January 2022

Sluggish Cognitive Tempo In A Pediatric Population

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SLUGGISH COGNITIVE TEMPO IN A PEDIATRIC POPULATION

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A Dissertation

Submitted to the Graduate Faculty

of the

University of North Dakota

in partial fulfillment of the requirements

for the degree of

Doctor of Philosophy

Grand Forks, North Dakota

August 5, 2022

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September 24, 2021

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ACKNOWLEDGEMENTS

I wish to express my gratitude to my adviser, Dr. Joseph Miller, who not only served as my dissertation chair but was a constant source of support and encouragement throughout my graduate career. I would also like to thank Dr. Thomas Petros, Dr. John Paul Legerski, Dr. Richard F. Ferraro, and Dr. Kara Wettersten for serving on my Faculty Advisory Committee and offering invaluable feedback. Finally, I deeply appreciate the degree to which my graduate experience was enriched through the bonds I formed with my cohort.

ABSTRACT

Sluggish cognitive tempo (SCT), a constellation of symptoms distinguished by daydreaming and lethargy, was previously thought to be characteristic of ADHD. However, it was found that this set of symptoms consistently loaded onto a separate factor. Increased interest in determining the diagnostic validity of SCT has led researchers to study SCT symptoms in relation to other psychological conditions, as well as various functional outcomes. The present study examined the extent to which SCT predicted poorer functioning across measures of cognition, academic achievement, and social problems above and beyond other factors that have been found to co-occur with SCT and independently relate to reduced performance in the aforementioned domains (e.g., IQ, ADHD symptoms, and internalizing symptoms). In a sample of 114 clinic-referred children and adolescents with and without ADHD diagnoses, two-step hierarchical regression results revealed that teacher rated SCT (n = 89) predicted simple processing speed performance over and above key covariates (IQ, ADHD symptoms, and internalizing symptoms). However, teacher ratings of SCT did not significantly relate to math computation performance or teacher rated social problems after adjusting for covariates. These results highlight the importance of continuing to explore potential functional deficits associated with SCT while being mindful of how other related factors, such as IQ, ADHD, and internalizing symptoms may influence those associations.

Keywords: Sluggish Cognitive Tempo, Attention-Deficit Hyperactivity Disorder, neuropsychological performance, social problems, internalizing symptoms, IQ

CHAPTER I

INTRODUCTION

Sluggish Cognitive Tempo

Sluggish Cognitive Tempo (SCT), a relatively recent concept, is characterized by sluggishness/drowsiness and daydreaming, and is thought to occur in approximately 11% of the population (Camprodon-Rosanas et al., 2017). In the Diagnostic and Statistical Manual of Mental Disorders, Third Edition (DSM-III), these symptoms were included as diagnostic criteria for Attention Deficit Disorder without Hyperactivity. However, researchers found that a lack of these symptoms were not significantly predictive of an absence of inattention, and were thus eliminated from the diagnostic criteria for Attention-Deficit/Hyperactivity Disorder Predominantly Inattentive Type (ADHD-IN) in the DSM-IV (McBurnett, Pfiffner, & Frick, 2001). Though SCT has been repeatedly demonstrated to have an association with ADHD-IN, it has been proposed by many researchers to be a separate construct, prompting social scientists to explore its potential diagnostic validity (Becker, Leopold, et al., 2016; Garner et al., 2017; McBurnett et al., 2001).

Recent research has led to greater characterization and understanding of this cluster of symptoms (Leopold et al., 2016). For instance, in order to identify core SCT symptoms from the various measures developed and utilized across 26 studies, a meta-analysis was conducted, finding that 13 items reliably loaded onto a single SCT factor. Four of these items demonstrated moderate to good internal consistency (appears to be in

a fog, daydreams, lethargic, and hypoactive; Becker, Leopold, et al., 2016). Measures developed to assess these symptoms have adequate test-retest reliability. In a study by Leopold et al. (2016) the parents of preschool-aged children completed a rating scale assessing SCT and ADHD symptoms following the completion of preschool, kindergarten, first grade, second grade, fourth grade, and ninth grade. Over a 10-year period, SCT symptoms were found to be generally stable, increasing slightly with age (Leopold et al., 2016). Similar results were obtained by researchers who collected parent or teacher ratings of SCT symptoms for children at six weeks to two years following the initial sampling (Bernad, Servera, Becker, & Burns, 2016; Bernad, Servera, Grases, Collado, & Burns, 2014; Burns, Servera, Bernad, Carrillo, & Cardo, 2013). Additionally, in studies examining inter-rater reliability, correlations of child/adolescent SCT symptom ratings between child caregivers, parents and teachers, teachers and classroom aids, and children and teachers have been moderate to strong (Becker, Leopold, et al., 2016; Becker, Luebbe, & Joyce, 2015; Bernad et al., 2014; Burns et al., 2013).

In relation to certain demographic correlates of SCT, the results are somewhat mixed. Many studies investigating sex disparities in SCT symptoms have failed to find significant differences between males and females (Becker, Burns, Schmitt, Epstein, & Tamm, 2017; Becker et al., 2013; Becker, Garner, Tamm, Antonini, & Epstein, 2019; Becker, Luebbe, Fite, Stoppelbein, & Greening, 2014; Bernad et al., 2014; Burns et al., 2013). Of the studies that did show variability, most tended to report higher incidences of SCT symptoms among males, while females were more likely to demonstrate greater levels of SCT (Becker, 2014; Becker, Leopold, et al., 2016; Camprodon-Rosanas et al., 2017; Khadka, Burns, & Becker, 2015). However, given the high co-occurrence of SCT

symptoms with ADHD, and lack of studies in which statistical control of ADHD symptoms was employed, it is uncertain as to whether comorbid ADHD symptoms might be underlying the observed differences (Becker, Leopold, et al., 2016; Camprodon-Rosanas et al., 2017). At present, few studies have explored the potential relationship between SCT and sociodemographic characteristics. Children with lower socioeconomic status and parents who reported lower levels of educational attainment tended to have significantly higher parent-rated SCT symptoms in two studies (Barkley, 2013; Camprodon-Rosanas et al., 2017). Additionally, the majority of research has found little to no difference across racial or ethnic groups in regard to prevalence of SCT symptoms (Barkley, 2013; Garner, Marceaux, Mrug, Patterson, & Hodgens, 2010). Interest in establishing further knowledge of clinically and functionally related factors to SCT has also increased over time. In addition to SCT's relationship with ADHD and inattentive symptoms, the current literature also suggests that SCT is associated with certain patterns in cognitive and academic performance, social functioning, and internalizing symptoms (Becker, Leopold, et al., 2016; Jacobson, Geist, & Mahone, 2018; Jacobson & Mahone, 2018; Tamm, Brenner, Bamberger, & Becker, 2018).

SCT in Relation to Cognitive, Academic, and Social Functioning

SCT has been shown to relate to decreased performance on several neuropsychological measures in pediatric samples. Past research has demonstrated a relatively stable association between elevated SCT symptoms and poorer sustained attention after controlling for inattentive and hyperactive/impulsive symptoms (Becker, Leopold, et al., 2016; Wahlstedt & Bohlin, 2010). Whereas, higher levels of SCT symptoms have been inconsistently related to slowed processing speed and decreased

mental flexibility (Baytunca et al., 2018; Tamm et al., 2018; Willcutt et al., 2014). One 2019 study also found that greater levels of SCT symptoms significantly correlated with a decrease in overall memory score after accounting for ADHD symptoms (Unsel-Bolat et al., 2019). Of note, most of the literature has focused on assessing executive functioning and attention, with few studies employing more comprehensive neuropsychological batteries (Becker, Garner, & Byars, 2016).

SCT symptoms have also been linked to academic problems, such as reduced homework completion, overall teacher-rated classroom performance, and lower achievement in specific areas, like mathematics and writing (Bauermeister, Barkley, Bauermeister, Martinez, & McBurnett, 2012; Langberg, Becker, & Dvorsky, 2014; Marshall, Evans, Eiraldi, Becker, & Power, 2014; Smith, Breaux, Green, & Langberg, 2018; Tamm et al., 2016). In addition, SCT symptoms have been shown to be significantly positively correlated with social withdrawal and isolation in children and adolescents in multiple studies (Becker et al., 2019; Bernad et al., 2016; Ferretti, King, Hilton, Rondon, & Jarrett, 2019). Taken together, it appears that SCT symptoms could have a significant bearing on a variety of functional domains. However, given the strong association between SCT and a number of psychological/neuropsychiatric factors, it is unclear as to how much of a contribution SCT makes to the aforementioned areas above and beyond co-morbid conditions. The following sections will address the relationship between SCT and ADHD, IQ, and internalizing symptoms, as well as how these may effect the observed functional deficits in children endorsing SCT symptoms.

SCT and ADHD

ADHD is a neurodevelopmental condition diagnosed in childhood, occurring in approximately three to five percent of the general population, in which symptoms of hyperactivity-impulsivity and/or inattention impair the individuals' ability to function in academic and social contexts (Sharma & Couture, 2014; Song, Dieckmann, & Nigg, 2018). Much of the current literature exploring the relationship between SCT and ADHD has suggested that, while highly comorbid (co-occurring in an estimated 39% to 59% of cases), they are independent constructs (Barkley, 2013; Bernad et al., 2016; Fassbender, Krafft, & Schweitzer, 2015; Garner et al., 2017; Jarrett et al., 2017; McBurnett et al., 2017; McBurnett et al., 2001; Wahlstedt & Bohlin, 2010; Willcutt et al., 2014). A 2001 study exploring the predictive power of SCT symptoms for inattention in a sample of 692 children, which included participants who met criteria for ADHD-IN, as well as healthy controls, found that individual SCT symptoms (forgetful, daydreams, and sluggish/drowsy) demonstrated adequate positive power (.94, .91, and .88, respectively) and negative predictive power (.68, .45, and .58, respectively). However, a subsequent factor analysis performed on inattentive and SCT symptoms, found that SCT symptoms loaded on to a separate factor (McBurnett et al., 2001). In a later study, the caregivers and teachers of children with ADHD completed the Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2000), which includes items used to assess inattentive, hyperactive/impulsive, and SCT symptoms. A factor analysis showed that SCT symptoms did not load on to a general ADHD factor, which encompassed both inattentive and hyperactive/impulsive symptoms, suggesting that SCT is distinct from ADHD (Garner et al., 2017).

