Published in final edited form as:

J Psychiatr Res. 2016 June ; 77: 116–124. doi:10.1016/j.jpsychires.2016.03.005.

Sluggish Cognitive Tempo in Children Referred to a Pediatric Sleep Disorders Center: Examining Possible Overlap with Sleep Problems and Associations with Impairment

Stephen P. Becker^{a,b,*}, Annie A. Garner^c, and Kelly C. Byars^{a,b,d}

^aDivision of Behavioral Medicine and Clinical Psychology, Cincinnati Children's Hospital Medical Center, 3333 Burnet Ave., MLC 10006, Cincinnati, Ohio, 45056, USA

^bDepartment of Pediatrics, University of Cincinnati College of Medicine, 3333 Burnet Ave., MLC 10006, Cincinnati, Ohio, 45056, USA

^cDepartment of Psychology, Saint Louis University, 3700 Lindell Blvd., St. Louis, Missouri, 63108, USA

^dDivision of Pulmonary Medicine, Cincinnati Children's Hospital Medical Center, 3333 Burnet Ave., Cincinnati, Ohio, 45056, USA

Abstract

Research supports the distinctness of sluggish cognitive tempo (SCT) (e.g., mental confusion and slowed behavior/thinking) from other psychopathologies. However, the relation between SCT and sleep functioning has not been adequately studied. We examined the association between SCT and sleep functioning in 325 children (62% male) ages 6-10 years referred to a pulmonary-based, accredited Sleep Disorders Center. Correlations between caregiver ratings of SCT, other psychopathologies (i.e., inattention/hyperactivity, oppositionality, depression, anxiety), sleep functioning (both behavioral and organic symptoms), as well as sleep disorder diagnoses, were examined. Unique effects of SCT and other psychopathologies on sleep problem severity controlling for child demographics were assessed using regressions. Regression analyses were also conducted to examine the unique effects of SCT on impairment (i.e., academic difficulties, parenting stress, and other psychopathologies) controlling for child demographics, sleep problem severity, and other psychopathology symptoms. SCT was weakly to moderately correlated with most measures of sleep (r s=.07-.39) and moderately to strongly correlated with measures of daytime sleepiness (r s=.33 and .53). SCT was uniquely associated with greater sleep functioning severity and impairment in academic functioning. SCT was also uniquely associated with higher

*Corresponding author. Division of Behavioral Medicine and Clinical Psychology, Cincinnati Children's Hospital Medical Center, 3333 Burnet Ave., MLC 10006, Cincinnati, Ohio 45229. Phone: +1 513 803 2066. Fax: +1 513 803 0084. stephen.becker@cchmc.org.

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Contributors

Dr. Becker conceived of the study, wrote the first draft of the manuscript, and carried out all statistical analyses. Dr. Byars designed the overall study from which data in this manuscript were used and coordinated all data collection. Drs. Garner and Byars aided in editing the initial draft. All authors contributed to and approved the final manuscript.

levels of depression and inattention/hyperactivity, but not anxiety, and negatively associated with oppositionality. Finally, SCT symptoms were uniquely associated with greater parent-child dysfunctional interaction. Findings demonstrate that SCT is related to, but not redundant with, sleep problems and daytime sleepiness specifically. Further, SCT remained associated with several domains of functional impairment in sleep-disordered children after controlling for clinically-relevant variables, highlighting the potential value in assessing SCT symptoms in children with sleep problems.

Keywords

ADHD; impairment; attention; daytime sleepiness; sleep; sluggish cognitive tempo

Introduction

There is increasing interest in understanding sluggish cognitive tempo (SCT), a behavioral construct characterized by excessive daydreaming, mental confusion or seeming to be “in a fog,” and slowed behavior or thinking (Barkley, 2014, Becker et al., 2014c). SCT was initially examined within the context of attention-deficit/hyperactivity disorder (ADHD) (Carlson and Mann, 2002, Milich et al., 2001). However, recent studies have shown SCT to be statistically distinct from ADHD, as well as other psychopathologies such as depression and anxiety (Becker et al., 2016). These studies also demonstrate that SCT is uniquely associated with a range of adverse outcomes, including academic problems, peer difficulties, loneliness, and emotion dysregulation (Becker et al., 2016). Thus, there is growing support for the distinctiveness of SCT from other psychopathologies that indicates SCT is an important dimension for understanding youth adjustment (Becker and Barkley, in press).

Understanding the relation between SCT and sleep is of particular relevance given that some investigators have questioned whether SCT is merely a proxy for sleep problems, and daytime sleepiness in particular. For instance, Willoughby et al. (2008) observed that “many of the items that are used to define SCT...are synonyms for the behavioral indicators of daytime sleepiness” (p. 1092), and Cortese et al. (2009) noted a similar apparent overlap. However, only five studies have directly examined the association between SCT and sleep, three of which were conducted in adult samples. Two studies conducted with college students with and without ADHD demonstrated that SCT was statistically distinct from, but also strongly associated with, daytime sleepiness ($r=.40-.51$) (Becker et al., 2014b, Langberg et al., 2014b), and SCT was also significantly associated with poorer nighttime sleep quality and sleep disturbances (e.g., night wakings). The third study found that adults with insomnia or probable ADHD had higher rates of SCT symptoms in comparison to other adults (Voinescu et al., 2012). These adult-focused studies provided initial empirical support for an association between SCT and sleep.

