Article

Evaluating the Structure of Sluggish Cognitive Tempo Using Confirmatory Factor Analytic and Bifactor Modeling With Parent and Youth Ratings

Assessment
2018, Vol. 25(1) 99–111

DOI: 10.1177/1073191116653471
journals.sagepub.com/home/asm
SAGE

Zoe R. Smith[1], Stephen P. Becker[2], Annie A. Garner[3], Cort W. Rudolph[3], Stephen J. Molitor[1], Lauren E. Oddo[1], and Joshua M. Langberg[1]

Abstract

The primary goals of this study were to evaluate the dimensionality of the Penny et al. Sluggish Cognitive Tempo Scale and to compare model fits for parent- and youth self-report versions. Participants were 262 young adolescents (ages 10-15) comprehensively diagnosed with attention-deficit/hyperactivity disorder. Both confirmatory factor analysis (CFA) and bifactor modeling were used to determine if the proposed three-factor structure previously identified through exploratory factor analysis could be confirmed. Results showed that although the three-factor CFA had better fit statistics than a one- or two-factor CFA, the bifactor model was the best-fitting model for both parent report and self-report. This implies that Sluggish Cognitive Tempo Scale is best conceptualized as having an underlying general factor, with three specific factors that may represent different etiologies. Importantly, results also showed low-to-moderate correlations between raters and equivalent or better fit statistics for self-report in comparison with parent report.

Keywords

SCT, factor structure, dimensionality, self-report, ADHD, assessment

The construct of Sluggish Cognitive Tempo (SCT) includes symptoms of slowness, mental confusion or "fogginess," excessive daydreaming, low motivation, and drowsiness/sleepiness. SCT first emerged in the literature in the 1980s, and has since reemerged, primarily focusing on the internal and external validity of SCT in children with attention-deficit/hyperactivity disorder (ADHD; Becker, Marshall, & McBurnett, 2014). With respect to internal validity (i.e., do SCT symptoms hold together statistically and also remain distinct from other psychopathologies?), although SCT is correlated with ADHD inattentive symptoms, multiple factor analytic studies show that the two constructs are overlapping but empirically distinct (Bernad, Servera, Grases, Collado, & Burns, 2014; Burns, Servera, Bernad, Carrillo, & Cardo, 2013; Garner, Marceaux, Mrug, Patterson, & Hodgens, 2010; Hartman, Willcutt, Rhee, & Pennington, 2004; Jacobson et al., 2012; McBurnett, Pfiffner, & Frick, 2001; Penny, Waschbusch, Klein, Corkum, & Eskes, 2009). Thus, studies examining SCT can be confident in examining the measurement and model of SCT without including ADHD symptoms in the model. With respect to external validity (i.e., are SCT symptoms related to demographics and/or impairment domains?), there is a growing body of research showing that SCT uniquely contributes to academic, social, and behavioral impairment above and beyond the influence of ADHD (Becker & Langberg, 2013; Becker, Luebbe, & Langberg, 2014; Bernad et al., 2014; Langberg, Becker, & Dvorsky, 2014; Marshall, Evans, Eiraldi, Becker, & Power, 2014; McBurnett et al., 2014). Given these findings, it has been hypothesized that SCT may be its own psychiatric disorder (Barkley, 2014) or a construct of transdiagnostic value (Becker, Leopold, et al., 2016). However, before the field can determine how to best conceptualize the SCT construct—either in isolation or in relation to ADHD—it remains significantly constrained by the fact that there is no gold standard or even uniform way of measuring SCT.

SCT Measurement Limitations

Currently, there are multiple measures of the SCT construct, each containing a different number and set of items. At least partly because extant research employs different measures

[1]Virginia Commonwealth University, Richmond, VA, USA
[2]Cincinnati Children's Hospital Medical Center, Cincinnati, OH, USA
[3]St. Louis University, St. Louis, MO, USA

Corresponding Author:
Zoe R. Smith, Virginia Commonwealth University, 806 W. Franklin St., P.O. Box 842018, Richmond, VA 23284, USA.
Email: smithz2@vcu.edu

of SCT, it remains unclear whether SCT in childhood is best conceptualized as a single- or a multifactor construct. Some studies support SCT as a single factor (e.g., Barkley, 2012; Becker, Luebbe, & Joyce, 2015; Lee, Burns, Snell, & McBurnett, 2014; Willcutt et al., 2014), while other studies suggest that SCT consists of multiple distinct factors (e.g., Barkley, 2013; Fenollar Cortés, Servera, Becker, & Burns, 2014; Jacobson et al., 2012; McBurnett et al., 2014; Penny et al., 2009). In addition, it is unclear what source/rater should be relied on to gather information about SCT. To date, almost all SCT research has focused on parent and teacher reports of SCT. This is probably because most SCT research has taken place in the context of ADHD, where parents and teachers are considered the most reliable and valid sources of information (Pelham, Fabiano, & Massetti, 2005). However, many SCT items query about internal states and SCT symptoms are significantly related to internalizing symptoms (Becker, Leopold, et al., 2016). It may be the case that, similar to internalizing symptoms, the best method for obtaining information about SCT in childhood is self-report. These limitations are discussed in more detail below, beginning with a review of factor analytic research focused on whether SCT is a single or multidimensional construct.