ADHD and SCT have also been proposed to have different neurobiological correlates (Fassbender et al., 2015; Jarrett et al., 2017). A study emphasizing the discrepancies between SCT and ADHD examined electroencephalography (EEG) activity during a resting period, following the completion of tests of sustained attention and inhibitory control, as well as questionnaires assessing behavioral and ADHD symptoms. While ADHD and SCT symptoms were significantly negatively related to performance on a task of sustained attention, only ADHD symptoms were significantly correlated with increased theta/beta ratios in frontal and frontocentral cortical areas. SCT was not significantly associated with any of the EEG indices examined (Jarrett et al., 2017). Correspondingly, a study utilizing fMRI during a cued flanker test to examine areas of neural activation associated with SCT and inattention in adolescents with ADHD found that SCT symptoms were related to reduced activity in the left superior parietal lobe, whereas inattentive symptoms were related to increased activity in the supplementary motor area (Fassbender et al., 2015). In addition, recent research has suggested that SCT and ADHD symptoms do not respond comparatively to pharmacological interventions. In a study by McBurnett et al. (2017), SCT and ADHD symptoms were assessed at baseline, and following a 16-week atomextine research trial with children diagnosed with ADHD and dyslexia, or ADHD only. After controlling for ADHD symptoms, there was no significant change detected in SCT symptoms before and after the completion of the trial (McBurnett et al., 2017).

In addition, while some studies have found that neurocognitive functions often associated with ADHD (i.e., working memory, response inhibition, and reaction time

variability) also related to SCT symptoms, others researchers who statistically adjusted for presence of ADHD symptoms were unable to replicate the aforementioned results (Becker, Leopold, et al., 2016; Wahlstedt & Bohlin, 2010; Willcutt et al., 2014). Further, other cognitive domains have been demonstrated to be independently related to SCT symptoms (Wahlstedt & Bohlin, 2010; Willcutt et al., 2014). For example, in a study by Willcutt et al. (2014), SCT uniquely related to poorer performance on tasks of sustained attention, naming speed, and processing speed after controlling for ADHD symptoms, while higher levels of inattention symptoms (as identified by the DSM-IV) were associated with decreased response inhibition and working memory performance, as well as greater response variability upon adjusting for hyperactivity/impulsivity and SCT symptoms. Similar results were reported regarding SCT symptoms and decreased sustained attention in an earlier study by Wahlstedt and Bohline (2010). Mental flexibility and memory performance have also been shown to relate to SCT apart from ADHD symptoms; however, these findings are not consistently represented in the literature (Baytunca et al., 2018; Unsel-Bolat et al., 2019). In a study by Baytunca and colleagues (2018) 83 children diagnosed with ADHD, 42 of which were identified as having co-occurring SCT symptoms, and 24 healthy controls completed tests of attention, cognitive flexibility/shifting, processing and psychomotor speed, and verbal and visual memory (Baytunca et al., 2018). The participants with both ADHD and SCT symptoms performed significantly worse on tasks of attention and mental flexibility than the ADHD without SCT symptoms and control groups (Baytunca et al., 2018). More recently, Unsel-Bolat et al. (2019) found that SCT was only uniquely associated with a lower total memory score, derived from measures of verbal and visual memory, when assessing a

variety of cognitive domains (i.e., memory, psychomotor speed, reaction time, mental flexibility, and complex attention) in children with and without ADHD. These results suggest that ADHD-IN and SCT have distinct neuropsychological profiles, and that co-occurring ADHD symptoms may significantly contribute to observed reductions in some cognitive functions in children with SCT symptoms.

Other studies have suggested that ADHD and SCT are related to different symptom dimensions, and demonstrate varying degrees of impairment over time (Bernad Mdel et al., 2016; Leopold et al., 2016; Servera, Bernad, Carrillo, Collado, & Burns, 2016; Willcutt et al., 2014). Generally, SCT has been associated with higher rates of anxious and depressive symptoms, and decreased social functioning, and to a lesser degree, academic functioning, after accounting for ADHD diagnoses/symptoms (Bauermeister et al., 2012; Becker et al., 2019; Becker & Langberg, 2013; Ferretti et al., 2019; Hartman, Willcutt, Rhee, & Pennington, 2004; Langberg et al., 2014; McBurnett et al., 2014; Servera, Saez, Burns, & Becker, 2018). For instance, Servera and colleagues (2018) reported that children who demonstrated elevated SCT symptoms without meeting criteria for ADHD were assessed as exhibiting more internalizing symptoms, particularly depressive symptoms, and shyness than subjects who were included in an ADHD-only group. In another study examining internalizing symptoms, as well as social and academic impairments in relation to SCT symptoms in children with ADHD, SCT was significantly associated with increased internalizing symptoms and social difficulties, but was not related to academic performance, after adjusting for ADHD symptomatology (Becker & Langberg, 2013). Decreased teacher-rated school functioning and poorer academic achievement in mathematics and writing have been found to be significantly

related to higher levels of SCT symptoms once ADHD was controlled for (Bauermeister et al., 2012; McBurnett et al., 2014; Tamm et al., 2016).

In a longitudinal study by Bernad et al. (2016), children were assessed using teacher and parent rating scales of SCT and ADHD-IN symptoms, Oppositional Defiant Disorder (ODD), anxiety and depression symptoms, academic impairments, and social interaction difficulties at three points (baseline, one year later, and two years later). Higher parent rated SCT symptoms predicted greater levels of internalizing symptoms (anxiety and depressive symptoms), as well as diminished academic and social functioning at both the one and two year intervals. Additionally, teacher rated SCT symptoms was predictive of increased depressive symptoms and social/academic difficulties, and reduced levels of ADHD-HI and ODD (Bernad et al., 2016). Whereas, greater levels of parent-rated ADHD-IN symptoms were predictive of hyperactivity/impulsivity, ODD, and academic problems, and teacher-rated ADHD-IN was associated with a general reduction in function across domains (Bernad et al., 2016). Further, the course of core SCT and ADHD symptoms (inattention and hyperactivity/impulsivity) appear to differ, with SCT symptoms increasing over time, inattentive symptoms holding stable, and hyperactivity/impulsivity symptoms declining over a 10-year period (Leopold et al., 2016).

SCT and IQ

In addition to ADHD and specific cognitive deficits, SCT has also been linked to lower general intellectual functioning (Becker, Leopold, et al., 2016; Hartman et al., 2004; Reeves et al., 2007). In 2004 Hartman and colleagues found that greater parent- and teacher-rated SCT levels were significantly associated with lower full-scale IQ scores

(as assessed using the Wechsler Intelligence Scale for Children-Revised [WISC-R]). Similarly, in a study by Reeves et al. (2007) the amount of SCT symptoms were significantly inversely related to estimated IQ in children with prior acute lymphoblastic leukemia. SCT was also found to be associated with lower estimated intellectual functioning in a meta-analysis by Becker, Leopold, et al. (2016).

Some studies have also reported non-significant relationships between SCT and neuropsychological outcomes/academic functioning after adjusting for IQ (Becker & Langberg, 2013; Willcutt et al., 2014). Willcutt et al. (2014) found that only sustained attention remained significantly associated with SCT after IQ was controlled for in a regression model, whereas prior zero-order correlations showed statistically significant relationships between SCT symptoms and sustained attention, processing and naming speed, working memory, and response variability. Inattention symptoms were shown to continue to significantly relate to diminished response inhibition and working memory performance, as well as increased response variability, after adjusting for IQ (Willcutt et al., 2014). These results may suggest that level of intellectual functioning has a particular influence over the relationship between SCT and cognitive functioning, as assessed via neuropsychological tests.

In another study by Becker and Langberg (2013) examining factors related to academic performance, higher SCT symptoms failed to significantly relate to parent-rated academic difficulties once ADHD symptoms and IQ were controlled for. This is consistent with previous research, which has shown IQ to be significantly associated with academic functioning and achievement beyond other cognitive and psychological factors (Deary, Strand, Smith, & Fernandes, 2007; Mayes & Calhoun, 2007; Mayes, Calhoun,

Bixler, & Vgontzas, 2008). For example, in one study by Mayes and colleagues (2008) IQ was found to be the best predictor of mathematics and reading achievement, when compared to performance on neuropsychological measures of working memory, language fluency, visuomotor and visuospatial abilities, and verbal memory, as well as parent-rated sleep disturbance in a sample of school-aged children.

IQ has pervasive effects on an individual's life, and lower IQ scores have been associated with higher rates of psychological disorders (i.e., major depressive disorder) and diminished social ability (Gigi et al., 2014; Keyes, Platt, Kaufman, & McLaughlin, 2017). In a study by Gigi and colleagues (2014) 76,962 youth classified as borderline intellectual functioning (as defined as an IQ between 71 and 84) were compared with 96,580 similarly aged adolescents within the normal range for intellectual functioning on measures of social functioning. It was found that subjects in the borderline IQ group had significantly lower scores on a subscale of social functioning, even after those who had co-morbid psychiatric disorders were removed from the analyses, when contrasted with the control group (Gigi et al., 2014).

