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Factor Structure of a Sluggish Cognitive Tempo Scale in Clinically-Referred Children

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Abstract "Sluggish cognitive tempo" (SCT) is a construct hypothesized to describe a constellation of behaviors that includes daydreaming, lethargy, drowsiness, difficulty sustaining attention, and underactivity. Although the construct has been inconsistently defined, measures of SCT have shown associations with symptoms of attention-deficit/hyperactivity disorder (ADHD), particularly inattention. Thus, better characterization of SCT symptoms may help to better predict specific areas of functional difficulty in children with ADHD. The present study examined psychometric characteristics of a recently developed 14-item scale of SCT (Penny et al., Psychological Assessment 21:380–389, 2009), completed by teachers on children referred for outpatient neuropsychological assessment. Exploratory factor analysis identified three factors in the clinical sample: *Sleepy/Sluggish, Slow/Daydreamy,* and *Low Initiation/Persistence*. Additionally, SCT symptoms, especially those loading on the *Sleepy/Sluggish* and *Slow/Daydreamy* factors, correlated more strongly with inattentive than with hyperactive/impulsive symptoms, while *Low Initiation/Persistence* symptoms added significant unique variance (over and above symptoms of inattention) to the predictions of impairment in academic progress.

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ADHD and SCT

Attention-deficit/hyperactivity disorder (ADHD) is one of the most frequently diagnosed neurodevelopmental disorders (Centers for Disease Control and Prevention [CDC], 2010), commonly diagnosed in childhood and often persisting into adulthood (Kessler et al. 2005). The current Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV), characterizes ADHD as having three subtypes: Hyperactive-Impulsive, Inattentive, and Combined (American Psychiatric Association 2000). Categorical representation of ADHD subtypes has been questioned, however, as evidence suggests that not only are the subtypes themselves heterogeneous (e.g., Elia et al. 2009; Goth-Owens et al. 2010), but the diagnostic symptoms are also developmental phenomena that change over time (Lahey et al. 2005; Larsson et al. 2011). For example, individuals within the Inattentive subtype may actually include children who previously met criteria for Hyperactive-Impulsive or Combined subtypes, but have "aged out" of their hyperactive symptomatology (Lahey et al. 2005; Larsson et al. 2011), or those children who are just subthreshold (with regard to Hyperactive-Impulsive symptoms) for the Combined subtype. Not surprisingly, research comparing neurobehavioral and neuropsychological function among children with different ADHD subtypes has been inconsistent—often failing to identify meaningful differences (e.g., Riccio et al. 2006; Riley et al. 2008).

Children demonstrating symptoms of the Inattentive subtype have also been described as displaying characteristics of sluggish cognitive tempo (SCT), a construct characterized by difficulty sustaining attention, daydreaming, lethargy, physical

underactivity, slowed movement, and decreased responsiveness (Carlson and Mann 2002; Garner et al. 2010). While diagnostic criteria for the ADHD-Inattentive subtype and SCT overlap, there is emerging evidence that some features of the SCT phenotype may be distinct from inattention, perhaps related to anomalous development of ventral prefrontal, right superior temporal, and posterior-inferior parietal cortices–areas which have been differentially implicated in regulation of attention in children with primarily Inattentive ADHD (Solanto et al. 2009), and may add unique variance in predicting neurobehavioral function, beyond that attributable to ADHD symptomatology (Murphy-Bowman et al. 2011). A confirmatory factor analysis of teacher and parent symptom ratings of SCT, inattention, and hyperactivity-impulsivity found that a three-factor solution fit the data best, suggesting that SCT and inattention represent distinct factors (Hartman et al. 2004); however, others have found SCT and inattentive symptoms to load together on the same factor (e.g., Todd et al. 2004), suggesting that further clarification is needed.

Within the Inattentive subtype, children with higher levels of SCT symptomatology have been found to show less externalizing behavior, but higher levels of unhappiness, withdrawal, anxiety/depression, and social dysfunction relative to children with lower levels of SCT symptomatology, suggesting a possible link between SCT and mood symptoms (Carlson and Mann 2002; Hartman et al. 2004). Garner and colleagues (2010) investigated the association between SCT and adjustment symptoms within a clinically-referred sample, finding that parent- and teacher-reported SCT symptoms were only weakly correlated (r=0.28 and 0.22, respectively) with ratings on the Anxious/Depressed scale of the Child Behavior Checklist (CBCL; Achenbach 1991; Achenbach and Rescorla 2007), with parent ratings of SCT correlating to a similar degree with ratings on the CBCL Aggressive behavior scale (r=0.20). In their sample, SCT ratings correlated more strongly with ratings of inattention (r=0.42 and 0.55, for parent and teacher ratings, respectively). Similarly, a recently published abstract found parent ratings of SCT symptoms to have more overlap with ratings of inattention than with ratings of anxiety in a community sample of children with ADHD and typically-developing controls (Murphy-Bowman et al. 2011). Moreover, higher levels of SCT symptoms were predictive of slowed processing speed, even after controlling for symptoms of inattention.