Factor Structure of SCT

One of the more widely used SCT measures, the 14-item Penny et al. (2009) scale, identified SCT as a multifaceted construct in a school-based sample of children. Specifically, an exploratory factor analysis (EFA) of parent-reported SCT on this scale revealed three separate dimensions; Slow (e.g., "is slow or delayed in completing tasks"), Sleepy (e.g., "seems drowsy"), and Daydreamer (e.g., "gets lost in his or her own thoughts"; Penny et al., 2009). In contrast, using teacher report, Penny et al. (2009) found that the Sleepy and Daydreamer items loaded together on one factor, creating a two-factor model of Slow and Sleepy/Daydreamer. However, Jacobson et al. (2012) later reported that an EFA with the teacher version of this scale in a clinic-referred sample of children resulted in a three-factor structure similar to that reported for the parent scale in Penny et al. (2009): Sleepy/Sluggish (e.g., "seems drowsy"), Slow/Daydreamy (e.g., "seems to be in his or her own world"), and Low Initiation/Persistence (e.g., "is unmotivated"). Importantly, these factors seem to be meaningful in that they are differentially related to impairment (Becker & Langberg, 2014; Jacobson et al., 2012; Langberg et al., 2014). For example, the Slow factor has been found to related to academic impairment and executive functioning above and beyond the other two factors and ADHD symptoms (Becker & Langberg, 2014; Langberg et al., 2014).

In addition, a better understanding of the factor structure of SCT has implications for theory and how SCT in conceptualized in relation to other psychopathologies. For example, some aspects of SCT (e.g., motivation, initiative) may overlap to a greater degree than other SCT symptoms with ADHD (Lee et al., 2014; Penny et al., 2009). Other SCT symptoms (e.g., drowsiness, low energy) may be more strongly related to sleep functioning (Becker, Pfiffner, et al., 2015). Still other SCT symptoms (e.g., daydreaming, being in a world of one's own, mental confusion/fogginess) may be most clearly independent from other psychopathologies (Becker, Leopold, et al., 2016). Thus, a clearer understanding of the factor structure of SCT may inform its conceptualization as both related to and distinct from other psychopathology domains, in turn, pointing to the possibility of shared etiologies or developmental pathways for specific SCT dimensions with other psychopathologies (e.g., ADHD). This remains an important empirical question, but progress toward answering this question will be greatly limited until the factor structure of SCT is first established.

Moving Beyond Exploratory Factor Analysis

As is made clear in the name, EFAs are exploratory, data-driven techniques that look for patterns in the data, typically run without any particular a priori theory about factor structure (Farrell, 1999; Floyd & Widaman, 1995). As such, EFAs are often difficult to replicate and the patterns and factor structure are often unique to a particular data set (Farrell, 1999; Floyd & Widaman, 1995). To truly evaluate the validity of a proposed theoretical factor structure, confirmatory factor analysis (CFA) must be used. CFAs assess the construct validity of a measure and evaluate the fit of the proposed dimensionality of the construct (Floyd & Widaman, 1995). Although increasingly used in research, the multifactor structure of the Penny et al. (2009) scale has not been validated in any type of sample using CFA. In addition, there has been minimal use of bifactor modeling strategies in evaluating measures of SCT. Given that psychological constructs are complex, and comparing unidimensional and multidimensional models might not fully conceptualize SCT, bifactor modeling may be needed (Reise, Moore, & Haviland, 2010). Bifactor modeling includes a latent structure with each item loading onto an underlying general factor that reflects the commonality and individual differences among items as they are related to the general factor (Reise et al., 2010), in this case the SCT construct. The bifactor model specifies a single general trait that explains some proportion of common variance of all items, but also contains grouped factors (or specific factors) that explain addition common variance (Reise et al., 2010). Thus, using bifactor modeling would allow for recognizing SCT as a multidimensional construct while also retaining a single general factor of SCT.