SCT and Internalizing Symptoms

Previous research has also found that internalizing symptoms (i.e., depressive and anxious symptoms) frequently co-occur with SCT (Becker, Leopold, et al., 2016; Bernad et al., 2016; Hartman et al., 2004; Rondon, Hilton, Jarrett, & Ollendick, 2018; Smith & Langberg, 2017). For example, Rondon et al. (2018) examined clinical and demographic factors in relation to diagnostic group (ADHD and SCT, ADHD, and SCT) in a sample of clinic-referred children and adolescents. SCT was discovered to uniquely associate with internalizing symptoms (Rondon et al., 2018). In a similar study by Smith and Langberg

(2019) self-reported sluggish cognitive tempo symptoms in adolescents with ADHD significantly predicted anxiety and depression. Despite the apparent relationship between SCT and externalizing symptoms, current evidence suggests that SCT is likely separate from anxiety and/or depression (Becker et al., 2014; Lee, Burns, Snell, & McBurnett, 2014; Smith, Eadeh, Breaux, & Langberg, 2019). In a recent study by Smith et al. (2019) the authors conducted multiple confirmatory factor analyses, with the results indicating that SCT was distinct from depression, anxiety, and daytime sleepiness.

Though no known studies have investigated the effect of internalizing symptoms on the relationship between SCT and laboratory measures of cognitive functioning, certain internalizing symptoms/disorders have been shown to be highly related to neuropsychological decrements. For example, elevated depressive symptoms have been linked to poorer sustained attention (a function that has been repeatedly demonstrated to negatively correlate with SCT symptoms), in addition to decreased psychomotor and processing speed, and worse spatial working memory performance (Weiland-Fiedler et al., 2004). Additionally, in a study by Han et al. (2016), which explored the effects of depressive and anxious symptoms on executive functioning in adolescents, it was found that level of internalizing symptoms significantly positive correlated to number of perseverative and non-perseverative errors on test of mental flexibility (Wisconsin Card Sorting Test; Heaton & Staff, 2003). Concurrently, Ajilchi and Nejati (2017) found that participants who met criteria for anxiety or depression performed significantly worse of tasks of mental flexibility, set-shifting, and selective attention when compared to healthy controls. There also exists some evidence for diminished memory function in individuals with depression (Liang et al., 2018). When comparing individuals diagnosed with major

depressive disorder to healthy controls, Liang and colleagues (2018) discovered that in addition to sustained attention, shifting, planning, processing speed, and working memory deficits, participants with depression displayed worse visual memory performance. Given the association between SCT and internalizing symptoms, and the documented relationship between mood symptoms and cognitive functioning, it would be reasonable to suspect that anxiety and depression may contribute to the observed patterns in neuropsychological performance in children with SCT (Ajilchi & Nejati, 2017; Ferrin & Vance, 2014; Han et al., 2016; Weiland-Fiedler et al., 2004).

At present, there has also been limited research pertaining to the potential influence of internalizing symptoms on school performance in children with SCT symptoms (Becker, Garner, et al., 2016). One study by Becker, Garner, et al. (2016) SCT symptoms were examined in relation to academic difficulties in children recruited from a sleep disorder clinic. The authors found that once internalizing and ADHD symptoms were controlled for in a multiple regression model, greater SCT symptoms continued to be significantly associated with reduced functioning in the following academic subjects, math, history/social studies, and science (Becker, Garner, et al., 2016). It would be useful to see if these results could be replicated to rule out the possibility of internalizing symptom effecting academic functioning in children with SCT, as depression, and less consistently, anxiety, have been associated with decreased academic performance in past literature (de Lijster et al., 2018; Hishinuma, Chang, McArdle, & Hamagami, 2012; Shahar et al., 2006).

Given the strong connection between depression and academic performance, researchers have attempted to clarify a directional/causal relationship. For instance, when

examining the relationship between depressive symptoms and GPA longitudinally using dynamic bivariate structural equation modeling in high school students, Hishinuma and colleagues (2012) found that symptoms of depression appeared to precede decrements in academic achievement. Similar findings were obtained in an earlier study by Shahar et al. (2006). In a review exploring the academic functioning in adolescents diagnosed with anxiety disorders, elevated anxiety was associated with decreased self-perception of academic ability, though across the included studies, results were mixed as to whether adolescents with anxiety had poorer outcomes than peers without psychological symptoms on objective measures of academic achievement (de Lijster et al., 2018).

Few published studies were found that explored the relationship between SCT and social difficulties while adjusting for internalizing symptoms. In one study by Becker et al. (2014) the caregivers of 677 psychiatrically hospitalized children between the ages six and 12 years completed the CBCL to assess depressive, anxiety, ADHD, and SCT symptoms. A hierarchical multiple regression revealed that SCT significantly predicted social impairment above parent-rated internalizing and ADHD symptoms (Becker et al., 2014). However, in a later study child self-reported SCT symptoms were no longer significantly associated with teacher-rated social and academic problems after controlling for other psychological symptoms (i.e., anxiety, depression, inattention, hyperactivity/impulsivity (Becker, Luebbe, et al., 2015). Prior research examining social functioning in youth with ADHD and depressive and anxiety symptoms has shown that participants diagnosed with comorbid depression, or who endorsed higher levels of social anxiety and anhedonia symptoms, were more likely to report poorer social skills and less peer acceptance (Becker, Langberg, Evans, Girio-Herrera, & Vaughn, 2015). These

results are consistent with past literature studying the impact of depression and anxiety on social problems in children/adolescents (Frojd et al., 2008; Prinstein, Borelli, Cheah, Simon, & Aikins, 2005). Depressive symptoms, in particular have been found to have a negative effect on social interaction (Chen, Cohen, Johnson, & Kasen, 2009).

Proposed Study

The proposed study aimed to clarify the effect of SCT above and beyond factors that have been shown to relate to SCT in the literature (ADHD symptoms, lower intellectual functioning, and internalizing symptoms) on cognitive and social functioning, as well as academic achievement (Becker, Garner, et al., 2016). This would add to the current literature by attempting to replicate past results, and providing more complete analyses utilizing a comprehensive neuropsychological battery in a clinic-referred adolescent sample. It was hypothesized that higher levels of SCT would relate to poorer performance on executive functioning/attention and memory measures, decreased parent and teacher-rated social functioning, and worse academic achievement, as previously demonstrated in the research (Baytunca et al., 2018; Ferretti et al., 2019; Smith & Langberg, 2017; Unsel-Bolat et al., 2019). Further, these relationships were hypothesized to be mediated by ADHD symptoms, estimated IQ, and anxiety and depressive symptoms. It was also hypothesized that level of SCT symptoms would also significantly positively correlate with internalizing and ADHD-IN symptoms, and negatively correlate with estimated intellectual functioning.

CHAPTER II

METHOD

Participants

The current study was designed to include 108 children and adolescents with and without formal ADHD diagnoses, between the ages of 9 and 14 years, referred to a psychological practice for cognitive testing. The initial data collection goal was based on the following rule for estimating sample size in multiple regression, $n \geq 104 + k$, where the number of predictors is 4 (Tabachnick & Fidell, 1996). A total of 114 cases were selected and entered. However, while 106 cases included a completed Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2000), only 89 cases included a completed Teacher Report Form (TRF; Achenbach & Rescorla, 2000), with 81 cases including both the CBCL and TRF. The CBCL and TRF were utilized to estimate SCT symptoms, internalizing symptoms, and social functioning and are discussed in more detail below. In order to verify that the sample size would be sufficient to detect a significant R^2 increase using multiple linear regression, an a priori power analysis using G*Power 3.1.9.7 (Faul, Erdfelder, & Buchner, 2009) was conducted, in which effect size (f^2) was equal to .15 (medium effect size; Cohen, 1992), alpha was set to .05, power was specified as .80, the number of tested predictors was one, and the total number of predictors was four. The model estimated that total of 55 participants would be needed to obtain sufficient power given the above specifications. Participants identified as having chronic medical and/or neurological conditions (i.e., epilepsy), and those who endorsed taking psychoactive

medications at the time of evaluation, were excluded from the analyses. Children who obtained an estimated general intelligence score over two standard deviations below the mean (standard score less than 70) were also excluded.

Measures

Intake form. The guardians of the children included in the study completed a brief form inquiring about the child's demographic information (age and sex), medical and developmental history, as well as any prescription medications being taken at the time of the evaluation.

Child Behavior Checklist (CBCL). The CBCL is a 113-item parent-completed questionnaire, in which the parent or guardian rates the degree to which the youth exhibits specific behavioral or emotional symptoms using a three-point scale, with (0) being *not true,* (1) being *somewhat or sometimes true*, and (2) being *very true or often true* (Achenbach & Rescorla, 2000). This instrument is composed of eight DSM-oriented scales (anxious/depressed, withdrawn/depressed, somatic complaints, social problems, thought problems, attention problems, rule-breaking behavior, and aggressive behavior), in addition to two empirically-derived summary scales (internalizing symptoms and externalizing symptoms scales; Achenbach & Rescorla, 2000). It also generates a SCT scale composed of the following items; "confused or seems to be in a fog," "daydreams or gets lost in his/her thoughts," "stares blankly," and "underactive, slow moving, or lacks energy," which have been widely used in the SCT literature (Camprodon-Rosanas et al., 2016; Garner et al., 2017; Hartman et al., 2004; Unsel-Bolat et al., 2019). The range of scores on the SCT scale is 0 to 8, with higher scores indicating greater SCT symptomatology. The current study utilized the raw scores from the SCT and attention

problems scale, with the scores of the overlapping items being subtracted from the attention problems scale total. This had previously been done within the SCT literature (Camprodon-Rosanas et al., 2016). Additionally, prior research has demonstrated the DSM-oriented attention problems subscale displays adequate sensitivity (0.39) and positive predictive power (0.75) in identifying ADHD (Kim et al., 2005). The T-scores for the internalizing symptoms scale and social problems scale will also be used to examine depressive/anxious symptoms and functioning.