Measurement of SCT

Although there is a growing body of work validating the SCT construct, and interest in better specification of the Inattentive ADHD subtype in the upcoming DSM-V (American Psychiatric Association 2010; Coghill and Seth 2011), there is little consensus regarding definition or measurement of these characteristics. Several studies have extracted items from the Child Behavior Checklist (CBCL; Achenbach 1991; Achenbach and Rescorla 2007) to study behaviors associated with SCT. Hartman et al. (2004) examined parent- and teacher-rated symptoms of SCT in a community sample, using five items on the CBCL believed to be characteristic of the construct, including: "confused or seems to be in a fog;" "daydreams or gets lost in his/her thoughts;" "stares blankly;" "underactive, slow moving, or lacks energy;" and "sluggish/slow to respond." Using these items, SCT symptoms were dissociated from symptoms of ADHD, although teacher ratings showed a stronger association between SCT and inattention while parent ratings suggested that both Inattentive and Combined subtypes showed significant SCT symptomatology (Hartman et al. 2004). In 2007, a new 4-item subscale to assess Sluggish Cognitive Tempo was formally included on the CBCL, including items used in earlier studies of SCT (Achenbach and Rescorla 2007). Using the CBCL SCT scale with parents and teachers in a clinical sample, Garner et al. (2010) found that children with the Inattentive subtype were rated as showing more symptoms of SCT than children with the Combined subtype, although both ADHD subtypes had higher SCT symptoms than a no-diagnosis group. Wahlstedt and Bohlin (2010) investigated teacher ratings of SCT in a non-referred, community-based sample in Sweden, using five SCT items from the CBCL teacher rating form. Symptoms of SCT and symptoms of DSM-IV-defined inattention were highly correlated; however, SCT was more strongly associated than DSM-IV-defined inattention with performance on measures of sustained attention than with inhibitory control. Recently, construct validity of the CBCL SCT subscale was examined using parent ratings in a sample of children with and without ADHD (Murphy-Bowman et al. 2011). Consistent with prior studies examining associations between SCT and ADHD-related symptomatology, the SCT scale was more strongly correlated with measures of similar constructs such as inattention and performance on timed tasks, than with measures of dissimilar constructs such as untimed verbal tasks or internalizing behaviors. Ratings on the SCT scale also uniquely predicted slowing in children's processing speed, after controlling for inattentive and hyperactive/impulsive symptomatology.

Noting the limitations of a 4- or 5-item rating scale, other researchers have developed measures assessing SCT-specific symptomatology in more depth. For example, McBurnett and Pfiffner 2005, in Pfiffner et al. (2007) developed a 15-item measure of SCT symptoms, including such items as "daydreams," "stares into space," "loses cognitive set," and "moves slowly." In a sample of children referred to an ADHD specialty clinic, this 15-item scale showed good internal consistency (Cronbach's alpha=0.90) as reported in Pfiffner et al. (2007). Unfortunately, no additional normative or psychometric data are available for this measure. More recently, Penny et

al. (2009) developed a 14-item scale of symptoms believed to represent the SCT construct. Items included "apathetic, shows little interest in things or activities;" "lacks initiative to complete work;" "effort on tasks fades quickly;" and "seems to be in a world of his or her own." In a preliminary validation study with a large sample of typically developing Canadian school children, this scale was found to reliably assess symptoms of SCT, with parent and teacher ratings suggesting a multifactorial structure. Consistent with prior research, all of the subscales on this measure were found to correlate more strongly with inattentive than hyperactive symptoms of ADHD; however, SCT symptoms were also more strongly associated with internalizing symptomatology than were inattentive symptoms. Given the literature to date, the Penny et al. 14-item SCT scale may represent the most comprehensive and promising measure of the SCT construct, although it has not yet been examined within a clinical population or within a United States sample.

In sum, although research investigating SCT is emerging, with clear implications for proposed diagnostic criteria for ADHD in the DSM-V, the construct has not been consistently defined. Thus, to date, there is no clear consensus regarding measurement. Currently, there are few published studies or measures of SCT, and those studies that exist have used a heterogeneous approach to item content and depth of coverage, sampling, and raters. Additionally, to our knowledge, few studies have examined whether the pattern of SCT symptoms in a typically developing community sample differs from the pattern seen in a clinically referred sample (e.g., Garner et al. 2010). Finally, even fewer studies have examined *teacher* ratings of the construct in a clinical sample. Teacher ratings may be especially relevant to diagnosis of ADHD, not only due to the requirement that symptoms be present across settings, but also as teachers regularly observe children completing less preferred and often effortful tasks –tasks which are most likely to elicit difficulties with attentional regulation.

Given these considerations, the purpose of the present study was to examine teacher ratings on the Penny et al. (2009) Sluggish Cognitive Tempo scale in a clinically referred sample. This scale was chosen because it appears promising, with published normative data and established preliminary validity in typically developing children. The present study examined whether the factor structure identified in the original validity study in Canada was consistently observed in a sample of clinically referred children within the U.S. We hypothesized that, given the strong overlap between SCT and inattentive ADHD symptoms, the factor structure of teacher ratings from a clinical sample might differ from the two-factor solution described in the community sample (Penny et al. 2009), as greater variability of symptom presentation is possible within a referred sample. Furthermore, we also hypothesized that the pattern of specific associations between SCT subscales and ADHD symptomatology would differ, with all SCT subscales showing stronger associations with the inattentive symptomatology than with hyperactive-impulsive symptoms.