Only two studies have examined SCT and sleep in children. In a sample of 746 children referred for neuropsychological assessment, Koriakin et al. (2015) found that parent ratings of their child’s sleep problems (i.e., difficulty falling asleep, difficulty waking, restless sleep) were significantly correlated with parent-rated SCT symptoms. However, the magnitude of

the correlations was modest ($r_s = .12-.24$), and only difficulty waking remained significantly associated with greater SCT symptoms when controlling for ADHD and internalizing symptoms (Koriakin et al., 2015). Similarly, Becker and colleagues (2015c) found that SCT was only modestly associated with sleep functioning in a sample of 147 children diagnosed with ADHD Predominantly Inattentive Type.

Although these two child studies demonstrated modest associations between SCT and sleep (Becker et al., 2015c, Koriakin et al., 2015), several methodological considerations should be noted. First, both studies relied on single-item, non-validated measures of sleep. It is thus difficult to compare results across studies, and the degree to which SCT is associated with validated measures of children's sleep remains unknown. Second, neither study included a measure of daytime sleepiness. Daytime sleepiness specifically has been hypothesized to be redundant with SCT (Willoughby et al., 2008), and empirical research with adults indicates that SCT is more strongly associated with daytime sleepiness as compared to other domains of sleep (Becker et al., 2014b). There is a clear need for studies that examine the relation between SCT and daytime sleepiness in pediatric samples, particularly since separate lines of research have shown both SCT (Becker et al., 2016, Bernad et al., 2015, Langberg et al., 2014a, Lee et al., 2015, Willcutt et al., 2014) and daytime sleepiness (Bruni et al., 2006, Dewald et al., 2010, Langberg et al., 2014c, Langberg et al., 2013, Meijer, 2008) to be associated with poorer academic functioning. Finally, the Becker et al. (2015c) study included only children with ADHD, and examining SCT in non-ADHD clinical samples has been identified as a research priority (Barkley, 2014, Becker, 2013, Becker et al., 2016).

The current study adds to the preliminary research examining the association between SCT and sleep and addresses several limitations of previous studies conducted with children. Specifically, we examined the association between SCT and sleep in a large sample of children referred to a pulmonary-based, accredited Sleep Disorders Center (SDC). Thus, while the types of sleep difficulties leading to referral were wide-ranging, all children were experiencing some degree of sleep disruption and were seen by a clinician with expertise in behavioral sleep medicine. Validated parent-report measures of sleep were collected as part of routine clinical care, and thus allowed for examination of SCT in relation to behavioral and organic sleep disorder symptoms, including daytime sleepiness. Associations between SCT and sleep disorder diagnoses were also examined. The magnitude of correlations was examined to evaluate (1) sleep domains most strongly associated with SCT, and (2) whether any association was so strong ($r > .85$) (Brown, 2015, Little, 2013) to suggest that SCT and sleep may be redundant constructs. Finally, since studies have found both SCT and sleep to be associated with functional impairment (Barkley, 2014, Becker et al., 2015a, Becker et al., 2016, Beebe, 2011, Gregory and Sadeh, 2015, Kirov and Brand, 2014), we examined whether SCT would be associated with impairment in academic, social, and mental health domains after controlling for demographics, psychopathology symptoms (i.e., ADHD, oppositionality, depression, anxiety) as well as both behavioral and organic sleep problem severity. This provides a stringent test of whether SCT is associated with impairment in sleep-disordered children, thus making an important contribution to the extant literature by examining SCT in relation to impairment in a non-ADHD clinical sample. Based on previous research (Becker et al., 2016), we hypothesized that SCT would remain associated with poorer academic functioning, greater ADHD and internalizing symptom severity, and

less oppositionality after controlling for demographics, sleep problem severity, and other psychopathology symptoms. Although previous research has found an association between SCT and interpersonal problems, these studies have focused on general social problems or peer problems specifically (Bauermeister et al., 2012, Becker, 2014, Khadka et al., 2015, Willcutt et al., 2014); we extend the available interpersonal functioning research by examining SCT in relation to the parent-child relationship and parenting stress. Since SCT is linked to social problems and peer difficulties, we hypothesized that SCT would be associated with difficulties in the parent-child relationship. However, given the established link between oppositionality and parenting stress (Reitman et al., 2002) we expected oppositional symptoms to be more consistently and strongly associated than SCT symptoms with parenting stress.

Material and Methods

Participants

The sample included 325 youth (202 boys, 123 girls) ages 6-10 years ($M=7.93$, $SD=1.40$) and their caregiver(s). The majority of children were non-Hispanic White (79%), with remaining participants Black (11%), Hispanic (2%), Asian/Asian American (2%), or Multiracial/Other (6%). Based on parent-report, the majority of participants ($n=234$, 72%) had been previously diagnosed with a mental health disorder, including ADHD ($n=159$, 49%), anxiety ($n=94$, 29%), oppositional defiant disorder ($n=37$, 11%), autism spectrum disorder ($n=25$, 8%), depression ($n=15$, 5%), and/or bipolar disorder ($n=10$, 3%). In terms of parents' marital status, 60% were married, 19% were unmarried, 12% were divorced, 5% were separated, 3% were remarried, and 1% were widowed. Annual family income was spread across four categories: 26% reported annual income <\$20,000, 27% reported annual income of \$20,000-49,000, 25% reported annual income of \$50,000-99,000, and 22% reported an annual income >\$100,000.

