. Prior to creating the interaction terms all continuous variables were grand mean centered. The interaction term for age in the prediction of parent-ratings of mathematics impairment was significant. The nature of the significance of the interaction term was examined by creating two age groups: younger (6–9 years old; *n*=179) and older (10–12 years old; *n*=71). The

multigroup modeling of the previously described simultaneous regression model was used to examine whether the influence of Total SCT on mathematics impairment differs in young children and older children by running a free model where all paths are free to vary across the two age groups and a constrained model were all paths are forced to equality. Chi-square values from both models were compared using a chi-square difference test where a significant change in chi-square indicates that the two groups differ from one another. Results suggested that the two age groups did not significantly differ from one another ($\Delta\chi^2$=31.10, Δdf=28 p=.31). The interaction term for gender was non-significant.

3.2.1.2. Teacher model.: Based on bivariate correlations, Total SCT was entered as a predictor for Numerical Operations and teacher impairment ratings of reading and writing. Total SCT was not a significant predictor of any academic outcomes when entered in a model with ADHD symptoms, IQ, and comorbidities. Exploratory moderation analyses were non-significant when using teacher Total SCT.

3.2.2 SCT dimensional analyses

3.2.2.1. Parent model.: Based on the bivariate analyses, Slow was entered as a predictor for Word Reading, Numerical Operations, and Spelling, and reading impairment ratings. Both Slow and Sleepy were entered as predictors for overall school impairment and writing impairment. Finally, Slow, Sleepy, and Daydreamy were entered as predictors for mathematics impairment. Even after controlling for parent-rated ADHD symptoms, comorbidities, and IQ, Slow remained significantly associated with poorer achievement in Word Reading and Spelling, but not Numerical Operations (Table 4), and with parent-rated overall school impairment, and impairment in reading, writing, and mathematics. Sleepy and Daydreamy were not significantly associated with academic impairment when IQ, parent rated ADHD symptom severity, comorbidity, and Slow were included in the analysis. Exploratory analyses examining potential moderators (age, gender) of the relation between Slow and achievement were non-significant with the exception of a significant interaction between Slow and age in predicting parent-rated mathematics impairment. As previously described, multigroup modeling (younger = 6–9 years old [n=179] and older = 10–12 years old [n=71]) was used to follow-up the significant Slow × age interaction. The constrained model had a significantly higher chi-square value than the free model ($\Delta\chi$2=75.535, Δdf=53 p=.02) suggesting that the relationship between Slow and mathematics impairment was different across the two age groups. In the model where all paths were free, SCT symptoms significantly predicted mathematics impairments in the younger group [B (SE) = .68 (.17); β (SE) = .36 (.36); p=.0003] but not the older group [B (SE) = −.21 (.28); β (SE) = −.12 (−.12); p=.44)].

3.2.2.2. Teacher model.: Based on the bivariate analyses, Slow was entered as a predictor for Word Reading, Numerical Operations, and Spelling, as well as ratings of reading impairment. Slow and Daydreamy were entered as predictors for mathematics and writing impairment. Even after controlling for teacher-rated ADHD symptom severity, comorbidities, and IQ, Slow symptoms remained significantly associated with poorer academic achievement in Spelling and Numerical Operations (ps <.05) and greater impairment in writing (Table 5). Daydreamy was not significantly associated with academic

impairment when IQ, teacher rated ADHD symptom severity, comorbidity, and Slow were included in the analysis. Exploratory moderation analyses were non-significant when using teacher-reported SCT symptom dimensions.

4. Discussion

The purpose of this study was to examine whether SCT as a unidimensional construct (SCT Total) and specific SCT dimensions (Slow, Sleepy, Daydreamy) were associated with academic achievement scores and ratings of academic impairment in children with ADHD. SCT Total predicted ratings but not objective measures of academic difficulties and this was only true for parent-reported ratings and not teacher ratings. In contrast, the Slow dimension of SCT, which includes apathy/disinterest, slowed pace, low motivation and initiative, and quickly fading effort, appears to be especially relevant for understanding the academic difficulties of children with ADHD.