To date, only two studies of SCT in childhood have used CFAs to understand which factor model (i.e., a

one-factor, two-factor, or three-factor model) best fits the SCT construct. McBurnett et al. (2014) found support for the fit of a four-factor structure including three SCT factors and a factor for ADHD symptoms in a clinical sample of children aged 7 to 11 years with ADHD. The four factors included an ADHD inattentive factor, a daydreaming factor, a sleepy/tired factor, and a working memory factor (e.g., "forgets what he or she was going to say," "loses train of thought"). In a CFA with a clinical sample of 131 Spanish children ages 6 to 16 with ADHD, Fenollar Cortés et al. (2014) found support for a two-factor construct of SCT that included slowness and inconsistent–alertness factors. Although both of these studies suggest that SCT is multidimensional, they used different measures and found support for different factor structures. Additional studies that directly compare multiple factor structures are needed to evaluate whether SCT is best conceptualized as unidimensional or multidimensional and, if multidimensional, whether a two- or three-factor model seems optimal. Furthermore, both of these studies only collected information about SCT from parents and teachers. Since SCT and internalizing symptoms are highly correlated and self-report is considered the best source of information for assessing internalizing symptoms (Klein, Dougherty, & Olino, 2005; Silverman & Ollendick, 2005), it seems critical to incorporate self-report into the measurement of SCT.

Self-Report of SCT in Childhood

Previous bifactor modeling studies examined SCT within the bifactor structure of ADHD using only parent and teacher raters (Garner et al., 2014; Lee, Burns, Beauchaine, & Becker, 2015). Only one study has collected self-report of SCT and also conducted a CFA or a bifactor analysis. Specifically, Becker, Luebbe, et al. (2015) modified the items of the Penny et al. (2009) scale for self-report (e.g., changing "does your child . . . " to "do you . . . ") and used exploratory structure equation modeling, which is a mixture of EFA and CFA, to evaluate the factor structure in a general education sample of 124 elementary-aged children. The exploratory structure equation modeling found the same three factors identified as present in the parent SCT measure (Slow, Sleepy, and Daydreamer). However, a bifactor model was conducted given the high correlations reported between the Slow and Sleepy factors. After conducting a bifactor analysis, the authors concluded that SCT was better conceptualized as one overarching general factor since the three specific factors did not demonstrate adequate reliability after accounting for the general SCT factor. However, this study has not been replicated in a clinical sample, self-report of SCT in youth remains largely unexamined, and no study has evaluated how youth report of SCT corresponds to parent report of SCT.

Present Study

Accordingly, the primary goal of the present study was to compare higher order analyses using CFAs and bifactor modeling on the parent- and self-report versions of the Penny et al. (2009) SCT Scale in a clinical sample of young adolescents with ADHD. Specifically, the main aim was to determine if the proposed three-factor structure as identified through EFA by Penny et al. (2009) could be confirmed using CFA with either parent report or self-report, and whether the three-factor structure fits better than a one- or two-factor structure. In this study, we only included SCT symptoms in the models, as opposed to also including ADHD symptoms of inattention, for two reasons. First, over 20 studies have already found SCT symptoms to be distinct from ADHD symptoms, including several studies using the same SCT measure as evaluated in this study (Becker, Leopold, et al., 2016). Second, the participants in this study were comprehensively diagnosed with ADHD, which significantly reduces variability in ADHD symptoms and could bias the findings. This is the first study to examine self-report of SCT in an ADHD sample, which remains important, as SCT may be more common in clinical samples than normative samples, and could potentially have different etiology and outcomes given the existing deficits seen in adolescents with ADHD. Using the Penny et al. (2009) scale, no study has found support for more than three factors of SCT, potentially because of the limited item pool ($N = 14$). Based on previous studies using this scale (Becker, Luebbe, et al., 2015; Jacobson et al., 2012; Penny et al., 2009), we predicted that the multifaceted nature of SCT would be confirmed as evidenced by the three-factor model demonstrating better fit than either a one- or two-factor model in both the parent and child scales. However, given that SCT factors are often highly correlated, bifactor modeling was also used to examine the dimensionality of SCT and whether the factors are best explained by an underlying SCT factor. A secondary goal of the study was to examine the correlation between self-report and parent report.

Method

Participants were 262 middle school students (boys 193, girls 69) from Grades 6 to 8 (ages 10-15; $M = 11.95$, $SD = 1.05$) who were comprehensively diagnosed with ADHD. Participants were recruited from six public middle schools in the Eastern United States. The sample was diverse with parents identifying 30.2% of the youth as African American ($n = 79$), 10.3% identified as biracial ($n = 27$), 56.5% identified as White ($n = 148$), 2.3% identified with another race ($n = 6$), and two participants chose not to respond. Per procedures described next, 171 participants (65.3%) were diagnosed with ADHD Predominantly Inattentive Presentation (ADHD-IA) and 91 (34.7%) were diagnosed with ADHD Combined Presentation (ADHD-C).