Sleep diagnoses were given according to International Classification of Sleep Disorders Diagnostic and Coding Manual, 2nd Edition (ICSD-2) (American Academy of Sleep Medicine, 2005) criteria. Primary diagnoses were as follows: 213 participants (66%) were diagnosed with a behavioral insomnia of childhood (67 with sleep-onset association type, 70 with limit-setting type, and 76 with combined type), 83 participants (26%) were diagnosed with psychophysiological insomnia, 14 participants (4%) were diagnosed with a parasomnia, 7 participants (2%) were diagnosed with delayed sleep phase syndrome (DSPS), 4 participants (1%) were diagnosed with hypersomnia, 2 participants (0.6%) were diagnosed with nocturnal enuresis, and 2 participants (0.6%) were diagnosed with rhythmic movement disorder. Twenty-one percent of participants met criteria for a secondary sleep disorder diagnosis, and 12% met criteria for three sleep disorder diagnoses.

Procedures

The study site was an accredited SDC located in a tertiary care pediatric hospital and staffed by board certified sleep physicians and a licensed psychologist certified in behavioral sleep medicine. Patients referred to the SDC were triaged based on referral question and parent reported history gathered during an intake telephone interview. Patients with a chief

complaint of insomnia, parasomnia, or circadian rhythm disturbance without symptoms suggestive of an organic sleep disorder were triaged only to the Behavioral Sleep Medicine Clinic (BSMC). Patients with symptoms suggestive of an organic sleep disorder (e.g., obstructive sleep apnea) in addition to insomnia, parasomnia or circadian rhythm disturbance were also triaged to the SDC psychologist and a board certified sleep physician. All primary caregivers completed pre-evaluation screening measures (see Measures).

All study procedures were approved by the hospital's Institutional Review Board (IRB) and carried out in accordance with the Declaration of Helsinki. Specifically, eligible families received print and verbal information explaining that the purpose of the study. Primary caregivers provided informed consent before being enrolled in the study. Inclusion criteria were age 6-10 years and completion of the diagnostic sleep evaluation. Participants were not compensated for consenting for their clinical data to be used for research purposes.

Measures

Child Behavior Checklist (CBCL)—Child SCT, depression, anxiety, ADHD, and oppositional symptoms were assessed using the CBCL (Achenbach and Rescorla, 2001). The CBCL is a caregiver-report measure of children's emotional and behavioral functioning. Caregivers rate each item on a 3-point scale (0=*not true*, 1=*somewhat or sometimes true*, 2=*very true or often true*). In the present study, the *DSM*-oriented attention-deficit/hyperactivity problems (ADHP; i.e., ADHD symptoms), oppositional defiant problems, anxiety, and affective (depression) scales were used. The *DSM*-oriented scales have demonstrated good internal consistency as well as convergent and discriminant validity with other parent- and self-report symptom scales and with *DSM-IV* diagnoses (Achenbach and Rescorla, 2001). The 4-item CBCL SCT scale was used ("*confused or seems to be in a fog*", "*daydreams or gets lost in his/her thoughts*", "*stares blankly*", "*underactive, slow moving, or lacks energy*"). The CBCL SCT scale is a commonly-used measure of SCT in children (Bauermeister et al., 2012, Garner et al., 2014), is strongly correlated with a longer measure of SCT (Skirbekk et al., 2011), and demonstrated adequate internal consistency in the present study ($\alpha=0.67$).

In addition to the CBCL symptom domains, four academic functioning items on the CBCL were rated on a 4-point scale (0=*failing*, 1=*below average*, 2=*average*, 3=*above average*) to assess the child's performance in reading/English, math, science, and history/social studies.

Children's Sleep Habits Questionnaire (CSHQ)—The CSHQ is a 33-item caregiver-report measure of sleep behavior and sleep disorders symptoms (Owens et al., 2000). The CSHQ has demonstrated validity for use with children and has been shown to differentiate clinical from control groups (Goodlin-Jones et al., 2008, Owens et al., 2000). Caregivers use a 3-point scale to rate the frequency of specific sleep symptoms/behaviors during the previous week ("*rarely*" to "*usually*"). The measure yields a total score and eight subscale scores for which higher scores represent more problematic sleep: Bedtime Resistance (6 items; $\alpha=0.71$ in the present study), Sleep Duration (3 items; $\alpha=0.73$), Sleep Anxiety (4 items; $\alpha=0.63$), Night Wakings (3 items; $\alpha=0.48$), Parasomnias (7 items; $\alpha=0.56$); Sleep

Disordered Breathing (3 items; $\alpha=0.72$), Daytime Sleepiness (8 items; $\alpha=0.75$), and Sleep Onset Delay (1 item).

Sleep Disorders Inventory for Students, Child Version (SDIS-C)—The SDIS-C (Luginbuehl et al., 2008) is a 41-item caregiver-report measure screening for sleep disorders that have an organic basis and is used for children ages 2-10 years old. Items are rated on a 7-point scale (1=*the child never exhibits this behavior*, 7=*child exhibits behavior multiple times per hour daily or nightly*). The SDIS-C yields a total score and four sleep disorder scales: Obstructive Sleep Apnea (11 items; $\alpha=0.81$ in the present study), Excessive Daytime Sleepiness (7 items; $\alpha=0.73$), Periodic Limb Movement Disorder (11 items; $\alpha=0.75$), and Delayed Sleep Phase Syndrome (4 items; $\alpha=0.82$).