Teacher Report Forms (TRF). The TRF, a 113-item questionnaire with 93 overlapping items with the CBCL, asks teachers to rate the child/adolescent based on behavioral emotional, and academic functioning. The child is rated using a three-point scale, ranging from 0 (not true) to 2 (very true or often true), resulting in eight subscales (anxious/depressed, withdrawn/depressed, somatic complaints, social problems, thought problems, attention problems, rule-breaking behavior, and aggressive behavior) and two summary scales (internalizing and externalizing symptoms). The TRF includes one additional SCT item beyond the four that are part of the CBCL, "apathetic or unmotivated," making the range of scores for the TRF SCT scale 0 to 10 (Achenbach & Rescorla, 2000). Similar to the CBCL, the use of the TRF has been represented in SCT research (Rondon et al., 2018). The raw scores from the SCT and attention scales, and the T-scores from the internalizing symptoms and social problems scale were examined, as with the CBCL, in addition to the TRF academic problems scale T-score.

Reynolds Intellectual Assessment Scales (RIAS). The RIAS is a relatively brief measure of general intellectual functioning, taking approximately 20-25 minutes to administer. It includes a Verbal Intelligence Index and a Nonverbal Intelligence Index, of

which the Composite Intelligence Index (CIX) is derived. Both the verbal and nonverbal indices are composed of two subtests (Reynolds & Kamphaus, 2003). The CIX standard score has a mean of 100 and standard deviation of 15. Previous analyses have revealed the reliability of the CIX to be high (α=.95), and there is evidence that the CIX performs comparably to Wechsler Intelligence Scale for Children, Fourth Edition (a widely used test of intellectual functioning) in estimating overall intellectual ability (Allen, Stolberg, Thaler, Sutton, & Mayfield, 2014; Hagmann-von Arx, Lemola, & Grob, 2018).

Wide Range Achievement Test, Fourth Edition (WRAT-IV). The WRAT-IV assesses academic skills in the following domains, reading, spelling, and mathematics (Wilkinson & Robertson, 2006). Three of the WRAT-IV subtests were be utilized in the present study. During the Word Reading subtest, participants read aloud from a list of words in order to measure their ability to decode and recognize words of increasing complexity. For the Spelling subtest, subjects are orally presented with various words and asked to reproduce them in written form. Finally, the Math Computation subtest allows participants 15 minutes to complete as many mathematical problems as possible. Age norms were used to obtain the standard scores for the WRAT-IV subtests, with higher scores suggesting greater levels of academic skill/achievement in that domain.

Wisconsin Card Sorting Test: Computer Version (WCST). The WCST assesses an individual's novel problem solving ability, mental flexibility, and executive functioning (Heaton & Staff, 2003). The objective of the test is for the child or adolescent to correctly match as many of the "cards" as possible to one of four key cards based on color, shape, or number using feedback provided by the computer program ("right" vs. "wrong"). After successfully completing 10 consecutive sorts based on one category, the program switches

to a new rule for matching without alerting the subject. The WCST variables that were examined in the current study include the number of sets completed, total errors, and perseverative errors. Percentile ranks and standard scores (mean of 100, standard deviation of 15) were used in the analyses to standardize performance across age ranges. Higher percentile ranks, T-scores, and standard scores indicate better performance on the WCST.

Trail Making Test for Older Children (TMT-C). The TMT-C measures processing speed, cognitive flexibility, set-shifting, and sequencing (Reitan & Wolfson, 1992). The test is divided into two parts, part A, in which the subject connects encircled numbers (1 to 15) in sequential order, and part B, where the subject is directed to alternate between number an letter while continuing to connect the circles in order (i.e., 1-A, 2-B, 3-C…). It is encouraged that these tasks be completed as quickly as possible without making mistakes, while the examiner times the subject's performance.

Integrated Visual and Auditory Continuous Performance Test (IVA + Plus). The IVA + Plus is a computerized continuous performance task used to assess aspects of both auditory and visual attention, such as response-control, response speed, and sustained attention functions, which have been shown to be negatively associated with SCT symptoms in past research (Sanford & Turner, 2004; Wahlstedt & Bohlin, 2010; Willcutt et al., 2014). During the test, which takes approximately 15 minutes to complete, the test-taker is instructed to respond (by clicking a mouse) when visually or auditorily presented with the number "1", while refraining from responding when he/she sees or hears the number "2". The test is divided into multiple blocks, in which the ratio of target to non-target stimuli varies in order to better detect impulsive responding. IVA + Plus

standard scores have a mean of 100 and standard deviation of 15, with higher scores indicating better performance.

Rey Complex Figure Test (RCFT). The RCFT assesses visuoconstructional ability and speed, as well as visuospatial recall and recognition memory (Meyers & Meyers, 1995). During the test subjects are asked to first copy the presented figure, taking care to replicate the image as accurately as possible, while being timed. Participants were then instructed to draw the figure from memory shortly after the copy trial (3 minutes), and again following a longer delay (30 minutes). Finally, subjects completed a recognition task in which they are to circle the images that are believed to have been a part of the larger figure.

Rey Auditory Verbal Learning Test (RAVLT). The RAVLT assesses verbal encoding and learning, as well as memory (immediate and delayed; Schmidt, 1996). During the RAVLT, the subject is read a list of 15 words and asked to recall as many words as possible over five learning trials. The participant is also verbally provided with, and instructed to recall, a distractor list before engaging in a free recall of the original word list. Following a 20-minute delay, the participant is again asked to recall as many words as possible from the first list, and then prompted to identify the words from the first list from a larger list.

Grooved Pegboard Test (GPT). The GPT measures motor speed and manual dexterity (Roy & Square-Storer, 1994) by observing how rapidly the participant is able to place 10-25 ridged pegs (depending on age) into correspondingly grooved holes, which are randomly oriented. Participants are first instructed to use only their dominant hand to

complete the task as quickly as possible, while inserting the pegs sequentially into the board. This is then repeated with the non-dominant hand.

Procedure

The present study utilized archival data from private practice in the Upper Midwest offering assessment and diagnostic services performed by licensed clinical psychologists. All neuropsychological tests were administered and scored by trained psychometrists or clinical psychology graduate students. Individual client files were selected based on completion of the aforementioned questionnaires and tests, as well as the inclusion criteria outlined in the "participants" section of the methods. No identifying information was entered into the dataset or included in the study, and individual cases were randomly assigned a subject code.

Analytic Strategy

First, descriptive statistics, including mean and standard deviation were obtained for all relevant variables. Normality was also assessed by examining histograms and utilizing the Shapiro-Wilk test for each variable of interest in order to guide appropriate test selection.

Zero-order correlations were then performed in order to determine if there were significant bivariate relationships between SCT symptoms and the variables of interest (neuropsychological performance, academic achievement, and social functioning).

Next, to evaluate the extent to which SCT independently predicts outcomes on measures that were previously found to significantly correlate with SCT symptoms, IQ, ADHD symptoms, and internalizing symptoms were entered as independent predictors in the first step of a hierarchical regression model, and SCT symptoms were added in the

last step. The dependent variables were measures of specific cognitive functions on neuropsychological tests (i.e., processing speed assessed using the TMT-C), academic achievement as assessed by the WRAT-IV subtests, and teacher or parent ratings of social functioning. The independent variables included were SCT, ADHD symptoms (assessed using the attention problems scale), and internalizing symptoms, as measured by the TRF and CBCL, in addition to estimated IQ using the CIX from the RIAS. To determine whether SCT symptoms predict decreased functioning above and beyond related clinical factors, the significance of the R-square change from the first model to the second model (F-change significance) was examined. All analyses were conducted using Statistical Product and Service Solutions software (SPSS) Version 27 using a two-tailed significance level of .05.

Post Hoc Analyses

Additional exploratory analyses were conducted post hoc in order to better elucidate SCT scale reliability by estimating internal consistency using Cronbach's alpha and inter-rater reliability between SCT scores across behavioral observers (teacher vs. caregiver) utilizing intraclass correlation. Differences in symptom/behavioral ratings across ADHD diagnostic groups were also examined using one-way ANOVAs. Further, potential interaction effects were explored between SCT symptoms and key covariates (IQ, ADHD symptoms, and internalizing symptoms) on measures of functioning (e.g., cognitive, academic, and social) that resulted in significant hierarchical regression models upon analysis of the main aims. To reduce the likelihood of committing a Type I error after repeating regression analysis for each model that had subsequently been found to be

significant, Bonferroni correction was applied in which $\alpha = .05$ and $n = 2$ to provide a significance level of .025.

CHAPTER III

RESULTS

Data Cleaning

Histograms were examined for each variable. In five cases, cognitive test scores were identified that were judged to be highly improbable (suggesting errors in scoring or data entry) and thus were excluded from analyses. These appeared as extreme outliers and incongruous with corresponding raw score data.

Demographic/Clinical Characteristics of Participants

Participants had a mean age of 11.11 years and were primarily male (57.9%). The mean standard score of the RIAS CIX, used to estimate premorbid intellectual functioning was 100.8 across the entire sample. 43% of participants had an ADHD diagnosis, with the inattentive subtype of ADHD being the most common (23.7%), followed by the combined subtype (18.4%). One participant was diagnosed with ADHD-NOS and no participants were diagnosed with ADHD, Predominately hyperactive/impulsive presentation. Two participants did not have diagnoses included in their files. See Tables 1 through 3 for descriptive statistics for demographic/clinical information, parent/teacher ratings, and cognitive/academic test scores.