Methods

Procedures

As part of routine clinical practice at a large outpatient neuropsychology assessment center, parents of children referred to the clinic request that their child's teacher complete a set of behavioral rating scales [including the Penny et al. (2009) SCT scale, the ADHD Rating Scale-IV (DuPaul et al. 1998), portions of the Vanderbilt Assessment Scales (Wolraich et al. 1998), and the Fabiano et al. (2006) Impairment Rating Scale] through a secure online survey engine prior to assessment. All questionnaire data were subsequently entered into the departmental clinical database. Following approval from the Institutional Review Board, the clinical database was queried and *de-identified* data were extracted for any child for whom teacher ratings on the SCT scale, ADHD Rating Scale-IV, Vanderbilt, and the Impairment Rating Scale were available. Additional data extracted from the clinical dataset included age, sex, race, ethnicity, and medication status. Using this data extraction method, teacher ratings from a total of 143 children were included in the analyses.

Study Measures

Sluggish Cognitive Tempo (SCT) Scale (Penny et al. 2009) The SCT scale is a 14-item teacher- or parent-report rating scale of symptoms that correspond to the SCT construct. Ratings are made on a four-point Likert scale (0 = Never or Rarely; 1 = Sometimes; 2 = Often; 3 = Very Often). Teacher ratings were used for the present investigation. The scale was originally normed on a Canadian sample of school children, and data from teacher reports in this sample yielded two factors, *Slow* and *Sleepy/Daydreamer*, accounting for 74.6 % of the variance. Internal consistency ranged between 0.93 and 0.96. Test-retest reliability estimates were not published for the teacher-report form, but estimates for the parent-report version were adequate (ranging from 0.70 to 0.87). Total composite score for the SCT scale is the sum of the ratings on all 14 items.

ADHD Rating Scale-IV, School Version (DuPaul et al. 1998) The ADHD Rating Scale-IV is an 18-item measure, reflecting the DSM-IV ADHD diagnostic criteria. The scale is designed to be completed by parents or teachers, although for the purposes of the current study, only the school version was used. Item content reflects DSM-IV diagnostic criteria

and items were rated based on the child's behavior over the past 6 months, using a four-point Likert scale (0 = Not at all; 1 = Sometimes; 2 = Often; 3 = Very Much). Subscales correspond to the DSM-IV Inattentive and Hyperactive/Impulsive criteria. Total subscale scores were obtained by adding item ratings (range: 0–27 for each). The ADHD Rating Scale-IV has been shown to demonstrate adequate reliability and validity (DuPaul et al. 1998); internal consistency estimates for the school version ranged from 0.88 to 0.94, with test-retest reliability over short periods of time ranging from 0.88 to 0.90. In the current sample, internal consistency for the ADHD Rating Scale-IV subscales was excellent (Inattention alpha=0.90; Hyperactivity/Impulsivity alpha=0.92).

Based on teacher ratings on the ADHD Rating Scale-IV, children were identified as displaying a high level of behavioral symptoms, consistent with behavioral criteria (using symptom counts based upon items endorsed as "often" or "very much" true) characteristic of the DSM-IV ADHD subtypes. Specifically, children for whom teachers endorsed at least six symptoms of inattention, but fewer than six symptoms of hyperactivity/impulsivity were considered as likely to display a presentation characterized by high levels of Inattention (or the high-Inattentive symptomatology group; high-I); children with at least six symptoms of hyperactivity/impulsivity but fewer than six symptoms of inattention were considered to display behaviors characterized by high levels of Hyperactivity/Impulsivity (or the high-Hyperactive/Impulsive symptomatology group; high-H/I); and children for whom teachers endorsed at least six symptoms of both inattention and hyperactivity/impulsivity were considered to present with symptomatology characterized by high levels of both types of behaviors (or the high-Combined symptomatology group; high-C). In each case, although no formal diagnosis of ADHD was made as data from multiple settings were not available, for the purposes of this study, the level of *perceived behavioral symptomatology,* according to teachers, was used to group children as primarily characterized by a particular behavioral presentation: high-I, high-H/I, or high-C for initial analyses. Children rated as showing fewer than six symptoms of both inattention and hyperactivity/impulsivity were considered to fall into the low symptomatology group (Low-Symptoms).

Vanderbilt Assessment Scale, Teacher Version (Wolraich et al. 1998) The Vanderbilt Assessment Scale is an observer-report measure of behavioral symptoms; for the purposes of this study, only the teacher-report version was used. Specifically, the seven items designed to assess for internalizing behavior symptoms suggestive of anxiety or depression were included to provide an estimate of internalizing symptoms (e.g., is fearful, anxious, or worried; feels worthless or inferior; is sad, unhappy, or depressed). Items are rated on a four-point scale (0 = Never; 1 = Occasionally; 2 = Often; 3 = Very Often). The anxiety score is the sum of ratings on the three anxiety symptom items (range=0 to 9); the depression score is the sum of ratings on the four items assessing depressive symptomatology (range=0 to 12). In this sample, internal consistency for the Vanderbilt affective scales was good: Anxiety items/scale alpha=0.84; Depression items/scale alpha=0.86.