Procedure

Participants who provided data for the current study were recruited as part of a larger study evaluating school-based intervention programs for adolescents with ADHD. All data evaluated in the present study were collected at baseline, prior to participants receiving any intervention. Recruitment methods included study announcement letters mailed to all parents at participating middle schools, flyers posted in each school, and direct referral by school staff. Interested parents completed a phone screen that included rating their child on each of the nine *DSM-5* (*Diagnostic and Statistical Manual of Mental Disorders, Fifth edition*) ADHD-IA symptoms on a 4-point Likert-type scale (0 = *rarely*, 1 = *sometimes*, 2 = *often*, 3 = *very often*). If a parent reported that their child had a previous diagnosis of ADHD or they endorsed the presence of at least four of nine ADHD-IA symptoms at clinically significant levels (i.e., *often* or *very often*), a full in-person evaluation was scheduled.

During the inclusion/exclusion evaluation, adolescents and parents/guardians independently were administered the *Parent Children's Interview for Psychiatric Syndromes* (P-ChIPS; Weller, Weller, Fristad, Rooney, & Schecter, 2000), a structured diagnostic interview which was administered by a doctoral student supervised by a licensed clinical psychologist. Additionally, parents and adolescents completed the *Behavior Assessment System for Children, Second edition* (Reynolds & Kamphaus, 2004), a measure designed to broadly screen for behavioral or mood problems in children. Parents and at least one teacher of each student also completed the *Vanderbilt ADHD Diagnostic Rating Scale* (VADRS; Wolraich et al., 2003), which is a 45-item measure that assesses symptoms of ADHD, oppositional defiant disorder (ODD), and conduct disorder (CD). Finally, adolescents were administered a brief battery assessing their cognitive and academic achievement abilities, including four subtests from the *Wechsler Intelligence Scale for Children, Fourth edition* (Wechsler, 2003), and seven subtests from the *Wechsler Individual Achievement Test, Third edition* (Wechsler, 2009).

Participants were considered eligible for the study if they met five criteria: (a) attended a participating middle school, (b) met full *DSM-5* diagnostic criteria for ADHD-IA or ADHD-C presentation based on the combination of parent report on the P-ChIPS and teacher report, (c) experienced significant impairment due to ADHD symptoms based on parent and/or teacher report, (d) had an estimated Full Scale IQ of at least 80 according to performance on the *Wechsler Intelligence Scale for Children, Fourth edition*, and (e) did not meet diagnostic criteria for any bipolar disorder, psychosis, or obsessive–compulsive disorder according to parent report on the P-ChIPS. To maximize generalizability, students with comorbid diagnoses of ODD, CD, and anxiety and mood disorders were allowed to participate in the study. Parent report on the P-ChIPS was used for externalizing comorbidities, with 30.6% meeting criteria for ODD, 3.2% for CD, while child report on the Children's Interview for Psychiatric Syndromes (ChIPS) was used for internalizing comorbidities, with 25.4% meeting for anxiety and 5.3% for depression.

Measures

Participants' parents/guardians completed a demographics questionnaire at the study baseline that included information on sex, race/ethnicity, grade in school, parent education and income, and ADHD medication status.

Children's Interview for Psychiatric Syndromes. The ChIPS (Weller et al., 2000) is a structured diagnostic interview for administration to parents and children (children: ages 6-18) and has a parent (P-ChIPS) and child version (ChIPS). The ChIPS has shown high internal consistency and test–retest reliability (Fristad, Teare, Weller, Weller, & Salmon, 1998) and high convergent validity in relation to the *Diagnostic Interview for Children and Adolescents–Revised—Child Version* (Fristad et al., 1998). A recent review of child and adolescent diagnostic interviews (Leffler, Riebel, & Hughes, 2015) found five separate studies documenting that the ChIPS has good concurrent validity with other validated diagnostic interviews, including the *Diagnostic Interview for Children and Adolescents–Revised—Child Version* and the *Schedule for Affective Disorders and Schizophrenia for School Aged Children*. Furthermore, the ChIPS has good construct validity, with the percentage of agreement between a consensus panel of child psychopathology experts and the results from ChIPS interviews ranging from 97.5% to 100%. Sensitivity averaged 87% across diagnostic categories and specificity averaged 76%, with sensitivity and specificity for attention deficit disorder being 100% and 44%, respectively (Fristad et al., 1998).

Vanderbilt ADHD Diagnostic Rating Scale. The VADRS is a *DSM-IV*-based scale that includes all 18 *DSM-IV* symptoms of ADHD. Parents and teachers rate how frequently each symptom occurs on a 4-point Likert-type scale (0 = *never*, 1 = *occasionally*, 2 = *often*, 3 = *very often*). The VADRS produces an Inattention score (sum of the nine inattention items) and a Hyperactivity/Impulsivity score (sum of the nine hyperactive/ impulsive items). The VADRS has excellent psychometric properties (Wolraich et al., 2003). In the present study, internal consistencies were the following: ADHD inattention $\alpha = .87$, ADHD hyperactivity–impulsivity $\alpha = .90$, ODD/CP $\alpha = .87$, and anxiety/depression $\alpha = .87$.