4.1 SCT and ratings of academic impairment

A recent meta-analysis evaluating the internal and external validity of SCT called for additional research to clarify whether SCT is best conceptualized as a unidimensional or multidimensional construct (Becker, et al., 2016). The present investigation responds to this call by including both Total SCT and SCT dimensions in our analyses. Parent SCT Total was not bivariately correlated with objective measures of academic functioning whereas it was a significant predictor of all parent-reported impairment ratings even after controlling for symptoms of ADHD, IQ and comorbidities. Although teacher SCT Total was bivariately correlated with numerical operations as an objective measure of problems in mathematics and with subjective measures of problems in reading and writing these relationships were no longer significant once ADHD symptoms, IQ and comorbidities were controlled for in a simultaneous regression model. In this study, SCT Total appeared have little external validity with academic achievement scores (consistent with the findings of Bauermeister et al., 2012; Langberg et al., 2014; and Marshall et al., 2014; cf. Willcutt et al., 2014) and only uniquely predicted subjective ratings of academic impairment and only when using parent ratings. However, additional research is needed, particularly with other forms of external validity (e.g., social impairments, executive functioning), before a definitive conclusion can be made regarding whether SCT is best captured by a single factor or multiple factors.

Parent-rated SCT Slow symptoms were strongly associated with parent-reported impairment across all academic domains, even after accounting for the contribution of ADHD, comorbidities, and IQ. Similarly, teacher-rated SCT Slow was significantly associated with impairment in writing. Several studies using clinical and community samples have also shown an association between the Slow dimension of SCT and parent and teacher ratings of academic impairments (Bernad, et al., 2014; Fenollar Cortés, et al., 2014; Jacobson, et al., 2012; Langberg, et al., 2014; Lee, Burns, Snell, & McBurnett, 2014) as well as between Slow and school grades (Langberg, et al., 2014). Interestingly, Slow symptoms are uniquely associated with problems in metacognitive executive functioning domains such as planning and organization (Becker & Langberg, 2014), and these metacognitive domains are in turn linked to poor academic performance in children with ADHD (Langberg, Dvorsky, & Evans,

2013). Future research will need to examine whether metacognitive deficits mediate the association between Slow and academic impairment.

4.2 SCT and academic achievement

This is the first study to examine separate SCT dimensions in relation to academic achievement scores. Higher parent ratings of Slow were associated with difficulties in reading single words accurately (Word Reading) and higher parent and teacher ratings of Slow were associated with difficulties spelling dictated words (Spelling). This is consistent with previous studies (Hartman, et al., 2004; Willcutt, et al., 2014) showing an association between SCT and reading problems and suggests that children with low motivation, high levels of disinterest, and a slow work pace are especially likely to experience reading difficulties.

Although previous studies have found SCT to be associated with lower math achievement (Bauermeister, et al., 2012; Hartman, et al., 2004), we did not find evidence for parent-rated SCT Slow symptoms to remain associated with math achievement after controlling for covariates. However, we did find evidence for teacher-rated Slow symptoms to remain significantly associated with poorer math achievement. Our results for parent raters are most consistent with those of Marshall and colleagues (Marshall, et al., 2014) who did not find parent-rated SCT to impact WIAT-III Numerical Operations performance in children with ADHD. However, Willcutt et al. (Willcutt, et al., 2014) used a composite of SCT using both parent and teacher ratings and found SCT to remain significantly associated with math achievement, even after controlling for IQ. Thus, it may be that teacher-rated SCT is more strongly associated than parent-rated SCT with math achievement. Although it is clear that both parents and teachers can reliably assess SCT (Becker, et al., 2016), it is possible that teachers are somewhat better able than parents to distinguish SCT from ADHD symptoms (Garner, et al., 2010; McBurnett, Pfiffner, & Frick, 2001). Moreover, SCT Slow symptoms likely interfere with how quickly or accurately a child completes their math work, particularly in the classroom setting in which teachers have ample opportunities to observe (e.g., “Students, complete this worksheet and then line up for lunch”). As discussed in more detail below, additional studies are needed that evaluate which rater is optimal for assessing SCT and/or more predictive of math performance. Future studies should also evaluate whether SCT is uniquely associated with certain domains of math achievement but not others (e.g., computation versus reasoning). Finally, future work is needed to replicate the finding from our exploratory moderator analyses showing that the effect of SCT Slow symptoms on parent-rated math impairment was stronger for younger children than older children; this finding is somewhat surprising given that academic work is typically more challenging as children grow older and one might expect findings in the opposite direction.