Parenting Stress Index, Short Form (PSI-SF)—The PSI-SF (Abidin, 1995) is a 36-item caregiver-report measure of parenting stress for children up to age 12. The PSI-SF comprises three subscales (12 items each), including Parental Distress ($\alpha=0.87$ in the present study), Parent-Child Dysfunctional Interaction ($\alpha=0.82$), and Difficult Child ($\alpha=0.85$). The Parental Distress subscale assesses a caregiver's perception of child-rearing competence and measures the distress a caregiver feels due to personal factors related to parenting, such as a lack of social support, stresses associated with other life roles, or parental depression. The Parent-Child Dysfunctional Interaction subscale assesses a caregiver's perception that the child does not meet expectations, as well as whether the parent perceives his or her interactions with the child as either positive/reinforcing or negative/unsatisfying. The Difficult Child subscale measures behavioral characteristics of the child that make him or her easy or difficult to manage, due to temperament, noncompliance, defiance, or demanding behavior. Caregivers answer each item using a 5-point scale (1=*strongly disagree*, 5=*strongly agree*). Items within each subscale are summed, with higher scores indicative of greater stress. Published psychometric properties of the PSI-SF demonstrate adequate test-retest reliability and internal consistency reliability, as well as external validity with child behavior (Abidin, 1995, Reitman et al., 2002).

Data Analytic Plan

All analyses were conducted in IBM SPSS, Version 23. First, zero-order correlation analyses were conducted to examine associations between SCT and other psychopathology symptom domains (i.e., inattention/hyperactivity, oppositionality, anxiety, depression) with the sleep variables (i.e., CSHQ scores, SDIS scores, sleep disorder diagnoses). A correlation of 0.10 is considered a small effect, 0.30 is considered a medium effect, and 0.50 is considered a large effect (Cohen et al., 2003). A correlation magnitude of .85 is considered the upper bound for the demonstration of discriminant validity (i.e., non-redundant constructs) (Brown, 2015, Little, 2013), and so a correlation between SCT and sleep that approaches or is greater than .85 would suggest that SCT and sleep should likely not be considered distinct constructs. Next, regression analyses were conducted to examine the unique effects of SCT and other psychopathology symptoms on sleep problem severity (i.e., CSHQ and SDIS total scores) above and beyond child demographics (i.e., age, sex, race [dichotomized as White and non-White]), and similar models were conducted with the CSHQ and SDIS daytime sleepiness subscales since redundancy between SCT and daytime sleepiness specifically has been

suggested. Finally, regression analyses were conducted to examine the unique effects of SCT on impairment (i.e., academic difficulties, parenting stress, and other psychopathologies) above and beyond child demographics, sleep problem severity, and other psychopathology symptoms. In these analyses the CSHQ and SDIS total scores were both used to control for both behavioral and organic sleep disorder symptoms. Of note, while these two sleep scores were strongly correlated ($r=.65$, $p<.001$), the magnitude of the correlation did not approach .85 and the regression models did not indicate problems with multicollinearity. The Durbin-Watson statistic ranged from 1.78-2.07 for all regression models. In these regression analyses, demographics and sleep problem severity were entered on Step 1, other psychopathology domains were entered on Step 2, and SCT was entered on Step 3. For all analyses, statistical significance was set at $p<.05$.

Results

Correlation Analyses

The zero-order correlations between psychopathology symptoms (including SCT) and the sleep variables are displayed in Table 1. The correlations between SCT and CSHQ domains were generally small in magnitude, with the exception of moderate correlations with the CSHQ Daytime Sleepiness and CSHQ Total scores. The correlations between SCT and SDIS domains ranged from being small (Delayed Sleep Phase Syndrome) to large (Excessive Daytime Sleepiness). Of note, the magnitude of the correlations between SCT and sleep functioning were generally similar, or in several cases smaller, to the magnitude of the correlations between other psychopathology domains and sleep. The one exception was a somewhat stronger correlation between SCT and SDIS Excessive Daytime Sleepiness ($r=.52$) as compared to the correlations between other psychopathologies and this sleep subscale ($r=.19-.42$), and Steiger's z -tests for dependent correlations confirmed that SCT was significantly more strongly correlated than other psychopathologies with SDIS Excessive Daytime Sleepiness ($ps<.05$). Finally, SCT was not significantly associated with having a behavioral insomnia or psychophysiological insomnia diagnosis (see Table 1).

SCT in Relation to Sleep Functioning

As displayed in Table 2, SCT remained significantly associated with sleep problem severity above and beyond child demographics and other psychopathology symptoms. Depressive symptoms were also associated with both CSHQ and SDIS total scores in the regression analyses; anxiety remained significantly associated with CSHQ Total and oppositionality remained significantly associated with SDIS Total. When examining the daytime sleepiness subscales specifically, both depression and SCT were significantly associated with greater daytime sleepiness in the final regression models (see Table 2).

SCT in Relation to Academic Functioning

Above and beyond demographics, sleep problem severity, and other psychopathologies, ADHD symptoms were consistently associated with poorer academic functioning (see Table 3). SCT did not contribute additional unique variance in relation to reading/English, but was uniquely and significantly associated with poorer functioning in math, science, and history/social studies. With the exception of ADHP, no other psychopathology domain nor either

measure of sleep functioning was significantly associated with academic functioning in the final regression model.