Sluggish Cognitive Tempo Scale. The parent-report version of the Penny et al. (2009) SCT Scale was used in this study. The SCT Scale consists of 14 items that are each rated on a

4-point scale from 0 = *never* to 3 = *very often*. As described above, factor analyses have identified three factors for the parent version: Sleepy, Slow, and Daydreamer (Penny et al., 2009). Test–retest reliability estimates range from 0.70 to 0.87 for the parent-report version. As in Becker, Luebbe et al. (2015), the parent-report scale was modified for use as a self-report measure in the present study (e.g., instead of "does your child . . . "; "do you . . . "). Each of the 14 items were changed to reflect the first person, and items were kept as similar as possible to the original parent-report version, but some words were changed to make it more understandable for children (e.g., instead of "lethargic" use "don't have energy"). In the present study, internal consistencies for parent and child total scores were $\alpha = .87$ and $\alpha = .86$, respectively.

Data Analysis

Analyses were conducted in M*plus* Version 7.13 (Muthén & Muthén, 1998-2012). CFA was used to estimate one (SCT), two (Slow and Sleepy/Daydreamer), and three (Slow, Sleepy, and Daydreamer) factor models based on the Penny et al. (2009) EFA in which latent factors were allowed to correlate for self-report and parent report separately. As was conducted in Becker, Luebbe, et al. (2015), the bifactor analyses used both parent- and self-report CFA findings to inform the bifactor models, that is, if the three factors CFA was the best-fitting model, the three specific factors would be included in the bifactor analyses. In addition, a bifactor model was estimated for self and parent-report in which all items loaded directly onto an underlying SCT general "g" factor and three specific factors (Slow, Sleepy, and Daydreamer). In the bifactor model, all factors (general and specific) were specified to be orthogonal to one another (Reise, 2012). In all models, items were treated as categorical indicators and robust weighted least squares (WLSMV estimator) was used. Estimated models were compared by examining various fit indices including comparative fix index (CFI; ideal study criterion ≥ 0.95), Tucker–Lewis index (TLI; ideal study criterion ≥ 0.95), root mean square error of approximation (RMSEA; ideal study criterion ≤ 0.06), and weighted root mean square residual (WRMR; ideal study criterion ≤ 0.90; Hu & Bentler, 1999; Kline, 2011; Yu, 2002). Chi-square difference testing to statistically compare models was used to test nested models against one another (one, two, and three correlated factor models). However, chi-square testing was not appropriate when comparing nonnested models such as the bifactor model, an orthogonal model, with the one-, two-, and three-factor nonorthogonal models. When comparing unnested models with one another, we compared model fit indices as described above. In addition, to formal statistical testing when appropriate, the overall global model fit (i.e., highest CFI and TLI indices; lowest RMSEA and WRMR indices) was assessed.

In order to formally test whether the fit of the models differed across raters, invariance analyses of the best-fitting models (bifactor model; see Results section for details) was conducted. In particular, a configural model in which factor loadings and thresholds were unconstrained, scale factors were fixed at one and factor means were set to zero across both raters was estimated. This model served as the baseline model for invariance testing. Given that the best-fitting model was nonorthogonal, metric (or factor loading invariance) could not be tested for parameterization reasons (see M*plus* Version 7. 1 Language Addendum; Muthén & Muthén, 1998-2012). Instead, a scalar invariance model was tested in which both factor loadings and thresholds were constrained to equality across groups (see M*plus* Version 7.1 Language Addendum for additional specifications). A chi-square likelihood test (DIFFTEST command in M*plus*) was used to statistically compare the models. A significant chi-square indicates a lack of invariance. Since chi-square testing can be overly sensitive in large samples, we also examined changes in model fit where an increase in RMSEA of ≥ 0.05 and/or a decrease in CFI ≤ 0.01 indicates that the models are not invariant (Little, 2013). Finally, correlations between "g" and specific factors across raters (self and parent) were estimated in M*plus*.[1]

Results

Means and standard deviations for self-report and parent report of SCT items are in Table 1. Model fit statistics for the eight models (four self-report and four parent report) are summarized in Table 2. For both self- and parent-report ratings, the three-factor model demonstrated statistically better fit than either the one- or two-factor models based on chi-square difference testing as well as global model fit. In the three-factor model, the latent factors were strongly correlated with one another when using self-report (rs = .69-.83) and to a lesser extent when using parent report (rs = .40-.57) suggesting that items might share variance with one another due to the presence of a common underlying general factor. Consistent with this hypothesis, the bifactor model was the best overall fitting model for both self and parent ratings, although it should be noted that the self-report model generally demonstrated better fit than the parent-report model.