Interestingly, SCT Daydreamy symptoms were not significantly bivariately correlated with any objective measure of academic achievement. Daydreamy was associated with parent-reported impairment ratings for mathematics, but not reading, writing, or overall school impairment, and with teacher-reported impairment ratings for mathematics and writing; however, these significant associations were reduced to non-significance after accounting for covariates in the models. Fenollar Cortés et al. (Fenollar Cortés, et al., 2014) reported a

significant bivariate correlation between the Daydreamy symptoms of SCT (i.e., Inconsistent Alertness) and a parent-report measure of learning problems. However, this association was reduced to non-significance in a regression analysis that also included Slow and inattentive symptoms. Thus, our findings correspond with those of Fenollar Cortés et al. (2014) in demonstrating Slow to have a more detrimental effect than Daydreamy on the academic functioning of children with ADHD.

4.3 SCT slow symptoms in relation to ADHD inattention and amotivation

Findings from this study must be considered in light of the fact that the SCT Slow scale consists of items that have mixed evidence in terms of discriminant validity with ADHD inattention. Specifically, some of the items on the Slow factor (i.e., lacks initiative, effort fades quickly, needs extra time for assignments, slow work/task completion) were shown to have lower internal validity than the items assessing apathy and motivation in a recent meta-analysis investigating SCT (Becker, et al., 2016). It is clear that SCT is strongly correlated with inattention (Willcutt, et al., 2012), and in our study SCT Slow was strongly correlated with ADHD inattention (parent r=.63, teacher r=.72) while Sleepy (parent r=.28, teacher r=.27) and Daydreamy (parent r=.38, teacher r=.58) were more moderately correlated with inattention. Moreover, in the initial validation study of the SCT Scale used in this study, parent-rated Slow symptoms were identified as one of three SCT dimensions, but these SCT items loaded with ADHD inattention items in a subsequent factor analysis (Penny, et al., 2009), consistent with findings from studies using other measures of SCT that included items assessing initiative and needing more time to complete tasks (Barkley, 2013; Lee, et al., 2014). Nonetheless, it is important to note that studies using the *Child and Adolescent Disruptive Behavior Inventory* (CADBI) have found SCT slowness to be distinct from ADHD (Bernad, et al., 2014; Fenollar Cortés, et al., 2014). The CADBI Slow items include slowed behavior, slowed thinking, and drowsiness, whereas the SCT Scale used in this study includes slowness as well as items assessing apathy, motivation, and initiative. It is possible that these latter items more closely correspond with ADHD inattention whereas the items assessing slowness/drowsiness specifically are more useful for identifying aspects of SCT that are distinct from ADHD [see also (Barkley, 2013; McBurnett, et al., 2014)]. Regardless, studies that have simultaneously examined SCT slowness and inattention have found Slow to significantly predict greater academic problems (Bernad, et al., 2014; Fenollar Cortés, et al., 2014; Jacobson, et al., 2012; Langberg, et al., 2014) and metacognitive executive functioning deficits (Becker & Langberg, 2014). Our study joins this growing body of research by showing Slow to be a stronger predictor of both academic achievement and impairment than inattention in children with ADHD.