Impairment Rating Scale (IRS; Fabiano et al. 2006) The Impairment Rating Scale is a brief observer-rated measure assessing the impact of a child's behavioral problems on specific domains of functioning. Raters were asked to quantify (on a 0 to 6 scale) the degree to which behavioral difficulties affect the child's functioning across academic (e.g., academic progress), social (e.g., relationships with peers and adults), and personal (e.g., self-esteem) domains. For the online version of this measure, teachers were asked to check a box on a 0 to 6 scale, indicating ascending severity, which corresponded to the degree to which the child's behavioral problems were felt to limit his or her academic progress. The IRS demonstrated adequate initial stability over a period of 2 to 6 months and adequate convergent and discriminant validity in identifying children with ADHD (Fabiano et al. 2006). The overall IRS score correlated with ADHD symptomatology, as rated by both parents and teachers.

Data Analysis

Exploratory factor analysis was conducted on the 14 items of the SCT scale, completed by teachers, to determine whether the component structure of the measure within a clinically referred population was consistent with that reported in the original community-based sample. Factors were extracted using principal axis factoring analysis, with Promax rotation. Next, the pattern of associations among total ADHD symptomatology, behavioral subtypes (defined by number of symptoms endorsed by teachers on the ADHD Rating Scale-IV), and SCT total and factor scores were examined. SCT symptomatology was examined across groups, including behavioral subtypes, using an ANOVA to determine whether the pattern of SCT symptomatology differed for children characterized by different behavioral presentations. Finally, hierarchical regression analyses were used to determine the association between SCT scale factors and teacher-rated school functioning.

Results

Sample

The sample included 143 children consecutively referred for clinical neuropsychological evaluation at an outpatient

hospital-based clinic, for whom teacher ratings were available (age M=9.18, SD=3.02, range: 3–18 years). In this sample, the majority (n=114) of children fell between ages 5 and 11 (i.e., elementary school age). Four were preschoolers and the remainder of the sample (n=25) was older. The majority were male (67 %) and Caucasian (51.7 %); 16.8 % were African-American, 4.2 % Asian, 0.7 % were multiracial, and 17.5 % of other racial backgrounds or unknown. Five participants (3.5 %) were of parent-reported Hispanic ethnicity. Additionally, medication data were available for 136 of the 143 participants. Of those for whom this information was provided, 29 (21.3 %) were prescribed stimulant medications and 10 (7.4 %) were prescribed non-stimulants (these groups are not exclusive as some children were reportedly prescribed both types of medication simultaneously).

Using the descriptive criteria outlined above for categorical characterization of the sample according to level of perceived behavioral symptomatology, 59.4 % (n=85) of the sample fell into the Low-Symptoms group, based on teacher ratings. Of those reported to exhibit a relatively high level of symptomatology (40.6 %; n=58), 63.8 % (n=37) fell into the high-I group, 13.8 % (n=8) fell into the high-H/I group, and 22.4 % (n=13) fell into the high-C group.

Factor Structure of the SCT Scale

Initial internal consistency of the SCT scale items in this clinical sample was excellent and comparable with that found in the initial validation study (Cronbach's *alpha*= 0.93). Exploratory factor analysis, using principal axis factoring with Promax (oblique) rotation, of teacher ratings on the SCT scale items extracted three factors which accounted for 68.03 % of the total variance; the first factor accounted for 50.32 % of the variance, factor 2 accounted for an additional 11.64 %, and factor 3 accounted for 6.07 % of the variance. Factors were determined to be significant based upon eigenvalues above 1.0 and examination of the scree plot. There were very minimal cross loadings between factors (see Table 1), with only one item ("appears lethargic") loading strongly on more than one factor. Based on item loadings, and using terminology proposed by the scale authors, factor 1 can be described as a *Sleepy/Sluggish* factor (e.g., appears to be sluggish, appears lethargic, is underactive/lacks energy), factor 2 represents *Slow/Daydreamy* behaviors (e.g., gets lost in own thoughts, daydreams, is slow or delayed in completing tasks), and factor 3 describes poor effort or *Low Initiation/Persistence* (e.g., effort fades quickly, lacks initiative to complete work). Factor scores for each individual on the three factors were calculated from the factor loadings, saved as variables following the factor analysis.

As an additional step, Comprehensive Exploratory Factor Analysis (CEFA; Browne et al. 2008) was undertaken to provide additional information regarding the fit of the factor structure in these data. Using CEFA with oblique rotation (GEOMIN), three possible factor solutions were examined: a 2-factor, 3-factor, and 4-factor solution. CEFA provides a variety of fit statistics that suggest that while the 4-factor solution provides a relatively better fit to these data (RMSEA=0.068, X^2=68.16) compared to a 3-factor solution (RMSEA=0.116, X^2=151.83) or a 2-factor solution (RMSEA=0.162, X^2=301.45), the 4-factor solution yields a fourth factor consisting of only two items, a less than ideal solution. In the 4-factor solution, two of the factors (the *Sleepy/Sluggish* and *Low Initiation/Persistence* factors) are

Table 1 Item factor loadings of the SCT scale

Item	Factor[a]		
	1	2	3
Seems drowsy	0.957		
Appears tired; lethargic	0.871		
Appears to be sluggish	0.845		
Has a yawning, stretching, sleepy-eyed appearance	0.833		
Is underactive, slow moving, or lacks energy	0.777		
Is apathetic; shows little interest in things or activities	0.468		0.463
Seems to be in a world of his or her own		0.864	
Gets lost in his or her own thoughts		0.846	
Daydreams		0.724	
Is slow or delayed in completing tasks		0.660	
Needs extra time for assignments		0.495	
Effort on tasks fades quickly			0.842
Lacks initiative to complete work			0.778
Is unmotivated			0.738

Factor loadings < 0.25 are not reported

[a]Factor 1: *Sleepy/Sluggish*; Factor 2: *Slow/Daydreamy*; Factor 3: *Low Initiation/Persistence*

entirely consistent with those obtained in the prior EFA using Principal Axis Factoring. Thus, in this case, the 3-factor solution provides a reasonable solution for these data, with clinically meaningful and robust factors.