The standardized factor loadings for self and parent bifactor models are summarized in Table 3. Across both the self and parent models, all items loaded above .40 on the general SCT factor (range from .54 to .71, for self-report, and .41 to .76, for parent report), with the exception of one self-report item ("apathetic; little interest") which loaded at .23 and one parent-report item ("tired; lethargic") which loaded at .35. Results also indicated that most of the Sleepy and Daydreamer items loaded strongly on their specific factor after controlling for the general SCT factor (and the

Table 1. Descriptive Statistics for Self-Report and Parent-Report Sluggish Cognitive Tempo (SCT) Items and Dimensions.

	Self-report		Parent report		
	Mean	*SD*	Mean	*SD*	*t* (*df*)
Slow					
Apathetic; little interest	1.02	1.05	0.66	0.76	
Effort fades quickly	0.94	0.86	1.90	0.82	
Is slow or delayed in completing tasks	1.21	0.80	1.88	0.80	
Lacks initiative	0.82	0.89	1.99	0.85	
Needs extra time	1.39	0.98	1.93	1.00	
Unmotivated	0.70	0.84	1.31	0.83	
Slow total mean score	1.01	0.56	1.61	0.60	−11.87 (520)*
Sleepy					
Drowsy	0.80	0.87	0.34	0.65	
Sluggish	0.67	0.74	0.69	0.84	
Tired; lethargic	0.81	0.85	0.43	0.69	
Underactive, slow moving, lacks energy	0.64	0.79	0.62	0.91	
Yawning, stretching, sleepy eyed appearance	1.34	0.95	0.70	0.89	
Sleepy total mean score	0.85	0.63	0.56	0.64	−5.36 (520)*
Daydreamer					
Daydreams	1.42	1.11	1.12	0.93	
Gets lost in own thoughts	1.24	1.04	1.29	0.97	
Seems to be in world of own	1.05	1.03	1.28	0.98	
Daydreamy total mean score	1.23	0.87	1.13	0.83	−0.06 (520)*
SCT total mean score (all 14 items)	1.003	0.55	1.15	0.52	−3.182 (520)*

Note. df = degrees of freedom. *N* ranges from 260 to 262 for self-report and 255 to 258 for parent report. All items are rated on a 4-point scale (0 = *not at all*, 3 = *very much*).
*$p < .001$.

loadings for all Sleepy and Daydreamer items were significant). However, the Slow items demonstrated more variability in their loadings on their specific factor, with several items having strong loadings on the specific Slow factor, while other items did not. Specifically, in the self-report bifactor model, the loadings of two items (*I am slow or delayed in completing tasks* and *I need extra time for assignments*) did not reach significance, and in the parent-report bifactor model one item had a significant negative loading on Slow (*is apathetic; shows little interest in things or activities*), while the loading of another item (*is unmotivated*) was nonsignificant.

Additional measures of the validity of internal structure of the bifactor model were calculated as described in Rios and Wells (2014). These measures provide information regarding whether the use of a total score (general SCT factor) or if use of specific subscale scores (specific factors) is recommended. In particular, measures of unique reliability of the general factor (omega hierarchical; ω_H) and of the specific factors (ω_h), were calculated. Large values of ω_H combined with low scores on the ω_h indicate that the subscales do not provide reliable information beyond the general factor and that the use of a total score may be indicated (Rios & Wells, 2014), and a minimum ω_h of .50 has been suggested as indicating specific factors being useful (Reise, Bonifay, & Haviland, 2013). Explained common variance (ECV) was also calculated to determine the unique variance accounted for by the general factor and specific factors above controlling for all other factors. As noted in Table 3, the reliability of the general factor was good for self-report (ω_H = .84) and acceptable for parent report (ω_H = .74) accounting for 72% of the variance and 50% of the common variance (Rios & Wells, 2014). In contrast, the reliability of the specific factors was low for both self-report and parent-report after accounting for the general factor with ω_h ranging from .02 to .04, for self-report, and .03 to .14, for parent-report. Moreover, the variance accounted for by the specific factors was minimal (ECV of specific factors ranging from 7% to 11% for self-report and 11% to 24% for parent report) after controlling for shared variance with the general factor.

The bifactor model was used for invariance testing across raters. Specifically, the fit of the bifactor model was estimated for both raters simultaneously allowing all parameters to be freely estimated. This model (configural model) exhibited adequate fit (χ^2 = 353.83, *df* = 126, *p* = .000) and

Table 2. Fit Indices From Confirmatory Factor Analyses of Self-Rating and Parent Rating of Sluggish Cognitive Tempo.