Table 1

Demographic Information Across Sample

Demographic and Clinical Characteristics	N = 114 Mean (SD)
Age	11.11 (1.70)
Sex (% Male)	57.9%
RIAS CIX (SS)	100.08 (9.86)
ADHD Diagnosis	
ADHD-I	23.7%
ADHD-C	18.4%
ADHD-NOS	0.9%
ADHD-H/I	0%
No ADHD Diagnosis	55.3%
Diagnosis Not Provided	1.8%

Note. RIAS CIX = Reynolds Intellectual Assessment Scales Composite Intelligence Index.
ADHD-I = Attention-Deficit/Hyperactivity Disorder, Predominately inattentive presentation.
ADHD-C = Attention-Deficit/Hyperactivity Disorder, Combined presentation.
ADHD-NOS = Unspecified Attention-Deficit/Hyperactivity Disorder.
ADHD-H/I = Attention-Deficit/Hyperactivity Disorder, Predominately hyperactive/impulsive presentation.

Table 2

Questionnaire Scores Across Entire Sample

Questionnaires	N	Mean (SD)
CBCL		
SCT Scale (Raw Score)	106	2.25 (1.89)
Attention Problems (Adjusted Raw Score)	106	7.74 (3.59)
Internalizing Symptoms (T-Score)	106	61.58 (11.35)
Social Problems (T-Score)	106	60.45 (8.10)
TRF		
SCT Scale (Raw)	89	3.44 (2.64)
Attention Problems (Adjusted Raw Score)	89	18.30 (11.70)
Internalizing Symptoms (T-Score)	89	56.73 (10.28)
Social Problems (T-Score)	89	57.69 (7.85)

Note. SCT = Sluggish Cognitive Tempo. CBCL = Child Behavior Checklist. TRF Teacher Report Form.

Table 3

Cognitive Test Standard Scores Across Entire Sample

Cognitive Test Scores	N	Mean (SD)
RIAS CIX	114	100.08 (9.86)
WRAT-IV		
Word Reading	113	98.15 (11.14)
Spelling	113	98.53 (13.46)
Math Computation	113	99.16 (13.67)
Wisconsin Card Sorting Test		
Total Errors	113	106.46 (15.33)
Perseverative Errors	113	107.58 (14.84)
TMT-C		
Part A	113	99.26 (21.42)
Part B	114	97.25 (17.07)
IVA + Plus		
Auditory Response Control	107	78.39 (20.68)
Visual Response Control	107	75.79 (21.23)
Auditory Sustained Attention	106	60.05 (37.41)
Visual Sustained Attention	106	61.20 (33.06)
Auditory Response Speed	106	60.05 (37.41)
Visual Response Speed	106	99.61 (16.22)
Rey Complex Figure Test		
Copy	111	88.07 (24.46)
Delayed Recall	114	87.02 (21.81)
Rey Auditory Verbal Learning Test		
Trials 1-5 Total	113	102.12 (25.5)
Delayed Recall	113	87.02 (21.81)
Grooved Pegboard Test		
Dominant Hand	113	92.81 (20.46)

Note. RIAS CIX = Reynolds Intellectual Assessment Scales Composite Intelligence Index. WRAT-IV = Wide Range Achievement Test, Fourth Edition. TMT-C = Trail Making Test for Older Children. IVA + Plus = Integrated Visual and Auditory Continuous Performance Test.

Bivariate Correlations

Zero-order correlations were used to identify significant relationships between caregiver/teacher rated SCT symptoms and social problems, as well as performance of measures cognition/academic achievement and proposed covariates (e.g., attention problems, internalizing symptoms, and estimated IQ). Both caregiver and teacher ratings of SCT were identified as being non-normally distributed based on visual inspection of the histograms and significant Shapiro-Wilk tests. The distributions continued to be negatively skewed after attempting log transformation, thus Spearman's rank-order correlation was used to examine all bivariate relationships between SCT symptoms and the variables of interest. As seen in Table 4, caregiver rated SCT symptoms were not significantly related to parent-rated social problems or any of the cognitive/academic achievement scores. Thus, no hierarchical regression models were conducted utilizing caregiver ratings of SCT symptoms. Of note, higher levels of caregiver rated SCT symptoms were significantly related to increased caregiver rated attention problems (r_s (104) = .40, p < .001) and internalizing symptoms (r_s (104) = .37, p < .001).

In contrast, higher levels of teacher rated SCT symptoms were significantly related to increased social problems (r_s (87) = .23, p = .032) and poorer performances on WRAT-IV Math Computation (r_s (86) = -.24, p = .026), TMT-C A (r_s (86) = -.28, p = .009), and TMT-C B (r_s (87) = -.23, p = .030). Teacher rated SCT symptoms were also significantly positively correlated with teacher rated attention problems (r_s (87) = .39, p < .001) and internalizing symptoms (r_s (87) = .42, p < .001). See Table 5.

Table 4

Bivariate Correlations Between CBCL SCT Total Score and Questionnaire/Dependent Variables

Measure	SCT Total (CBCL)
Attention Problems (CBCL)	0.40**
Internalizing Symptoms (CBCL)	0.36**
Social Problems (CBCL)	0.15
RIAS CIX	-0.03
WRAT-IV Word Reading	0.04
WRAT-IV Spelling	0.09
WRAT-IV Math Computation	-0.05
WCST Total Errors	-0.04
WCST Perseverative Errors	-0.01
TMT-C Part A	-0.16
TMT-C Part B	0.01
IVA + Auditory Response Control	-0.03
IVA + Visual Response Control	-0.10
IVA + Auditory Sustained Attention	-0.03
IVA + Visual Sustained Attention	-0.01
IVA + Auditory Response Speed	0.08
IVA + Visual Response Speed	-0.05
RCFT Copy	<0.01
RCFT Delayed Recall	0.06
RAVLT Trials 1-5 Total	-0.02
RAVLT Delayed Recall	-0.01
GPT Dominant Hand	-0.10

Note. *$p < .05$, **$p < .01$. SCT = Sluggish Cognitive Tempo. CBCL = Child Behavior Checklist. RIAS CIX = Reynolds Intellectual Assessment Scales Composite Intelligence Index. WRAT-IV = Wide Range Achievement Test, Fourth Edition. WCST = Wisconsin Card Sorting Test. TMT-C = Trail Making Test for Older Children. IVA + = Integrated Visual and Auditory Continuous Performance Test. RCFT = Rey Complex Figure Test. RAVLT = Rey Auditory Verbal Learning Test. GPBT = Grooved Pegboard Test.

Table 5

Bivariate Correlations Between TRF SCT Total Score and Questionnaire/Dependent Variables

Measure	SCT Total (TRF)
Attention Problems (TRF)	0.39**
Internalizing Symptoms (TRF)	0.42**
Social Problems (TRF)	0.23*
RIAS CIX	-0.10
WRAT-IV Word Reading	0.05
WRAT-IV Spelling	-0.02
WRAT-IV Math Computation	-0.24*
WCST Total Errors	-0.07
WCST Perseverative Errors	-0.02
TMT-C Part A	-0.28*
TMT-C Part B	-0.23*
IVA + Auditory Response Control	-0.16
IVA + Visual Response Control	-0.11
IVA + Auditory Sustained Attention	-0.04
IVA + Visual Sustained Attention	-0.04
IVA + Auditory Response Speed	0.06
IVA + Visual Response Speed	-0.12
RCFT Copy	0.01
RCFT Delayed Recall	-0.06
RAVLT Trials 1-5 Total	-0.19
RAVLT Delayed Recall	-0.12
GPT Dominant Hand	0.03

Note. *$p < .05$, **$p < .01$. SCT = Sluggish Cognitive Tempo. TRF = Teacher Report Form. RIAS CIX = Reynolds Intellectual Assessment Scales Composite Intelligence Index. WRAT-IV = Wide Range Achievement Test, Fourth Edition. WCST = Wisconsin Card Sorting Test. TMT-C = Trail Making Test for Older Children. IVA + = Integrated Visual and Auditory Continuous Performance Test. RCFT = Rey Complex Figure Test. RAVLT = Rey Auditory Verbal Learning Test. GPBT = Grooved Pegboard Test.

Hierarchical Regressions

Four hierarchical regression models were performed to examine whether teacher rated SCT symptoms predicted poorer performance/outcomes on measures that were found to significantly correlate with SCT symptoms (e.g., Math Computation, TMT-C A, TMT-C B, and teacher rated social problems) over and above attention problems, internalizing symptoms, and IQ. In order to accomplish this aim, the proposed covariates were entered in the first step, with teacher SCT symptoms added in the second.

For Math Computation, the hierarchical linear regression model was significant at stage 1 (F (3, 84) = 3.70, p = .015) but did not explain a significantly larger proportion of the variance at stage 2 after including teacher rated SCT symptoms (F (1, 83) = 2.07, p = .154). Math Computation assesses the academic achievement in mathematics under time constraints. Estimated IQ (as measured by the RIAS CIX) was the only significant predictor of performance on Math Computation, with lower IQ being associated with poorer performance after adjusting for all other predictor variables (b = .35, p = .027). See Table 6.

For TMT-C A, the hierarchical linear regression model was not statistically significant at stage 1 (F (3, 84) = 1.53, p = .211). However, after the addition of teacher rated SCT symptoms in stage 2, the amount of variance explained increased by 7.5% with a significant change in R^2 (F (1, 83) = 7.15, p = .009). The overall model at this stage was also significant (F (4, 83) = 3.02, p = .022), with higher levels of teacher rated SCT symptoms being associated with slower completion times on TMT-C A, which measures simple processing speed, after adjusting for all covariates (b = - 2.49, p = .009). See Table 7.