Supplementary analyses examining the factor structure for only those children within the elementary school age (e.g., between ages 5 and 11 years, inclusive) revealed no substantial differences. The three factors remained consistent with those presented in Table 1, with one exception. The "is apathetic" item, which previously showed a sizeable cross-loading on both factors 1 and 3, loaded more strongly on factor 3 (0.56) in the elementary group, although it continued to load on factor 1 as well (0.37). Thus, comparisons within pre-pubertal children do not suggest a substantively different structure to the SCT scale as compared with the total sample.

SCT Scale Total and ADHD Symptoms

Initial analyses examined associations between SCT and age and gender; in this sample, age was not significantly correlated with total SCT scores ($r=-0.08$, $p=0.358$). There was also no association between SCT total score and child gender ($t_{(141)}=-0.38$, $p=0.704$). SCT total scores were compared across the four groups defined by ADHD Rating Scale-IV symptom counts (i.e., low levels of behavioral symptomatology and those with patterns of specific symptom characteristics: high-I, high-H/I, and high-C). Examining ANOVA results, there was a significant main effect of group [$F(3,139)=28.86$, $p<0.001$, $\eta_p^2=0.38$]. Post-hoc tests (i.e., Scheffe) revealed significant differences between the low-symptoms group and children in both the high-I ($p<0.001$) and high-C ($p=0.002$) groups, with both symptomatic groups rated as exhibiting higher levels of SCT symptomatology than the low-symptoms group. In contrast, children in the high-H/I group were not significantly different from the low-symptoms group on teacher SCT ratings. Furthermore, quantifying ADHD-related symptoms dimensionally, the overall composite SCT score was significantly ($p<0.001$) more strongly associated with teacher reports of inattentive symptoms than with hyperactive/impulsive symptoms, as measured by the Inattention scale ($r=0.75$, $p<0.001$) and the Hyperactive/Impulsive scale ($r=0.14$, $p=0.096$) totals from the ADHD Rating Scale-IV (see Table 2).

SCT Factors and ADHD Symptoms

The associations among the three extracted SCT factors and ratings of ADHD symptoms were also examined. Fisher's r-to-z transformations were then used to examine differences in the magnitude of the correlations between the SCT factors and Inattention and Hyperactive/Impulsive subscale totals from the ADHD Rating Scale-IV. Using this method, each of the three SCT factors was significantly more strongly correlated (all $p<0.05$) with inattentive symptoms than with hyperactive/impulsive symptoms (see Table 2). In particular, the *Low Initiation/Persistence* ($r=0.82$) and *Slow/Daydreamy* ($r=0.72$) factors were more strongly correlated ($p<0.001$) with inattentive symptoms than the *Sleepy/Sluggish* factor ($r=0.46$, $p<0.001$). Of note, the *Low Initiation/Persistence* factor was the only SCT subscale which was also significantly correlated with hyperactive/impulsive symptoms ($r=0.29$, $p<0.001$).

Linear regression analysis was used to predict teacher ratings of SCT from ratings of ADHD symptomatology. Teacher ratings of inattentive and hyperactive/impulsive symptoms (e.g., continuous ADHD Rating Scale-IV Inattention and Hyperactivity/Impulsivity subscale totals) were entered simultaneously in the analysis. Together, these symptoms accounted for a significant proportion of the variance in total SCT scores ($R^2=0.62$, $p<0.001$), with the inattentive symptoms accounting for more than twice the amount of variance ($\beta=0.89$, $p<0.001$) than the hyperactive symptoms ($\beta=-0.29$, $p<0.001$).

To further examine specificity of SCT symptoms and separability of SCT characteristics from symptoms of ADHD, SCT items and items from the ADHD Rating

Table 2 Correlations between SCT, ADHD symptomatology, and affective symptomatology

	F1	F2	F3	IA	HI	Anx	Depr
F1: Sleepy/Sluggish	–	0.591**	0.558**	0.455**	−0.009	0.082	0.235**
F2: Slow/Daydreamy		–	0.681**	0.723**	0.152	0.157	0.175
F3: Low Initiation/Persistence			–	0.818**	0.293**	0.127	0.217**
IA Total				–	0.483**	0.119	0.179*
HI Total					–	0.042	0.215**
Anx Total						–	0.589**

SCT Sluggish Cognitive Tempo; *F1* Sleepy/Sluggish; *F2* Slow/Daydreamy; *F3* Low Initiation/Persistence; *IA* ADHD Rating Scale-IV Inattentive Total; *HI* ADHD Rating Scale-IV Hyperactive/Impulsive Total; *Anx Total* Total Anxiety score from Vanderbilt Teacher Rating Scale; *Depr* Total Depression score from Vanderbilt Teacher Rating Scale