	χ^2	*df*	RMSEA	CFI	TLI	WRMR	χ^2 difference test	*df*	*p*
Self-report									
One factor	238.94***	77	0.090	0.926	0.912	1.119			
Two factor	217.63***	76	0.084	0.935	0.922	1.062			
One factor vs. two factor							114.789	1	.000
Three factor	135.40***	74	0.056	0.972	0.965	0.802			
Two factor vs. three factor							106.930	2	.000
Bifactor	**109.08*** **	**63**	**0.053**	**0.979**	**0.970**	**0.695**			
Parent report									
One factor	889.15***	77	0.201	0.784	0.744	2.708			
Two factor	631.94***	76	0.168	0.852	0.823	2.257			
One factor vs. two factor							17.268	1	.000
Three factor	342.72***	74	0.118	0.928	0.912	1.505			
Two factor vs. three factor							51.04	2	.000
Bifactor	**231.66*** **	**63**	**0.101**	**0.955**	**0.935**	**1.168**			

Note. CFI = comparative fit index; TLI = Tucker–Lewis index; RMSEA = root mean square error of approximation; WRMR = weighted root mean square residual; *df* = degrees of freedom. Nonorthogonal models were not statistically compared with the orthogonal (bifactor) models as these models are not nested; bold indicates best-fitting model.
***$p < .001$.

was tested against a model in which factor loadings and thresholds were set to equality across raters (scalar model). This model exhibited a worse fit as indicated by statistical difference testing ($\chi^2 = 48$, $df = 48$, $p = .000$) and by changes in model fit ($\Delta CFI = 0.012, \Delta RMSEA = 0.002$). Examination of chi-squares for parent report ($\chi^2 = 261.26$) and self-report ($\chi^2 = 92.57$) in the configural model suggests that the self-report model is better fitting than the parent-report model. Table 3 also depicts the correlations between self- and parent-report latent "g" and specific factors. These correlations were weak and nonsignificant with the exception of self- and parent-reported specific factors Daydreamer which were moderately correlated ($r = .40$, $p = .001$).

Discussion

This was the first study to use both CFA and bifactor modeling to evaluate the dimensionality of SCT in a clinical sample and only the second study to include self-report of SCT. The CFA results from the present study support prior exploratory findings (i.e., EFA) with this same scale (Jacobson et al., 2012; Penny et al., 2009) in demonstrating that a three-factor model (Sleepy, Slow, and Daydreamer) best fit the data. In addition, we replicated and extended previous research (Becker, Luebbe, et al., 2015) in finding that a bifactor model was the best-fitting model across both youth and parent ratings, supporting the presence of an overarching SCT factor. Importantly, the strongest fit statistics came from the bifactor model with self-report, suggesting that similar to internalizing symptoms, it may be important to obtain children's own perspectives of their SCT symptoms. Consistent with this proposition, latent self- and parent-report factors were weakly correlated with one another (with the exception of Daydreamer) suggesting that each reporter provides unique information. These findings are discussed in more detail below.

SCT Factor Structure and Dimensionality

Using CFA with both parent and self-report, the present study adds to an accumulating body of research suggesting that SCT is likely a multidimensional construct (e.g., Barkley, 2013; Fenollar Cortés et al., 2014; Jacobson et al., 2012; McBurnett et al., 2014; Penny et al., 2009). Specifically, the CFA in this study supports previous exploratory work with the Penny et al. (2009) scale in confirming the presence of three distinct SCT factors (Sleep, Slow, Daydreamer). More recently, Becker, Luebbe, et al. (2015) examined a self-report version of the Penny et al. (2009) measure in a general school-based sample, and although support was found for a three-factor model, the specific factors demonstrated poor reliability in comparison with a general SCT factor. The present study provides further validation for the use of a bifactor model with the Penny et al. (2009) SCT Scale, for both youth self and parent-report. Specifically, although a three-factor model was hypothesized and supported through CFA, the moderate correlations between the factors and the bifactor analyses indicated that there is also a general, overarching SCT factor. The general SCT factor is reliable, and when accounted for, rendered the reliability of the three separate factors weak and accounting for minimal variance. Thus,

Table 3. Standardized Loadings and Measures of Internal Validity for Bifactor Model (Best-Fitting Model).