Likewise, given that the SCT Slow dimension includes items assessing apathy, motivation, initiative, and effort, it will be important for future research to evaluate the extent to which the SCT Slow dimension relates to or overlaps with other constructs assessing student motivation and engagement. That is, studies to date have focused on distinguishing SCT from other psychopathology domains such as ADHD, depression/anxiety, and daytime sleepiness (Becker, et al., 2016), but it is likewise important to determine if SCT – or specific aspects of SCT – can be distinguished from amotivation. This is especially important given the large literature linking low student motivation and engagement to poorer

academic functioning (Malmberg, Walls, Martin, Little, & Lim, 2013; Wang & Holcombe, 2010). In addition, no interventions have been developed for SCT specifically, and it may be useful for intervention work in this area to draw from interventions targeting student amovitation (Cheon & Reeve, 2015; Hidi & Harackiewicz, 2000). In sum, additional research is warranted to disentangle the complicated overlapping of SCT Slow symptoms in relation to ADHD inattention and amotivation, and whether specific items within the Slow factor are more strongly predictive of academic impairment than others.

4.4 ADHD symptoms in relation to academics

At the bivariate level, parent and teacher ratings of impairment were significantly associated with parent and teacher-rated symptoms of ADHD inattention. In addition, achievement scores were significantly associated with teacher-rated inattention. However, inattention symptoms were not meaningful predictors of academic functioning in a model containing SCT dimensions and covariates. In fact, in a few instances symptoms of ADHD predicted better academic functioning. This finding is most likely due to a suppression effect as this is not consistent with a large body of literature documenting a strong relationship between ADHD and academic functioning as indicated by rating scales and achievement tests (Willcutt, et al., 2013).

4.5 Limitations and future directions

We did not have information on other indicators of academic functioning, including learning disability status, homework completion, organization, and grades. Future studies should include comprehensive measures of impairment rather than the single items used in this study, as well as broader achievement batteries that include subtests measuring higher order skills (e.g., math reasoning, reading comprehension) and fluency/productivity. Rater variance may have inflated the relation between SCT and academic impairment ratings. Indeed, the magnitude of correlations was higher between SCT and impairment ratings (average absolute parent and teacher r=.26 and .20, respectively) than SCT and WIAT scores (average absolute parent and teacher r=.10 and .14, respectively). In addition, our study is consistent with the majority of other studies examining SCT in school-aged children in assessing SCT with parent and teacher rating scales. However, since SCT is clearly associated with internalizing problems (Becker, et al., 2016) for which self-report is generally considered important, future studies would benefit from including child self-report of SCT as part of a comprehensive multi-informant strategy. In line with this approach, a recent study validating a child self-report measure of SCT found child-reported SCT to be significantly associated with children's own ratings of poorer academic functioning (Becker, et al., 2015). Finally, there may have been a restricted range in the ADHD symptoms given our use of a sample of children diagnosed with ADHD. Longitudinal studies are needed in children with and without ADHD to assess the etiological role of SCT symptoms in academic impairment.

4.6 Conclusion

Our findings support the importance of considering SCT multi-dimensionally in understanding academic impairments commonly experienced by children with ADHD, particularly since several studies that did not find a significant impact of SCT on academics

were those that utilized few items to assess SCT or assessed SCT unidimensionally [e.g., (Becker & Langberg, 2013; Carlson & Mann, 2002; Marshall, et al., 2014)]. Our results indicate that SCT Slow symptoms are associated with academic problems in children with ADHD, though more work is needed to better understand the nature of SCT Slow symptoms in relation to ADHD inattention and amotivation. It appears SCT is important to assess clinically and may be an appropriate target for intervention. Treatment of SCT symptoms may differ from the treatment of ADHD, particularly for those children with elevations on the SCT Slow dimension (Becker, et al., 2014). For example, extended time on tests and tasks may be contraindicated for children with ADHD inattention due to their higher rates of distractibility; however, it may be beneficial for SCT Slow children who maintain effort while working but are unable to complete tasks within the given time constraints, particularly if efforts are continuously monitored and reinforced.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