*$p\leq0.05$, **$p\leq0.01$

Scale-IV were together subjected to an exploratory factor analysis. Using principal axis factoring, with Promax rotation, this additional analysis revealed four factors, explaining 64.00 % of the variance (see Table 3). The first factor, explaining 36.29 % of the variance, was uniquely comprised of those items assessing characteristics of hyperactivity/impulsivity (e.g., interrupts, has difficulty awaiting turn). The third factor explained an additional 5.69 % of the variance and was comprised only of items from the *Slow/Sluggish* SCT factor, without overlap from hyperactive/impulsive or inattentive behavior items. The second and fourth factors (explaining 18.09 and 3.93 % of the variance, respectively) were comprised of items from both the SCT scale and the inattentive items from the ADHD Rating Scale-IV. Specifically, the second factor contained all of the *Low Initiation/Persistence* items from the SCT scale along with those items assessing characteristics of the inattentive ADHD subtype that pertain to task completion and persistence (e.g., avoids sustained effort, fails to finish work, difficulty sustaining attention). The fourth factor likewise contained all of the *Slow/Daydreamy* items as well as those characteristics of ADHD which relate to forgetfulness and distractibility (e.g., is forgetful, is easily distracted, loses things).

SCT and Internalizing Symptoms

We further examined the associations between the SCT scale total score and teacher-reported symptoms of anxiety and

Table 3 Factor loadings of the SCT scale and ADHD rating scale-IV items

	Item	Factor[a]			
		1	2	3	4
HI	Interrupts	0.906			
HI	Difficulty awaiting turn	0.858			
HI	Blurts out	0.822			
HI	Difficulty playing quietly	0.776			
HI	On the go	0.746			
HI	Talks excessively	0.720			
HI	Runs/climbs excessively	0.690			
HI	Leaves seat	0.647	0.291		
HI	Fidgets or squirms	0.481			
SCT	Effort on tasks fades quickly		0.958		
IA	Avoids sustained effort		0.919		
IA	Makes careless mistakes		0.752		
SCT	Is unmotivated		0.722		
SCT	Lacks initiative to complete work		0.698		
IA	Fails to finish work		0.633		0.252
IA	Difficulty sustaining attention		0.557		
IA	Difficulty organizing		0.452		0.360
SCT	Seems drowsy			0.906	
SCT	Yawning, sleepy-eyed appearance			0.875	
SCT	Appears to be sluggish			0.845	
SCT	Appears tired; lethargic			0.823	
SCT	Is underactive, slow moving, or lacks energy			0.763	
SCT	Is apathetic; shows little interest		0.385	0.540	
SCT	Seems to be in own world				0.942
SCT	Gets lost in own thoughts				0.884
SCT	Daydreams				0.838
SCT	Is slow or delayed in completing tasks	−0.263			0.668
IA	Forgetful				0.618
SCT	Needs extra time for assignments	−0.370	0.313		0.501
IA	Easily distracted	0.354	0.335		0.470
IA	Does not listen	0.403			0.408
IA	Loses things				0.354

[a]Factor loadings < 0.25 are not reported. *HI* Item from ADHD Rating Scale-IV Hyperactivity/Impulsivity items; *IA* Item from ADHD Rating Scale-IV Inattentive items; *SCT* Item from Sluggish Cognitive Tempo scale

depression, as rated on the Vanderbilt Rating Scale. Using a conservative threshold for significance ($p \leq 0.01$), given multiple comparisons conducted, the SCT total score was significantly, but weakly, correlated with ratings of depressive symptomatology ($r=0.24$, $p=0.003$) but not with ratings of anxiety ($r=0.15$, $p=0.079$). Examining the pattern of associations between these estimates of internalizing symptomatology and the SCT factors, there was a clear pattern of weak, but specific correlations: the *Sleepy/Sluggish* and *Low Initiation/Persistence* factors were significantly correlated with ratings of depressive symptomatology ($r=0.24$, $p=0.005$ and $r=0.22$, $p=0.009$, respectively), but not with ratings of anxiety ($r=0.08$, $p=0.333$ and $r=0.13$, $p=0.131$, respectively).

SCT Factors and Impairment Ratings

Hierarchical linear regression analyses were performed to determine the degree to which symptoms of SCT contribute to children's functional academic impairment, perceived impact on classroom functioning, and children's self-esteem, as rated by teachers on the Impairment Rating Scale. Teacher ratings of inattentive symptoms (ADHD Rating Scale-IV Inattention scale total) were entered on the first step, followed by the three SCT factor scores (*Sleepy/Sluggish, Slow/Daydreamy*, and *Low Initiation/Persistence*) entered simultaneously on the second step. After controlling for inattentive symptoms, the three SCT factors together accounted for a significant proportion of unique variance in impairment in academic progress ($\Delta R^2=0.06$, $p=0.009$; total model $R^2=0.31$). In particular, the *Low Initiation/Persistence* factor ($\beta=0.41$, $p=0.003$) accounted for the largest proportion of the variance in teacher ratings of children's reported academic impairment. Conversely, after controlling for inattentive symptoms, the three SCT factors did not add significantly to predictions of teacher ratings regarding children's behavioral impact upon the classroom ($\Delta R^2=0.04$, $p=0.092$). Similarly, after controlling for inattentive symptoms, the SCT factors did not predict children's impairment in self-esteem, as rated by their teachers ($\Delta R^2=0.03$, $p=0.205$). When ratings of depressive symptoms were added into the regression (on the second step, following inattentive symptom totals), the SCT factors remained significant predictors of impairment in academic progress ($\Delta R^2=0.06$, $p=0.009$). As might be expected, while SCT symptoms did not significantly predict teacher ratings of impairment in child self-esteem, ratings of depressive symptoms did predict teacher rated impairment in self-esteem ($\Delta R^2=0.27$, $p<0.001$).