TMT-C B was non-normally distributed, as determined by a significant Shapiro-Wilk Test and negatively skewed histogram. A logarithmic transformation was performed; however, this did not improve normality. Therefore, a hierarchical logistic regression was run. Standard scores at or below 85 (at least one standard deviation lower than the normative mean) were coded as a 0, while scores higher than 85 were coded as a 1. The overall model failed to attain significance at stage 1 (*Chi-square* [3] = 2.43, p = .488) or stage 2 (*Chi-square* [4] = 4.92, p = .296), thus the results were not interpreted. See Table 8 for regression coefficients.

Finally, for teacher rated social problems, a hierarchical logistic regression was conducted due to the non-normal distribution of this variable (based on a significant Shapiro-Wilk test and visual inspection of histogram), and the failure to approximate a normal curve after logarithmic transformation. T-scores at or above 65 were coded as 1 and scores of 64 or below were coded as 0. Scores of 65 and greater fall into the "borderline clinical" to "clinical" range, while scores of 64 or less are classified as "normal" (Achenbach & Rescorla, 2000). The overall model was statistically significant at stage 2 (*Chi-square* [4] = 27.78, p < .001) but the model fit did not improve significantly with the addition of SCT symptoms (*Chi-square* [1] = 1.19, p = .276). Increased levels of teacher rated attention problems and internalizing symptoms were associated with increased odds of borderline clinical to clinical social problems by 10% (OR = 1.10, *p* = .006) and 16% (OR = 1.16, *p* < .001), respectively. See Table 9.

Table 6

Hierarchical Linear Regression for WRAT-IV Math Computation Performance

	Step 1				Step 2			
Predictor Variable	B	SE	β	*p*	B	SE	β	*p*
Attention Problems (TRF)	-0.09	0.13	-0.08	.501	-0.04	0.14	-0.03	.793
RIAS CIX	0.35	0.16	0.24	.028	0.35	0.16	0.24	.027
Internalizing Symptoms (TRF)	-0.25	0.15	-0.19	.084	-0.18	0.15	-0.13	.244
SCT Symptoms (TRF)	---	---	---	---	-0.88	0.61	-0.17	.154
R^2	---	0.12	---	.015	---	0.14	---	---
R^2 Change	---	---	---	---	---	0.02	---	.154

Note. N = 88. TRF = Teacher Report Form. RIAS CIX = Reynolds Intellectual Assessment Scales Composite Intelligence Index. SCT = Sluggish Cognitive Tempo.

Table 7

Hierarchical Linear Regression for Trail Making Test A Performance

	Step 1				Step 2			
Predictor Variable	B	SE	β	*p*	B	SE	β	*p*
Attention Problems (TRF)	0.12	0.21	0.07	.573	0.27	0.21	0.15	.200
RIAS CIX	0.22	0.25	0.10	.365	0.22	0.24	0.10	.351
Internalizing Symptoms (TRF)	-0.45	0.23	-0.22	.051	-0.24	0.23	-0.12	.306
SCT Symptoms (TRF)	---	---	---	---	-2.49	0.93	-0.31	.009
R^2	---	0.05	---	.211	---	0.13	---	---
R^2 Change	---	---	---	---	---	0.08	---	.009

Note. N = 88. TRF = Teacher Report Form. RIAS CIX = Reynolds Intellectual Assessment Scales Composite Intelligence Index. SCT = Sluggish Cognitive Tempo.

Table 8

Hierarchical Logistic Regression for Trail Making Test B Performance

Predictor Variable	Step 1				Step 2			
	β	Odds Ratio	SE	*p*	β	Odds Ratio	SE	*p*
Attention Problems (TRF)	-0.03	0.97	0.03	.218	-0.02	0.98	0.03	.449
RIAS CIX	-0.04	0.97	0.03	.274	-0.03	0.97	0.03	.300
Internalizing Symptoms (TRF)	-0.004	1.00	0.03	.896	0.01	1.01	0.04	.719
SCT Symptoms (TRF)	---	---	---	---	-0.19	0.83	0.13	.121
Nagelkerke R^2	---	0.05	---	---	---	0.09	---	---
R^2 Change	---	---	---	---	---	0.04	---	---

Note. N = 89. TRF = Teacher Report Form. RIAS CIX = Reynolds Intellectual Assessment Scales Composite Intelligence Index. SCT = Sluggish Cognitive Tempo.

Table 9

Hierarchical Logistic Regression for Teacher Ratings of Social Problems

Predictor Variable	Step 1				Step 2			
	β	Odds Ratio	SE	*p*	β	Odds Ratio	SE	*p*
Attention Problems (TRF)	0.09	1.10	0.03	.008	0.10	1.10	0.04	.006
RIAS CIX	0.02	1.02	0.04	.585	0.02	1.02	0.04	.620
Internalizing Symptoms (TRF)	0.14	1.15	0.04	.002	0.15	1.16	0.04	<.001
SCT Symptoms (TRF)	---	---	---	---	-0.14	0.87	0.13	.288
Nagelkerke R^2	---	0.41	---	---	---	0.43	---	---
R^2 Change	---	---	---	---	---	0.02	---	---

Note. N = 89. TRF = Teacher Report Form. RIAS CIX = Reynolds Intellectual Assessment Scales Composite Intelligence Index. SCT = Sluggish Cognitive Tempo.

Post Hoc Analyses

Reliability Analyses

Given that no significant bivariate correlations were found between caregiver ratings of sluggish cognitive tempo and parent rated social problems or performance on cognitive/academic achievement measures, secondary analyses were conducted with the purpose of evaluating the internal consistency of teacher and parent rated SCT scales. The CBCL SCT scale (4 items) was found to have a Cronbach's alpha of 0.64, while the TRF SCT scale (5 items) had a Cronbach's alpha of 0.78. Further, in order to assess agreement between parent and teacher ratings of SCT, an intraclass correlation was performed. An intraclass correlation (ICC) of 0.46 was found between teacher and caregiver ratings based on a one-way random effects model of SCT scores.

Group Comparisons

Additionally, two one-way ANOVAs were performed in order to examine how caregiver and teacher rated symptoms differed across ADHD diagnostic groups. As shown in Table 10, a one-way ANOVA revealed statistically significant differences in caregiver rated SCT symptoms ($F(3,102) = 3.15$, $p = .028$), attention problems ($F(3,102) = 5.62$, $p = .001$), and social problems ($F(3,102) = 3.47$, $p = .019$) across ADHD diagnostic groups. More specifically, a Tukey post hoc test showed that caregiver rated SCT symptoms were significantly higher among the caregivers of children diagnosed with the inattentive subtype of ADHD (3.19±1.92, $p = .035$) when compared to parents of children who did not meet diagnostic criteria for ADHD (2.00±1.81). Additionally, significantly higher levels of attention problems were endorsed by parents of children

diagnosed with the combined presentation of ADHD (10.15±3.22, $p < .001$) than were by parents of children without an ADHD diagnosis (6.66±3.55). Poorer social functioning was also reported by the caregivers of children with ADHD, combined subtype (64.20±9.10, $p = .012$) when compared to parents of children diagnosed with the inattentive subtype of ADHD (56.92±6.99). There were no significant differences in teacher ratings of internalizing symptoms among the diagnostic groups.

As displayed in Table 11, significant differences were found in teacher rated levels of attention problems across ADHD diagnostic groups (F (3,85) = 7.58, $p < .001$). Higher levels of attention problems were reported by teachers of children diagnosed with the combined subtype of ADHD (29.24±8.71) when compared to teachers of children diagnosed with the inattentive subtype of ADHD (16.71±3.22, $p = .003$) and without any ADHD diagnoses (15.29±11.35, $p < .001$). No significant group differences were found in teacher-ratings of sluggish cognitive tempo symptoms, internalizing symptoms, or social problems.

Table 10

One-Way Analyses of Variance in CBCL Ratings of SCT, Attention, Internalizing Symptoms, Social Problems Across ADHD Diagnostic Groups

Measure	No ADHD Diagnosis (n=58)		ADHD-C (n=20)		ADHD-I (n=26)		ADHD-NOS/Other (n=2)		*F* (3,102)	η^2
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*		
SCT Scale	2.00	1.81	1.80	1.79	3.19	1.92	1.50	2.12	3.15*	.08
Attention Problems	6.66	3.55	10.15	3.22	8.23	2.98	8.50	4.95	5.62**	.14
Internalizing Symptoms	62.81	11.11	61.65	11.22	58.92	11.76	59.5	19.09	0.72	.02
Social Problems	60.86	7.68	64.20	9.10	56.92	6.99	57.00	9.90	3.47*	.09

Note. *$p < .05$, **$p < .01$.

Table 11

One-Way Analyses of Variance in TRF Ratings of SCT, Attention, Internalizing Symptoms, Social Problems Across ADHD Diagnostic Groups

Measure	No ADHD Diagnosis (n=49)		ADHD-C (n=17)		ADHD-I (n=21)		ADHD-NOS/Other (n=2)		*F* (3,85)	η^2
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*		
SCT Scale	2.88	2.64	3.88	2.87	4.48	2.27	2.50	0.71	2.14	.07
Attention Problems	15.29	11.35	29.24	8.71	16.71	9.39	16.00	18.38	7.58***	.21
Internalizing Symptoms	57.20	11.27	55.88	9.08	56.48	9.48	55.00	7.07	0.09	.003
Social Problems	57.10	8.62	60.35	7.68	56.91	5.74	57.50	10.60	0.81	.03

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

Interaction Effects

To explore the potential moderating effects of the proposed covariates on the association between teacher rated sluggish cognitive tempo symptoms and cognitive/functional outcomes that had previously shown significant relationships in regression models conducted for the main aims (e.g., scores on Math Computation, TMT-C A, and teacher rated social problems), interaction terms were created and examined using centered variables in multiple regression. However, none of the interaction terms were significantly associated with the aforementioned dependent variables, as displayed in Tables 12-14. See Figure 1 for a scatter plot illustrating the relationship between SCT and IQ by normal vs. borderline clinical to clinical levels of teacher rated social problems.