SCT Items and Factor Loading for Parents and Teachers

SCT Item	Penny et al., 2009 Parent Factor	Jacobson et al., 2012 Teacher Factor
Apathetic	Slow	Slow
Unmotivated	Slow	Slow
Lacks initiative	Slow	Slow
Effort fades quickly	Slow	Slow
Needs extra time for assignments	Slow	Daydreamy
Slow/delayed in completing tasks	Slow	Daydreamy
Underactive/slow moving	Sleepy	Sleepy
Sluggish	Sleepy	Sleepy
Drowsy	Sleepy	Sleepy
Appears tired/lethargic	Sleepy	Sleepy
Yawning/stretchy/sleepy-eyed	Sleepy	Sleepy
Daydreams	Daydreamy	Daydreamy
Lost in own thoughts	Daydreamy	Daydreamy
World of his/her own	Daydreamy	Daydreamy

Table 2

Inter-correlations and Descriptive Statistics– Parent Variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. SCT Total	--															
2. Slow	.86**	--														
3. Sleepy	.79**	.50**	--													
4. Daydreamy	.72**	.44**	.40**	--												
5. Word Reading	−.08	−.17**	−.07	.10	--											
6. Numerical Operations	−.06	−.14*	−.03	.06	.52**	--										
7. Spelling	−.08	−.17**	−.06	.09	.85**	.54**	--									
8. Overall School Impair	.31**	.44**	.19**	−.03	−.44**	−.35**	−.43**	--								
9. Reading Impair	.13**	.26**	.03	−.04	−.63**	−.33**	−.53**	.60**	--							
10. Writing Impair	.28**	.39**	.14*	.06	−.39**	−.24**	−.36**	.58**	.56**	--						
11. Mathematics Impair	.35**	.43**	.20**	.14*	−.28**	−.42**	−.25**	.69**	.43**	.45**	--					
12. IQ	−.15**	−.27**	−.10	.09	.51**	.52**	.45**	−.41**	−.41**	−.24**	−.43**	--				
13. Inattention Symptoms	.56**	.63**	.28**	.38**	.02	−.08	.01	.31**	.15*	.25**	.28**	−.011	--			
14. Hyp/Imp Symptoms	.03	.16*	−.11	−.02	−.05	.07	−.02	.07	.02	.12	−.07	.04	.38**	--		
15. Medication Status	.00	−.004	−.03	.05	−.01	−.12	−.09	−.09	−.07	.03	.02	−.03	.03	.04	--	
16. ODD/CD Dx	.10	.16*	.09	−.04	.01	−.02	.02	.08	.05	−.04	.06	−.06	.24**	.32**	.09	--
17. Anx/Depressive Dx	.27**	.28**	.24**	.09	.06	.04	.06	.08	−.03	.01	.06	−.04	.20**	.08	.15*	.11
Mean	1.1	1.5	0.4	1.2	95.8	94.7 14.6	95.3 14.3	3.6	3.4	3.8	3.4	100.4	2.2	1.6	n/a	n/a
SD	0.5	0.6	0.6	0.9	15.3			1.1	1.3	1.0	1.2	14.5	0.6	0.8		
n	243	243	243	243	252	252	252	249	249	249	249	252	250	250	252	252

Note. Impair=Impairment; Hyp/Imp=hyperactivity/impulsivity; ODD=oppositional defiant disorder; CD=conduct disorder; Anx=anxiety; DX=diagnosis.

*p<.05.