Discussion

Although there is a growing body of work examining contributions of SCT to children's outcomes, few studies have examined the construct of SCT in depth (e.g., using more than a few items), within a clinical sample, and via teacher ratings of children's behavior. The present study examined the psychometric characteristics of a recently developed measure of SCT (Penny et al. 2009) within a sample of children referred for neuropsychological evaluation in the United States. The SCT scale showed excellent internal consistency within this sample (using teacher ratings) and exploratory factor analysis suggested extraction of three primary factors from the scale, which we have labeled *Sleepy/Sluggish*, *Slow/Daydreamy*, and *Low Initiation/Persistence*.

The three factors obtained from teacher ratings in this clinical sample differed slightly from the two factors extracted from teacher ratings in the original, non-clinical sample (Penny et al. 2009), which the authors labeled *Slow* and *Sleepy/Daydreamer*. The three factors obtained in the current sample appear to be somewhat more distinct in this clinical population, with greatly reduced cross loadings, as compared to the factors obtained in the original, non-clinical sample. The wider range, increased variability, and greater intensity of ADHD-related symptomatology evident in a referred sample make more it likely that an increasingly distinct factor structure (e.g., three factors) would be evident within a referred sample. With regard to the correspondence between the current three-factor structure and the original two-factor solution, all of the items which loaded on our *Sleepy/Sluggish* factor appeared to be drawn from the larger *Sleepy/Daydreamer* factor in the original sample, with our factor more specific to a sleepy or lethargic presentation. Two additional items drawn from the original *Sleepy/Daydreamer* factor (e.g., daydreams, seems to be in a world of his or her own) clearly loaded on a different factor in the present analysis, the *Daydreamy* factor. Similarly, all of the items which loaded on our *Low Initiation/Persistence* factor appeared to have been drawn from the original *Slow* factor; the three remaining items on the original *Slow* factor loaded together onto our *Daydreamy* factor. Although three items shared quite high cross loadings with both factors in the original two-factor solution of teacher reported behavior (e.g., is apathetic, is unmotivated, gets lost in his or her own thoughts), in the present analysis those items loaded more cleanly on two different factors, with the first two items loading on our *Low Initiation/Persistence* factor and the third loading onto our *Slow/Daydreamy* factor.

Notably, the three-factor solution identified in the present analysis is quite consistent with the three-factor solution obtained from parent reports of behavior in the original, non-clinical population. Our *Sleepy/Sluggish* factor is comprised of exactly the items that loaded on the second factor in the original analysis of parent reported behaviors, which the authors labeled *Sleepy*. All of the items on our *Low Initiation/Persistence* factor are drawn from items which loaded onto the original parent reported *Slow* factor, with

the exception of two additional items which are more clearly related to speed of task completion (e.g., is slow or delayed in completing tasks, needs extra time for assignments). In our analyses, these two specific items loaded together with the three items that were originally part of the *Daydreamer* factor onto our *Slow/Daydreamy* factor.

It is notable that the motivational or effort-based items loaded together in teacher ratings of clinically-referred children, resulting in a *Low Initiation/Persistence* factor in the present sample, given that children with neurodevelopmental disabilities are at higher risk of being perceived as putting forth less effort than their typically developing peers. Alternatively, it may be that children who are perceived as less motivated or giving less effort are more likely to struggle academically or have co-occurring learning difficulties and be referred for evaluation, especially an outside evaluation (e.g., at a hospital outpatient clinic) rather than a school-based evaluation. Additionally, the *Low Initiation/Persistence* factor appears to be associated with ADHD-related symptomatology more broadly and is significantly correlated with both inattentive and hyperactive/impulsive behaviors. The *Low Initiation/Persistence* factor also was the primary factor contributing significantly to prediction of academic difficulties within the classroom setting. Given the co-occurring learning difficulties common to children with ADHD, especially in those referred for clinical evaluation, it is not surprising that the factor that may best reflect a pattern of withheld or reduced effort in the face of frustration is most correlated with teacher reports of academic impairment. Conversely, the *Sleepy/Sluggish* factor was least predictive of academic impairment ratings, but the factor most significantly (albeit weakly) correlated with internalizing (e.g., depressive) symptoms. Taken together, these findings suggest that this factor might be qualitatively different from cognitive slowness/processing speed in general; the behavioral characteristics described by items loading on the Sleepy/Sluggish factor (drowsiness, lethargy, etc.) may contribute in a different way to functional impairment.

Previous work has yielded differing findings regarding the relation between SCT and inattentive symptoms. Hartman and colleagues (2004) found that SCT and inattention are separable constructs representing distinct factors, while others have not found this distinction (e.g., Todd et al. 2004). Our data appear to further support the specificity of the SCT construct, particularly those items pertaining to sluggishness, lethargy, and underactivity. Aspects of SCT that reflect poor initiation, impersistence, and a tendency to daydream appear to be less distinct and show more overlap with inattentive symptoms of ADHD.