Table 12

Interactions Computed with Multiple Linear Regression for WRAT-IV Math Computation Performance

Predictor Variable	B	SE	β	*p*
Attention Problems (TRF)	-0.06	0.14	-0.05	.664
RIAS CIX	0.32	0.17	0.21	.065
Internalizing Symptoms (TRF)	-0.17	0.17	-0.13	.311
SCT Symptoms (TRF)	-0.80	0.65	-0.15	.218
SCT Symptoms (TRF) * Attention Problems (TRF)	-0.01	0.05	-0.01	.920
SCT Symptoms (TRF) * RIAS CIX	0.04	0.06	0.07	.514
SCT Symptoms (TRF) * Internalizing Symptoms (TRF)	-0.04	0.07	-0.06	.604

Note. All variables were centered and product terms were created from centered variables. TRF = Teacher Report Form. RIAS CIX = Reynolds Intellectual Assessment Scales Composite Intelligence Index. SCT = Sluggish Cognitive Tempo.

Table 13

Interactions Computed with Multiple Linear Regression for WRAT-IV Trail Making Test A Performance

Predictor Variable	B	SE	β	*p*
Attention Problems (TRF)	0.32	0.21	0.18	.138
RIAS CIX	0.22	0.25	0.10	.392
Internalizing Symptoms (TRF)	-0.42	0.25	-0.20	.102
SCT Symptoms (TRF)	-2.22	0.96	-0.28	.024
SCT Symptoms (TRF) * Attention Problems (TRF)	0.01	0.08	0.01	.944
SCT Symptoms (TRF) * RIAS CIX	-0.16	0.09	-0.20	.069
SCT Symptoms (TRF) * Internalizing Symptoms (TRF)	-0.07	0.11	-0.08	.532

Note. All variables were centered and product terms were created from centered variables. TRF = Teacher Report Form. RIAS CIX = Reynolds Intellectual Assessment Scales Composite Intelligence Index. SCT = Sluggish Cognitive Tempo.

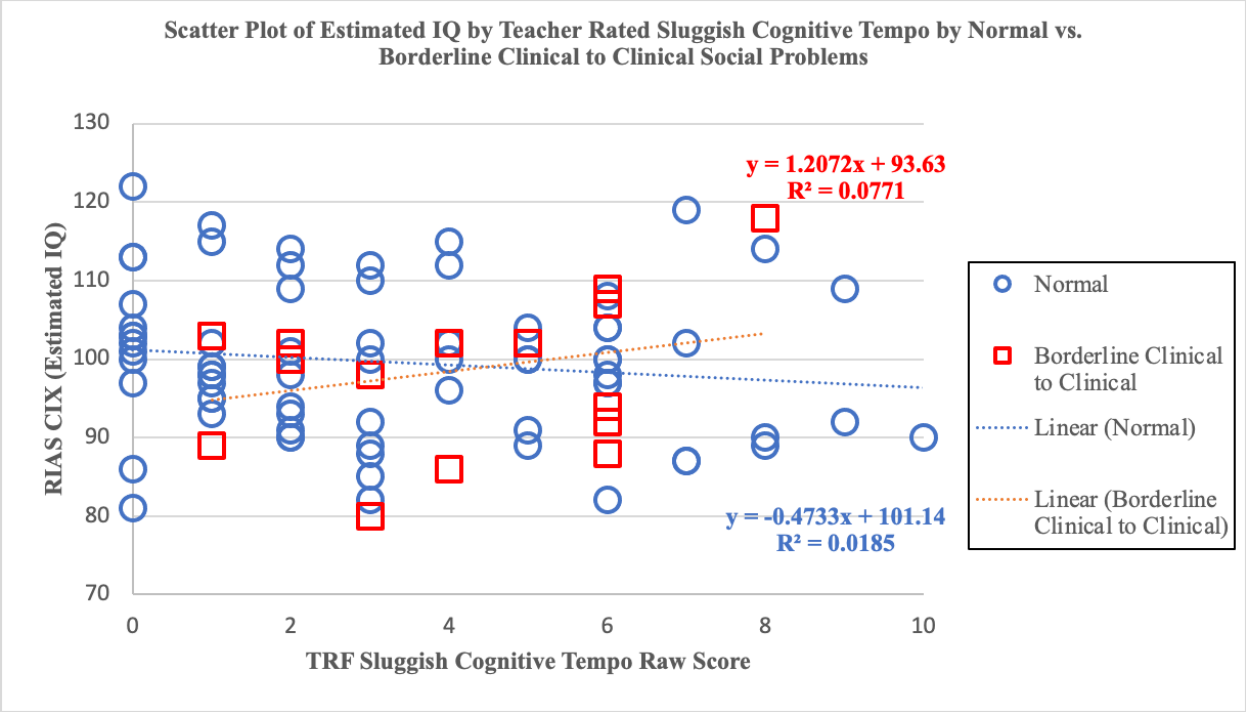
Table 14

Interactions Computed with Binomial Logistic Regression for Teacher Ratings of Social Problems

Predictor Variable	β	Odds Ratio	SE	*p*
Attention Problems (TRF)	0.10	1.10	0.04	.010
RIAS CIX	-0.03	0.97	0.04	.514
Internalizing Symptoms (TRF)	0.17	1.19	0.50	<.001
SCT Symptoms (TRF)	-0.23	0.79	0.24	.330
SCT Symptoms (TRF) * Attention Problems (TRF)	0.01	1.01	0.02	.379
SCT Symptoms (TRF) * RIAS CIX	0.03	1.03	0.02	.039
SCT Symptoms (TRF) * Internalizing Symptoms (TRF)	-0.01	0.81	0.02	.809

Note. All variables were centered and product terms were created from centered variables. TRF = Teacher Report Form. RIAS CIX = Reynolds Intellectual Assessment Scales Composite Intelligence Index. SCT = Sluggish Cognitive Tempo.

Figure 1



Note. RIAS CIX = Reynolds Intellectual Assessment Scales Composite Intelligence Index. TRF = Teacher Report Form.

CHAPTER IV

DISCUSSION

The aim of the current study was to explore the extent to which SCT symptoms predicted poorer performance across measures of academic achievement, cognitive functioning, and social difficulties above and beyond factors that have been associated with SCT and functional/cognitive outcomes in previous studies (e.g., internalizing symptoms, attention problems, and lower IQ). While it was hypothesized that both teacher and caregiver ratings of SCT would significantly correlate with reduced performance on measures of executive functioning/attention, memory, and academic achievement, as well as poor teacher or parent rated social functioning, it was expected that SCT would fail to explain a significant amount of the variance in these domains over and above the aforementioned key covariates.

Bivariate Findings

As described in the results section, caregiver ratings of SCT did not significantly correlate with any of the academic, cognitive, or functional measures. These results were surprising given the findings from previous studies, particularly the seemingly stable association between SCT and sustained attention in the literature (Becker, Leopold, et al., 2016; Wahlstedt & Bohlin, 2010). In addition, parent rated SCT failed to significantly correlate with estimated IQ, contrary to what has been reported in past studies (Becker, Leopold, et al., 2016; Hartman et al., 2004; Reeves et al., 2007). However, as expected

based on previous findings, higher levels of parent rated sluggish cognitive tempo were associated with greater levels of parent reported attention problems and internalizing symptoms (Becker, Leopold, et al., 2016).

Additionally, the present study found that higher teacher ratings of SCT were associated with poorer performances on Math Computation, measures of simple processing speed (TMT-C A) and complex processing speed/set-shifting (TMT-C B), and greater teacher rated social problems, though the effect size of the aforementioned correlations was small. Previous studies have demonstrated a negative relationship between SCT symptoms and academic performance, specifically in the area of mathematics in children with ADHD (Hartman et al., 2004; Tamm et al., 2013). Moreover, there is evidence in the literature to support an association between higher levels of SCT symptoms and slower processing speed/reduced cognitive flexibility, though these results have been less consistently reported (Baytunca et al., 2018; Tamm et al., 2018; Willcutt et al., 2014). There were no significant correlations found between teacher rated SCT symptoms and scores on tests of memory, novel problem solving, or attention. Similar to caregiver ratings of SCT, increased teacher rated SCT symptoms was associated with higher levels of teacher rated attention problems and internalizing symptoms, while teacher rated SCT failed to significantly correlate with estimated IQ.

Hierarchical Regression Findings

Consistent with initial hypotheses, teacher rated SCT symptoms did not explain a significantly greater amount of the variance in Math Computation performance when added in the second step of a hierarchical regression model, with IQ emerging as the only significant predictor. Similarly, the addition of teacher rated SCT symptoms failed to

significantly improve model fit or predict severity of teacher rated social problems. However, higher levels of teacher rated attention problems and internalizing symptoms were associated with poorer social functioning. Contrastingly, a significant increase in explained variance was observed when teacher rated SCT was added as a predictor for TMT-C A performance. The clinical relevance and relation to the existing literature will be subsequently discussed.