**p<.01. Medication status was coded as 0 (not on medication) or 1 (on medication).

Table 3

Inter-correlations and Descriptive Statistics– Teacher Variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. T SCT Total	--														
2. T Slow	.80**	--													
3. T Sleepy	.80**	.45**	--												
4. T Daydreamy	.86**	.57**	.51**	--											
5. Word Reading	−.12	−.25**	.03	−.08	--										
6. Numerical Operations	−.21**	−.31*	−.08	−.14	.52**	--									
7. Spelling	−.09	−.23**	.04	−.06	.85**	.54**	--								
8. T Reading Impair	.13	.21**	.002	.12	−.61**	−.37**	−.50**	--							
9. T Mathematics Impair	.26**	.33**	.10	.24**	−.43**	−.50**	−.41**	.70**	--						
10. T Writing Impair	.32**	.46**	.08	.28**	−.52**	−.39**	−.46**	.63**	.58**	--					
11. IQ	−.17**	−.27**	−.06	−.12	.51**	.52**	.45**	−.57**	-.66**	−.40**	--				
12. T Inattention Symptoms	.63**	.72**	.27**	.58**	−.16*	−.19*	-.09	.21**	.26**	.42*	−.17*	--			
13. T Hyp/Imp Symptoms	.04	.24**	−.20	.08	−.07	.09	−.06	−.03	−.13	.12	.07	.46**	--		
14. Medication Status	−.02	−.03	.02	−.03	−.01	−.12	−.09	−.11	.03	.06	−.03	−.004	.002	--	
15. ODD/CD Dx	−.05	.08	−.01	−.16*	.01	−.02	.02	.05	.04	.04	−.06	.07	−.01	.09	--
16. Anx/Depressive Dx	.002	.01	.08	−.08	.06	.04	.06	−.20**	−.06	−.12	−.04	−.09	−.15	.15*	.11
Mean	2.3	2.6	1.7	2.6	95.8	94.7 14.6	95.3 14.3	3.6	3.6	3.9	100.4	2.0	1.1	n/a	n/a
SD	0.7	0.9	0.8	0.9	15.3			1.1	1.0	0.9	14.5	0.8	0.9		
n	174	174	174	174	252	252	252	172	170	172	252	172	172	252	252

Note. T=Teacher; Impair=Impairment; Hyp/Imp=hyperactivity/impulsivity; ODD=oppositional defiant disorder; CD=conduct disorder; Anx=anxiety; DX=diagnosis.

* $p<.05$.

** $p<.01$. Medication status was coded as 0 (not on medication) or 1 (on medication).

Table 4

Parent Regression Model

	Achievement			Impairment			
	Word Reading	**Numerical Operations**	**Spelling**	**Overall School**	**Reading**	**Writing**	**Mathematics**
	R^2=.28	R^2=.26	R^2=.22	R^2=.30	R^2=.20	R^2=.22	R^2=.35
	Estimate (S.E.)	**Estimate (S.E.)**	**Estimate (S.E.)**	**Estimate (S.E.)**	**Estimate (S.E.)**	**Estimate (S.E.)**	**Estimate (S.E.)**
SCT Slow	−0.61 (0.29) * [−.16]	0.02 (0.29) [.01]	−0.64 (0.27) * [−.17]	0.08 (0.02) ** [.30]	0.06 (0.03) * [.18]	0.09 (0.02) ** [.35]	0.08 (0.02) ** [.26]
SCT Sleepy	--	--	--	0.01 (0.02) [.03]	--	0.01 (0.02) [.03]	−0.01 (0.02) [−.01]
SCT Daydreamy	--	--	--	--	--	--	0.04 (0.02) [.09]
Inattention	4.91 (1.99) * [.19]	−1.57 (1.88) [−.06]	4.24 (1.84) * [.17]	0.16 (0.15) [.09]	0.03 (0.18) [.01]	0.02 (0.15) [.01]	0.22 (0.15) [.11]
Hyperactivity/Impulsivity	−2. 18 (1.19) * [−.14]	1.21 (1.00) [.06]	−1.89 (1.09) [−.10]	0.01 (0.09) [.01]	0.00 (0.12) [0.0]	0.16 (0.09) [.12]	−0.23 (0.10) * [−.15]
ODD/CD Diagnosis	1.99 (2.00) [.06]	0.03 (2.06) [0.0]	1.72 (1.91) [.05]	−0.03 (0.15) [−.01]	0.02 (0.18) [.01]	−0.32 (0.14) ** [−.14]	0.05 (0.15) [.02]
Anxiety/Depressive Diagnosis	4.38 (2.68) [.09]	3.08 (2.06) [.07]	4.50 (2.28) * [.10]	−0.13 (0.15) [−.04]	−0.41 (0.23) [−.10]	−0.35 (0.17) * [−.10]	−0.20 (0.19) [−.05]
IQ	0.53 (.05) ** [.51]	0.51 (.05) ** [.52]	0.43 (0.06) ** [.44]	−0.02 (0.00) ** [−.34]	−0.03 (.01) ** [−.37]	−0.01 (0.00) ** [−.18]	−0.03 (0.00) ** [−.39]