SCT in Relation to Parenting Stress

As shown in Table 4, no psychopathology domain was significantly associated with the Parental Distress subscale (though oppositionality was marginally associated with Parental Distress in the final model, $p=.06$). As expected, oppositionality was significantly associated with both Parent-Child Dysfunctional Interaction and Difficult Child scores. SCT also significantly contributed unique variance in predicting Parent-Child Dysfunctional Interaction.

SCT in Relation to Other Psychopathologies

Results of the analyses examining the association between SCT and other psychopathology domains are summarized in Table 5. As expected, SCT remained significantly positively associated with depression and ADHD symptoms above and beyond demographics, sleep problem severity, and other psychopathologies, but did not remain significantly associated with anxiety. Also as expected, whereas depression and ADHD remained significantly positively associated with oppositionality in the regression analysis, SCT symptoms were significantly *negatively* associated with oppositionality in the regression model.

Discussion

Although SCT has been the focus of recent research, the majority of studies have focused on distinguishing SCT from ADHD, often in ADHD-specific samples (Becker et al., 2016). In order for research in this area to advance, there is a clear need for studies in clinical samples other than ADHD (Becker and Barkley, in press). The current study makes a significant contribution to the extant literature by being the first study to examine SCT in a sleep-disordered sample, which is especially important since similarities between SCT and sleep problems – and daytime sleepiness in particular – have been observed (Becker et al., 2014b, Cortese et al., 2009, Langberg et al., 2014b, Willoughby et al., 2008). This is only the third study to examine the association between SCT and sleep in children, and the first to use well-validated measures of sleep functioning that also include subscales assessing daytime sleepiness. Furthermore, this is one of the first studies to examine whether SCT is associated with functional impairment in a non-ADHD clinical sample. That is, this study was not only able to examine the extent to which SCT and sleep problems are redundant constructs, but also evaluated whether SCT was associated with impairment in sleep-disordered children, above and beyond sleep problem severity and other psychopathology symptoms.

What is the Relation between SCT and Sleep in Sleep-Disordered Children?

Findings from this study do not support the suggestion that SCT is synonymous or redundant with sleep problems or daytime sleepiness. None of the correlations between SCT and sleep approached a magnitude that would suggest SCT is redundant with sleep problems, and in most cases the associations between SCT and sleep functioning were similar (or smaller) in magnitude to the associations between other psychopathology domains and sleep. The SDIS Excessive Daytime Sleepiness scale was the one exception,

whereby SCT evinced a stronger association than other psychopathology domains with scores on this subscale. This is the first study to examine the relation between SCT and daytime sleepiness, and we found SCT to be strongly related to daytime sleepiness ($r=.33$ and $.51$ for CSHQ and SDIS, respectively) at a magnitude remarkably similar to the Becker et al. (2014b) ($r=.51$) and Langberg et al. (2014b) ($r=.40$ in a general college student sample and $.51$ in a sample of college students with ADHD) studies conducted with adults. We similarly found SCT to remain significantly associated with overall sleep problems, as well as daytime sleepiness specifically, above and beyond child demographics and inattention/hyperactivity, oppositional, depressive, and anxiety symptoms. Thus, while SCT is distinct from sleep problems, SCT symptoms are nevertheless associated with increased sleep problems among children referred to a sleep disorders clinic.

Is SCT Uniquely Associated with Impairment in Sleep-Disordered Children?

While previous research has shown SCT to be associated with a range of impairments in children with ADHD, it has been unknown to date whether SCT is associated with impairment in other clinical samples. Consistent with previous research (Becker et al., 2016), we found SCT to remain uniquely associated with academic problems, inattention/hyperactivity, and depressive symptoms, even after controlling for sleep problem severity and other psychopathology symptoms. Specifically, several recent studies have found SCT to concurrently (Burns et al., 2013, Langberg et al., 2014a, Lee et al., 2014, Willcutt et al., 2014) and longitudinally (Bernad et al., 2015, Bernad et al., 2014) predict academic problems in community and ADHD samples, and similar findings emerged in our sample of sleep-disordered children. However, it should be noted that ADHD symptoms were the strongest and most consistent psychopathology domain to be associated with academic problems, which is also consistent with some previous research (Bauermeister et al., 2012, Becker and Langberg, 2013, Belmar et al., 2015, Bernad et al., 2015).

In addition, a clear link has been established between SCT and social/peer problems (Becker, 2014, Becker et al., 2014a, Burns et al., 2013, Lee et al., 2014, Willcutt et al., 2014), and this study extends this linkage to family functioning and parenting stress specifically. Although ODD symptoms were strongly associated with both dysfunctional interactions in the parent-child relationship and stress associated with parenting a difficult child, SCT contributed unique variance in the dysfunctional parent-child interactions domain specifically. This domain of parenting stress includes parents' feelings of competence and overall satisfaction with the child (Abidin, 1995, Reitman et al., 2002), and SCT symptoms may negatively impact both of these areas since SCT is associated with slowed responsiveness, information processing difficulties, poorer socio-emotional and academic functioning, and some deficits in daily life executive functioning that may interfere with tasks such as organization (Barkley, 2013, Becker and Langberg, 2014, Becker et al., 2015b, Mikami et al., 2007, Willcutt et al., 2014). Although speculative in the absence of additional research, it is also possible that children with high levels of SCT symptoms are less enjoyable to parent and display less warmth and positive affect in reciprocal interactions with their caregivers, particularly since SCT is linked to problems in emotion regulation (Becker et al., 2015b, Flannery et al., 2014, Jarrett et al., 2014).