With regard to psychometric properties of the scale, Penny et al. (2009) reported sizable cross loadings between the factors on teacher ratings. The authors noted that three items (e.g., is apathetic, is unmotivated, gets lost in his or her own thoughts) loaded equally well on both factors found in the original study. This pattern was not observed in the current study, in which only one of those items ("is apathetic") showed a pattern of significant cross-loading on both the *Sleepy/Sluggish* and *Low Initiation/Persistence* factors. Overall, there were few significant cross loadings for items on the SCT scale in this sample.

In summary, preliminary construct validity of the Penny SCT scale in a clinical sample was established via a pattern of stronger associations between SCT symptomatology and ratings of inattention and distractibility than hyperactivity and impulsivity on the ADHD Rating Scale-IV. These findings are consistent with similar findings of associations between SCT symptomatology and inattention using the SCT scale of the CBCL conducted by Hartman et al. (2004) and Garner et al. (2010). Additionally, symptoms of SCT uniquely predicted impairment in children's academic progress, even after accounting for their level of inattentive symptomatology. These findings add to a growing body of research that suggests that sluggish cognitive tempo is not entirely explained by DSM-IV defined inattention. This unique constellation of symptomatology, particularly that reflected in the *Low Initiation/Persistence* factor, may correspond to the impersistence, especially motor impersistence, frequently seen in children with ADHD (Mahone et al. 2006). Future work should examine the association between SCT, particularly that aspect measured by the *Low Initiation/Persistence* factor, and measures of motor persistence in children with ADHD.

These results suggest that measurement of SCT can help to better characterize the symptomatology seen in children with ADHD. Although previous work has suggested that SCT shares symptom overlap with anxiety or other internalizing behaviors, recent work (Murphy-Bowman et al. 2011) has shown a degree of dissociation between ratings of SCT and informant ratings of anxiety. Data from the current sample also suggest only weak associations between teacher-reported SCT symptoms and teacher-reported symptoms of depression or anxiety. As such, behaviors characteristic of SCT are not clearly defined by inattentive symptomatology alone, nor are they clearly accounted for by internalizing behaviors. Since SCT symptomatology accounts for significant variance in children's performance on measures of processing speed, some portion of the SCT construct may be best explained by overall speed of cognitive response preparation.

Finally, given current discussions surrounding changes in ADHD diagnostic criteria for the upcoming revision of DSM-IV (APA 2010), and potential inclusion of a restricted-Inattentive subtype, reliable and validated measures of SCT will be necessary to better assess characteristics of the construct, especially within this restricted Inattentive subtype of ADHD. Careful measurement of SCT may also help to better

predict outcomes for these children, and ultimately, identify those children most likely to benefit from specific types of interventions.

Although the present findings provide an important initial step in detailed measurement of the SCT construct within a clinically-referred sample, there were several limitations in the current study. Most notably, data were collected from children referred to an outpatient neuropsychology evaluation service and as a result, typically developing children were not included as a control group against which the pattern seen in clinic-referred children can be compared. In this sample, almost two-thirds of those with a relatively elevated level of ADHD-related symptomatology demonstrated primarily inattentive symptoms; results therefore may not generalize to samples comprised of children with primarily hyperactive-impulsive presentations. However, it is notable that recent data suggest that approximately twice as many American school-aged children are diagnosed with the predominantly inattentive subtype of ADHD (4.3 %) compared to the hyperactive-impulsive (2.0 %) or combined subtypes (2.2 %) (Froehlich et al. 2007; Merikangas et al. 2010). Therefore, our sample approximates the relative prevalence of the different symptom presentations in children in this country.

Additionally, measures of SCT, ADHD-related symptomatology, and ratings of academic impairment were all completed by children's teachers, thus results may be confounded by similar methodology and raters. Teacher ratings were not available for every child referred for neuropsychological evaluation, as obtaining such pre-visit information depends upon both parent and teacher willingness and time constraints. Notably, there might have been differences in demographic characteristics between those children for whom ratings were obtained and those without these teacher ratings; we could speculate that children for whom such pre-visit data are available may come from homes with parents who have better organizational capabilities for managing pre-visit paperwork and scheduling or who may have higher levels of educational attainment. This might suggest that their children, also, may be apt to demonstrate less severe clinical symptomatology with regard to inattention, impulsivity, and/or SCT. As a result, this bias could limit the size of effects seen in our findings, suggesting potentially larger associations in a more heterogeneous sample. Similarly, children for whom such ratings are available may be more likely to also have teachers who are more likely to have time to complete such ratings, have the organizational and time management skills to do so, and feel invested in their students. These teachers may be less likely to teach students within impoverished, inner-city schools; thus, potential teacher bias may also suggest that our finding may represent an underestimate of effects. Furthermore, given the pattern of weak correlations observed between parents and teachers in children's behavioral ratings (e.g., Achenbach et al. 1987), future work should examine correspondence between teacher and parent ratings on this measure in a clinical sample. It will also be important for future studies to examine specific associations between teacher and parent ratings of SCT and performance-based measures of children's attentional regulation, processing speed, and response time, in order to better validate this scale as a measure of the SCT construct.

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