Note. SCT=sluggish cognitive tempo; ODD=oppositional defiant disorder; CD=conduct disorder. All estimates are unstandardized. Standardized estimates presented in [brackets]. S.E,=standard error, --=not included in the model based on bivariate correlations.

* p<.05.

** p<.01.

Table 5

Teacher Regression Model

	Achievement			Impairment		
	Word Reading	**Numerical Operations**	**Spelling**	**Reading**	**Mathematics**	**Writing**
	R^2=.28	R^2=.34	R^2=.24	R^2=.37	R^2=.50	R^2=.33
	Estimate (S.E.)	**Estimate (S.E.)**	**Estimate (S.E.)**	**Estimate (S.E.)**	**Estimate (S.E.)**	**Estimate (S.E.)**
Teacher SCT Slow	−2.99 (1.73) [−.17]	−3.45 (1.48) * [−.21]	−3.86 (1.61) * [−.24]	−.01 (0.11) [−.01]	0.10 (0.09) [.09]	0.25 (0.10) * [.25]
Teacher SCT Sleepy	--	--	--	--	--	--
Teacher SCT Daydreamy	--	--	--	--	0.05 (0.08) [.04]	0.02 (0.08) [.02]
Teacher Inattention	1.99 (2.06) [.10]	−0.13 (1.64) [−.01]	3.83 (1.97) [.21]	0.19 (0.13) [.13]	0.19 (0.12) [.15]	0.21 (0.14) [.18]
Teacher Hyperactivity/Impulsivity	−1.68 (1.23) [−.10]	2.02 (1.00) * [.13]	−1.88 (1.25) [−.12]	−0.10 (0.10) [−.08]	−0.23 (0.07) ** [−.20]	−0.01 (0.08) [−.01]
ODD/CD Diagnosis	1.31 (1.83) [.04]	0.51 (1.89) [.02]	0.44 (0.06) [.04]	0.02 (0.14) [.01]	−0.02 (0.12) [−.01]	−0.03 (0.13) [−.01]
Anxiety/Depressive Diagnosis	3.50 (2.51) [.07]	3.29 (2.40) [.07]	1.25 (1.72) [.08]	−0.76 (0.25) ** [−.21]	−0.27 (0.12) [−.08]	−0.32 (0.25) [−.11]
IQ	0.53 (0.05) ** [.51]	0.48 (0.05) ** [.49]	0.44 (0.05) ** [.45]	−0.04 (0.01) ** [−.56]	−0.04 (0.00) ** [−.61]	−0.02 (0.00) ** [−.32]

Note. SCT=sluggish cognitive tempo; ODD=oppositional defiant disorder; CD=conduct disorder. All estimates are unstandardized. Standardized estimates presented in [brackets]. S.E.=standard error, --=not included in the model based on bivariate correlations.

* p<.05.

** p<.01.