Finally, since sleep problems are clearly associated with a range of mental health domains (Becker et al., 2015a, Beebe, 2011, Gregory and Sadeh, 2015, Kirov and Brand, 2014), we examined whether SCT would be associated with other psychopathology symptoms even after accounting for sleep problem severity. As hypothesized and again consistent with previous research (Bauermeister et al., 2012, Becker and Langberg, 2013, Becker et al., 2014a, 2016, Burns et al., 2013, Garner et al., 2013, 2014, Lee et al., 2014, Leopold et al., 2015, 2016, McBurnett et al., 2014, Penny et al., 2009, Willcutt et al., 2014), SCT remained significantly associated with both inattention/hyperactivity and depressive symptoms. Interestingly, in the regression analyses SCT remained significantly associated with depression but not anxiety. This finding adds to a small but growing body of research indicating that while SCT is clearly associated with internalizing symptoms, this seems to be more specific to depression as opposed to anxiety (Barkley, 2013, Becker et al., 2014a, Fenollar Cortés et al., 2014, Garner et al., 2013, Jacobson et al., 2012). Depression and anxiety are both characterized by high negative affect, but can be differentiated based on physiological hyperarousal (anxiety) or low positive affect/anhedonia (depression) (Anderson and Hope, 2008, Clark and Watson, 1991). Since SCT appears to be more strongly associated with depression than anxiety, it stands to reason that SCT should be associated with high negative affect and low positive affect, and less clearly associated with physiological hyperarousal. Studies are needed to directly test this hypothesis. Lastly, our hypothesis that SCT would be *negatively* associated with ODD symptoms after controlling for inattention/hyperactivity and other psychopathology symptoms was supported. Several studies have now found that, when controlling for ADHD, SCT is associated with fewer externalizing behaviors (Becker et al., 2014a, Bernad et al., 2014, 2015, Jacobson et al., 2012, Lee et al., 2014). Our ability to replicate this finding in a clinical sample of sleep-disordered children provides important support for the likely generalizability of this finding across sample types. What seems to be coming clear is that while SCT may reduce a child's risk of having disruptive behavior problems, it may likewise confer risk for increased mood problems. Longitudinal research across developmental periods will be needed to more directly test these differential associations, which if supported would have implications for prevention and intervention efforts.

Limitations and Future Directions

Our use of a large sample of children referred to a sleep disorders clinic is a strength, particularly given calls to examine SCT in non-ADHD clinical samples (Barkley, 2014, Becker, 2013, Becker and Barkley, in press). However, it cannot be assumed that our results will generalize to other clinical samples, and we were unable to verify parent-report of comorbid mental health diagnoses (e.g., ADHD, anxiety, autism) or conduct diagnostic interviews as part of participants' clinic visit. In addition, while we were able to examine several facets of sleep functioning using well-validated parent rating scales and sleep disorder diagnoses, we did not have ratings from other informants (e.g., teachers, children themselves), objective measures of sleep (e.g., polysomnography, actigraphy, multiple sleep latency test), or other methods for assessing impairment (e.g., school grades, observed parent-child interactions). As such, shared method variance may have contributed to our findings related to impairment, although this seems unlikely since the sleep severity ratings and other psychopathology ratings were also parent-report measures. Since this was an

initial examination of SCT in a sleep-specific sample, we chose not to adjust for the number of analyses conducted, and it will be important for future studies to replicate our findings, particularly in more diverse samples and different age groups (e.g., adolescents). Also, we used the SCT items from the CBCL since this measure is used as part of the standardized assessment battery for the study site. Of note, the CBCL SCT items have been frequently used (Bauermeister et al., 2012, Becker and Langberg, 2013, Garner et al., 2013, 2014), are distinct from the other CBCL domains examined in this study (Becker et al., 2014a), and correlate with longer measures of SCT (Skirbekk et al., 2011), and findings using the CBCL SCT scale seem to converge with studies using SCT-specific scales (Becker et al., 2016). Nevertheless, it would be helpful for future research to use an SCT scale that has a larger item pool of SCT items, particularly since there is ongoing interest in whether SCT is unidimensional or multidimensional (Becker, 2013, Becker et al., 2016) and certain facets of SCT may be more strongly related to sleep problems/daytime sleepiness (Becker et al., 2015c). Finally, a large body of research demonstrates ADHD to be associated with sleep problems in children (Cortese et al., 2009, Kirov and Brand, 2014), and perhaps our use of the limited CBCL measure of ADHD symptoms contributed to the surprising lack of association between inattentive/hyperactive-impulsive symptoms and sleep functioning in the regression analyses in the present study.

Conclusion

This is the first study to examine SCT in a sleep-disordered sample, and also the first study to examine in children the association between SCT and daytime sleepiness. Findings demonstrate that SCT is related to, but not redundant with, sleep problems and daytime sleepiness. Further, SCT was associated with several domains of functional impairment in sleep-disordered children, above and beyond sleep problem severity, demographic characteristics, and other psychopathology symptoms. Additional studies are needed to replicate and extend these findings, but these initial results suggest that SCT may be associated with impairment across clinical conditions and that it may be valuable to assess for SCT in behavioral sleep medicine evaluations.