The association between estimated IQ and performance on Math Computation is unsurprising given the well-established link between IQ and academic achievement, and mathematics in particular (Mayes et al., 2009; Mayes & Calhoun, 2008). Additionally, at least one study has shown that the relationship between SCT and parent rated academic performance was diminished after adjusting for IQ (Becker & Langberg, 2013). Taken together, the current findings suggest that it is worthwhile for researchers to control for IQ when examining relationships between SCT and academic achievement.

Relatively few studies have explored the relationship between SCT and social difficulties, though the existing research has presented conflicting results as to whether SCT predicts poorer social functioning beyond ADHD and internalizing symptoms (Becker et al., 2014; Becker, Luebbe, et al., 2015). However, internalizing symptoms – especially depressive symptoms – have been shown to relate to social difficulties in children (Chen et al., 2009; Frojd et al., 2008; Prinstein et al., 2005). Further, social impairment has been consistently observed among children with ADHD, with hyperactive/impulsive symptoms being identified as particularly detrimental (Ng, Heinrich, & Hodges, 2021). These findings are generally consistent with the current

results and indicate that future research on SCT and social functioning should consider the potential mediating role of ADHD and internalizing symptoms.

While statistically significant, the addition of SCT symptoms to the hierarchical regression model examining simple processing speed (as measured by TMT-C A) only accounted for an additional 7.5% of variance explained. Thus, the clinical implications of SCT over and above internalizing symptoms, attention problems, and IQ are likely negligible. Previous studies report conflicting results regarding the association between SCT symptoms and processing speed (Tamm et al., 2018; Willcutt et al., 2014). Additional research is needed to clarify whether such a relationship exists and if it persists after adjusting for relevant covariates.

SCT Scale Reliability

In order to estimate the internal consistency and inter-rater reliability of the CBCL and TRF SCT scales Cronbach's alpha and an intraclass correlation were computed. The Cronbach's alpha for the CBCL SCT scale was found to be slightly lower than the generally accepted range of 0.70 - 0.95 at 0.64, which is also somewhat lower than the values obtained in previous research (Becker, Leopold, et al., 2016; Musicaro, Ford, Suvak, Sposato, & Andersen, 2020). In this case, the reduced Cronbach's alpha was likely due to the relatively small number of items comprising the scale rather than lack of agreement between items, as each item individually showed correlation coefficients of .63 or higher when correlated with the total scale score (Tavakol & Dennick, 2011). Of note, the Cronbach's alpha for the TRF SCT scale was within the acceptable range. The inter-rater reliability between parent and teacher ratings of SCT was found to be poor. Previous research on SCT has reported moderate inter-rater reliability between caregivers

and teachers, while inter-rater reliability has been stronger between parents or teachers/classroom aides (Becker, Leopold, et al., 2016). Future research should continue to investigate the utility of the CBCL and TRF SCT items relative to scales specifically designed to assess SCT symptoms, such as the Barkley Sluggish Cognitive Tempo Scale – Children and Adolescents (Barkley, 2018).

Group Comparison Findings

Secondary analyses were conducted in order to investigate how caregiver and teacher rated psychological symptoms/behavior differed between sample diagnostic groups (no ADHD diagnosis, ADHD-IN, ADHD-C, ADHD-NOS/other). SCT has been found to be associated with inattention symptoms and commonly co-occur with ADHD-IN in literature (McBurnett et al., 2001). This was generally supported in the current study, as children with ADHD-IN had significantly greater levels of caregiver rated SCT symptoms than children without an ADHD diagnosis and overall had highest ratings of SCT across groups. Additionally, children with the combined type of ADHD had higher levels of caregiver rated social problems when compared to children with the inattentive subtype, which is consistent with previous findings regarding the negative relationship between hyperactive/impulsive symptoms and social functioning (Ng et al., 2021). Children with ADHD-C were also significantly more likely to have higher levels of teacher rated attention problems (when compared to children without an ADHD diagnosis and children with the inattentive subtype of ADHD) and greater levels of parent rated attention problems (when compared to children with no ADHD diagnosis). These results may be explained by the scale's inclusion of items directed at assessing both inattentive and hyperactive/impulsive symptoms (Achenbach & Rescorla, 2000).

While outside the scope of the current study, future researchers may choose to examine the mediational effects of SCT across ADHD diagnostic groups on psychological/behavioral symptoms, as well as neuropsychological test performances, in larger clinical samples.

Interaction Findings

In regard to the non-significant interaction effects, it is believed that the ability to detect significant interactions was likely limited by sample size and the restricted range/skewness of SCT measure scores. To date, most research has focused on mediation rather than moderation analyses within the literature.

Limitations

It is acknowledged that the choice to not correct for multiple comparisons in the analyses of the main aims increases the likelihood of committing Type 1 errors and is a limitation of the current study. At each level of the analyses, effect sizes were generally small and thus when more stringent criteria were subsequently applied, such as lowering the alpha to .01, significant effects largely did not persist. The only exceptions were the bivariate associations between SCT and attention problems/internalizing symptoms, the relationship between teacher rated attention problems/internalizing symptoms and social problems after adjusting for all other covariates, and the association between teacher rated SCT and simple processing speed before and after accounting for IQ, internalizing symptoms, and attention problems. Given the relatively small number of significant results at an alpha level of .05, the decision was made to discuss these findings in hopes of providing a more complete understanding of how SCT might relate to functional outcomes and contrasting the current results with those from previous studies. As stated

above, the effect sizes for most of the statistical tests used to investigate the relationships between SCT and cognitive, academic, and social functioning were small and therefore the ability to draw conclusions regarding the implications of SCT is limited.

Additionally, the distributions of both the CBCL and TRF SCT scales were negatively skewed, with a greater number of respondents reporting little to no SCT symptoms. This pattern of responding, along with the relatively small sample size, likely reduced power to find significant relationships. Further, the test used to measure sustained attention (IVA + Plus) had multiple instances in which scores were not available due to invalid response patterns. Thus, it is conceivable that this may have also impacted the current results if children with higher ratings of SCT were more likely to obtain an invalid performance. To this author's knowledge, no prior studies have examined task engagement via performance validity testing in relation to SCT, which could enhance understanding of the observed deficits in cognitive and academic performances.

This study utilized the CBCL and TRF, which depend on the summation of 4 and 5 items, respectively, to provide an estimate of SCT symptoms. While these tools assess commonly recognized symptoms of SCT (e.g., daydreaming and a general slowness/sluggishness) – suggesting good content validity – and have been used widely in the research, estimates of internal consistency (for the CBCL SCT scale specifically) and inter-rater reliability were poor (Camprodon-Rosanas et al., 2016; Garner et al., 2017; Rondon et al., 2018). Thus, it is possible that scale selection could have had influenced the current results. Further exploration of CBCL and TRF SCT scale

reliability and validity is warranted. More specifically, it would be useful for future studies to include information on convergent validity between various SCT measures.

The present study was archival and did not have access to additional pertinent demographic information, such as family socioeconomic status, parental educational attainment, or racial identity, which would have been useful in better characterizing and understanding the current sample. Moreover, previous research has highlighted a significant negative association between socioeconomic status and SCT, as well as parental education and SCT (Barkley, 2013; Camprodon-Rosanas et al., 2017). Therefore, it would be worthwhile to investigate these factors as possible covariates in future studies.

Implications and Future Directions

A primary strength of the current study is that it expanded upon the existing literature by employing a wider array of neuropsychological tests, in addition to parent and teacher rated behavioral measures, and examined the ability of SCT to predict functional deficits over and above a more complete set of covariates (internalizing symptoms, attention problems, and IQ). Indeed, the findings imply that the aforementioned covariates are important to consider when exploring the relation between SCT and functional outcomes. Notably, performance of tests of academic achievement in mathematics and teacher ratings of social problems were better explained by the included covariates. However, simple processing speed performance appeared to be uniquely associated with SCT. While few significant associations between SCT and functional outcomes were found, these results should not be dismissed. Of the relatively limited number of studies that have examined SCT in relation to neuropsychological and

academic achievement tests, the overall literature has been inconclusive regarding specific cognitive deficits, with sustained attention being the most common. Additional research is needed in order to better elucidate the potential functional implications of SCT (Becker, Leopold, et al., 2016; Tamm et al., 2018; Wahlstedt & Bohlin, 2010; Willcutt et al., 2014).

While not a primary aim, the current study also lends supports a growing body of research which has demonstrated a significant bidirectional association between SCT and internalizing symptoms (Becker, Leopold, et al., 2016; Bernad et al., 2016; Hartman et al., 2004; Rondon et al., 2018). More recently, Becker, Webb and Dvorsky (2019) found that higher teacher ratings of SCT predicted greater levels of teacher rated depression and anxiety, as well as higher child ratings of depression, six months later. Depressive and anxiety symptoms were not predictive of future SCT ratings. These results suggest that SCT may precipitate internalizing symptoms; however, more research is required to establish evidence of a causal relationship.

Moreover, in order to support SCT as an independent diagnostic category, it is crucial to better understand how other factors, such as sleep, medical status, and psychosocial history/demographics might precede or relate to SCT symptom presentation. In a study by Musicaro and colleagues (2020) the authors found that interpersonal trauma was predictive of SCT after adjusting for other psychological symptoms, including affective, anxiety, attention, and conduct problems. Sleep and somatic complaints have also found to significantly associate with SCT, as have socioeconomic status and parental education (Barkley, 2013; Camprodon-Rosanas et al., 2017; Mayes, Calhoun, & Waschbusch, 2021; Rondon, Hilton, Jarrett, & Ollendick,

2020). As researchers continue to identify a greater range of factors that relate to SCT symptoms it is important to refine research methodology to better rule out other constructs or diagnoses that might better explain the symptoms of SCT itself, or the associations between SCT and other symptoms/functional deficits.

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