Acknowledgement

Dr. Becker is supported by award number K23MH108603 from the National Institute of Mental Health (NIMH). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health (NIH).

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Highlights

- Examined SCT in relation to sleep and impairment in sleep-disordered children.
- SCT is related to, but not redundant with, sleep problems or daytime sleepiness.
- SCT is related to sleep problems and impairment in sleep-disordered children.

Table 1

Correlations of Psychopathology Domains with Children's Sleep Functioning and Primary Sleep Disorder Diagnosis

Children's Sleep Habits Questionnaire (CSHQ)									
	Bedtime Resist.	Sleep Onset	Sleep Duration	Sleep Anxiety	Night Wakings	Parasomnias	Sleepdisord. Breathing	Daytime Sleepiness	CSHQ Total
SCT	.05	.07	.12 *	-.03	.04	.21 ***	.18 **	.33 ***	.31 ***
Depression	.13 *	.24 ***	.31 ***	.06	.12 *	.23 ***	.13 *	.30 ***	.40 ***
Anxiety	.24 ***	.19 **	.10	.25 ***	.04	.21 ***	.07	.18 **	.32 ***
ADHP	.09	.18 **	.21 ***	-.01	.03	.12 *	.06	.12 *	.20 ***
Oppositionality	.11 *	.19 **	.20 ***	.03	.06	.17 **	.03	.18 **	.26 ***

Sleep Disorders Inventory for Students (SDIS)				
	Obstructive Sleep Apnea	Periodic Limb Movement Disorder	Delayed Sleep Syndrome	Excessive Daytime Sleepiness
SCT	.36 ***	.39 ***	.12 *	.52 ***
Depression	.26 ***	.39 ***	.26 ***	.42 ***
Anxiety	.16 **	.24 ***	.09	.19 **
ADHP	.23 ***	.38 ***	.23 ***	.19 **
Oppositionality	.18 **	.40 ***	.24 ***	.24 ***

Sleep Disorder Diagnosis ^a			
	Behavioral Insomnia of Childhood: Sleep-Onset Association	Behavioral Insomnia of Childhood: Limit-Setting	Psychophysiological Insomnia
SCT	-.11	.05	-.01
Depression	-.04	.06	.01
Anxiety	.01	-.15 **	.03
ADHP	-.06	.11	-.01
Oppositionality	-.17 **	.15 **	-.02

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Note. N=325. ADHP = attention-deficit/hyperactivity problems. SCT = sluggish cognitive tempo.

^a For sleep disorder diagnoses, 0=diagnosis not present, 1=diagnosis present. Given the small number of participants diagnosed with a parasomnia, delayed sleep phase syndrome, hypersomnia, nocturnal enuresis, or rhythmic movement disorder, correlations with these sleep disorder diagnosis were not examined.

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

Table 2

Multiple Regression Models Examining Sluggish Cognitive Tempo Symptoms and Other Psychopathology Domains in Relation to Sleep Functioning

	Step 1	Step 2	Step 3
CSHQ Total			
R^2	.01	.19	.22
F	1.47	17.58***	9.21**
Depression		.31***	.23**
Anxiety		.15*	.15*
ADHP		-.01	-.05
Oppositionality		.05	.07
SCT			.17**
SDIS Total			
R^2	.02	.26	.32
F	1.75	25.37***	29.21***
Depression		.32***	.20**
Anxiety		-.05	-.05
ADHP		.16*	.10
Oppositionality		.14*	.18**
SCT			.29***
CSHQ Daytime Sleepiness			
R^2	.01	.10	.15
F	0.71	8.44***	18.19***
Depression		.27***	.16*
Anxiety		.05	.06
ADHP		-.05	-.10
Oppositionality		.06	.09
SCT			.25***
SDIS Excessive Daytime Sleepiness			
R^2	.02	.20	.33
F	2.46	17.38***	62.60***
Depression		.41***	.23***
Anxiety		-.02	-.02
ADHP		-.02	-.11
Oppositionality		.05	.11
SCT			.42***

Note. All models included age, sex (dummy-coded), and race (dummy-coded) entered at Step 1, but the unique effects for these variables are not shown for simplicity purposes (full results available from the corresponding author). Coefficients shown are standardized beta coefficients. ADHP = attention deficit/hyperactivity problems. CSHQ = Children's Sleep Habits Questionnaire. SCT = sluggish cognitive tempo. SDIS = Sleep Disorders Inventory for Students.

*
 $p < .05$.

**
 $p < .01$.

 $p < .001$.

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Table 3

Multiple Regression Models Examining Sluggish Cognitive Tempo Symptoms in Relation to Academic Functioning

	Step 1	Step 2	Step 3
Reading/English			
R^2	.11	.19	.20
F	7.23 ***	7.26 ***	3.48
CSHQ Total	.06	.03	.03
SDIS Total	-.29 ***	-.16 *	-.12
Depression		-.11	-.08
Anxiety		.11	.11
ADHP		-.32 ***	-.30 ***
Oppositionality		.07	.05
SCT			-.12
Math			
R^2	.05	.12	.14
F	3.05 *	6.58 ***	6.36 *
CSHQ Total	.10	.09	.09
SDIS Total	-.25 **	-.16 *	-.11
Depression		-.10	-.05
Anxiety		.02	.02
ADHP		-.33 ***	-.30 ***
Oppositionality		.17 *	.14
SCT			-.16 *
Science			
R^2	.04	.10	.12
F	2.25 *	4.80 **	5.93 *
CSHQ Total	.04	.000	.002
SDIS Total	-.18 *	-.06	-.02
Depression		-.06	-.02
Anxiety		.12	.12
ADHP		-.30 ***	-.26 **
Oppositionality		.06	.04
SCT			-.16 *
History/Social Studies			
R^2	.09	.16	.19
F	5.28 ***	6.54 ***	9.68 **
CSHQ Total	.03	.01	.01
SDIS Total	-.26 **	-.14	-.09

	Step 1	Step 2	Step 3
Depression		-.14	-.08
Anxiety		.11	.11
ADHP		-.32***	-.28***
Oppositionality		.12	.09
SCT			-.20**

Note. All models included age, sex (dummy-coded), and race (dummy-coded) entered at Step 1, but the unique effects for these variables are not shown for simplicity purposes (full results available from the corresponding author). Coefficients shown are standardized beta coefficients. ADHP = attentiondeficit/hyperactivity problems. CSHQ = Children's Sleep Habits Questionnaire. SCT = sluggish cognitive tempo. SDIS = Sleep Disorders Inventory for Students.

*
 $p < .05$.

**
 $p < .01$.

 $p < .001$.

Table 4

Multiple Regression Models Examining Sluggish Cognitive Tempo Symptoms in Relation to Parenting Stress

	Step 1	Step 2	Step 3
Parental Distress			
R^2	.10	.17	.17
F	4.96***	4.77**	0.47
CSHQ Total	-.03	-.04	-.04
SDIS Total	.28**	.10	.09
Depression		.07	.05
Anxiety		.01	.01
ADHP		.15	.14
Oppositionality		.16	.18 [†]
SCT			.05
Parent-Child Dysfunctional Interaction			
R^2	.12	.32	.34
F	6.11***	16.69***	4.68*
CSHQ Total	-.08	-.14	-.15
SDIS Total	.38***	.08	.06
Depression		.19*	.13
Anxiety		.05	.05
ADHP		.13	.09
Oppositionality		.32***	.35***
SCT			.15*
Difficult Child			
R^2	.22	.53	.53
F	12.83***	37.03***	0.002
CSHQ Total	.10	.03	.03
SDIS Total	.39***	.03	.03
Depression		.19**	.19**
Anxiety		.08	.08
ADHP		.12	.12
Oppositionality		.44***	.44***
SCT			-.003

Note. All models included age, sex (dummy-coded), and race (dummy-coded) entered at Step 1, but the unique effects for these variables are not shown for simplicity purposes (full results available from the corresponding author). Coefficients shown are standardized beta coefficients. ADHP = attention-deficit/hyperactivity problems. CSHQ = Children's Sleep Habits Questionnaire. PSI = Parenting Stress Index. SCT = sluggish cognitive tempo. SDIS = Sleep Disorders Inventory for Students.

[†] $p = .06$

* $p < .05$.

** $p < .01$.

 $p < .001$.

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Table 5

Multiple Regression Models Examining Sluggish Cognitive Tempo in Relation to Other Psychopathology Domains

	Step 1	Step 2	Step 3
Depression			
R^2	.22	.45	.50
F	17.80 ***	44.81 ***	27.44 ***
CSHQ Total	.21 **	.11 *	.10
SDIS Total	.30 ***	.17 **	.08
Anxiety		.35 ***	.32 ***
ADHD		.06	.01
Oppositionality		.25 ***	.27 ***
SCT			.24 ***
Anxiety			
R^2	.12	.35	.35
F	8.88 ***	36.68 ***	0.02
CSHQ Total	.30 ***	.22 ***	.22 ***
SDIS Total	.04	-.18 **	-.18
Depression		.42 ***	.41 ***
ADHD		.19 **	.19 **
Oppositionality		.04	.04
SCT			.01
ADHP			
R^2	.14	.43	.44
F	10.57 ***	52.09 ***	6.82 **
CSHQ Total	-.06	-.12 *	-.12 *
SDIS Total	.40 ***	.20 **	.15 *
Depression		.06	.01
Anxiety		.17 **	.16 **
Oppositionality		.47 ***	.49 ***
SCT			.13 **
Oppositional			
R^2	.16	.46	.47
F	11.87 ***	57.74 ***	7.17 **
CSHQ Total	-.01	-.04	-.04
SDIS Total	.39 ***	.13 *	.17 **
Depression		.25 ***	.29 ***
Anxiety		.03	.03

	Step 1	Step 2	Step 3
ADHD		.45 ***	.46 ***
SCT			-.13 **

Note. All models included age, sex (dummy-coded), and race (dummy-coded) entered at Step 1, but the unique effects for these variables are not shown for simplicity purposes (full results available from the corresponding author). Coefficients reported are standardized beta coefficients. ADHP = attention-deficit/hyperactivity problems. CSHQ = Children's Sleep Habits Questionnaire. SCT = sluggish cognitive tempo. SDIS = Sleep Disorders Inventory for Students.

*
 $p < .05$.

**
 $p < .01$.

 $p < .001$.