	General SCT		Specific slow		Specific sleepy		Specific daydream	
	Self	Parent	Self	Parent	Self	Parent	Self	Parent
Apathetic; little interest	.23	.64	.22	−.22				
Effort fades quickly	.49	.55	.25	.69				
Is slow or delayed in completing tasks	.64	.68	.19^{ns}	.27				
Lacks initiative	.61	.67	.37	.47				
Needs extra time	.62	.63	−.14^{ns}	.23				
Unmotivated	.70	.76	.52	.05^{ns}				
Drowsy	.62	.43			.73	.85		
Sluggish	.66	.68			.35	.49		
Tired; lethargic	.66	.35			.32	.85		
Underactive, slow moving, lacks energy	.67	.63			.18	.59		
Yawning, stretching, sleepy eyed appearance	.62	.45			.20	.55		
Daydreams	.54	.46					.49	.63
Gets lost in own thoughts	.71	.41					.43	.76
Seems to be in world of own	.57	.63					.48	.61
ω_H	.84	.74						
ω_h			.02	.03	.04	.14	.02	.06
ECV (%)	.72	.50	.07	.11	.11	.24	.09	.14
Correlation coefficient (*r*)	.23		−.18^{ns}		−.11^{ns}		.40	

Note. SCT = sluggish cognitive tempo; ECV = expected common variance; ω_H =omega hierarchical for g; ω_h = omega hierarchical for specific factors. All estimates were significant ($p < .05$) unless noted as nonsignificant (*ns*).

the separate SCT dimensions contain too little true score variance to be viewed independent of the general SCT factor. Fit for the self-report bifactor model was excellent; however, only one of the four fit indices (CFI = 0.95) met best practices criteria when using parent report. This suggests that parent report may need to be explored further, with the potential for creating a new item pool.

What do these findings mean for the study and measurement of SCT? Most critically, it will be essential to examine whether the general SCT factor or specific SCT factors are most strongly and consistently associated with functioning and clinically relevant outcomes. Since there are now a handful of studies using both exploratory and confirmatory factor analytic techniques that have found support for a two-factor (Barkley, 2013; Fenollar Cortés et al., 2014) or three-factor (Becker, Luebbe, et al., 2015; Jacobson et al., 2012; McBurnett et al., 2014; Penny et al., 2009) model of SCT, it is important to examine whether the specific factors are differentially associated with functioning. There is some evidence using the Penny scale that the SCT Slow dimension is most strongly related to ADHD inattention (Jacobson et al., 2012; Penny et al., 2009) and that the three SCT factors differentially relate to other psychopathology domains and impairment (e.g., Becker, Luebbe, et al., 2015; Langberg et al., 2014). Likewise, Fenollar Cortés et al. (2014) found that the inconsistent alertness aspect of SCT was associated with peer problems, whereas the slow aspect of SCT was associated with depression and learning problems. If additional research finds that the individual SCT factors are uniquely related to impairment (e.g., social vs. academic impairment), there would be clinical merit to retaining a multidimensional understanding of the SCT structure. In many ways, this approach would be similar to current conceptualizations of ADHD. That is, research supports an overarching ADHD factor (Burns, Moura, Beauchaine, & McBurnett, 2014; Martel, Roberts, Gremillion, von Eye, & Nigg, 2011; Ullebø, Breivik, Gillberg, Lundervold, & Posserud, 2012), yet the specific symptoms dimensions are valid (Willcutt et al., 2014) and clinically meaningful (e.g., inattention being more strongly predictive of academic impairment; Langberg et al., 2014; Willcutt et al., 2014). It may be the case that SCT can be understood similarly with a general factor that underlies specific factors of Sleepy, Slow, and Daydreamer, similar to the general factor of ADHD underlying inattention and hyperactivity/impulsivity (Ullebø et al., 2012).

As summarized by Martel et al. (2011), a bifactor model also has implications for etiology, development, and treatment. Almost nothing is known regarding the etiology of SCT, and support for a bifactor model of SCT suggests that there may be multiple, distinct etiologies that contribute to the SCT phenotype. Likewise, it is likely that there may be intraindividual variability in the clinical presentation of SCT, with some individuals exhibiting more behavioral symptoms (e.g., slowness, sluggishness), other individuals exhibiting more cognitive symptoms (e.g., daydreaming,

getting lost in one's thoughts), and still other individuals exhibiting both behavioral and cognitive symptoms of SCT. The implications of such findings would be tailoring intervention approaches based on an individual's symptom profile (e.g., behavioral activation, cognitive–behavioral therapy, organization skills training), particularly if, as discussed above, the SCT dimensions differentially relate to functional impairment. Finally, as noted by Martel et al. (2011), support for a bifactor model allows for sensitivity to developmental change. For instance, just as individuals with ADHD may at various times exhibit more inattentive versus hyperactive–impulsive symptoms (and vice versa; American Psychiatric Association, 2013; Willcutt et al., 2014), an individual's SCT symptom profile may likely change across development. SCT symptoms are stable and increase slightly across childhood and adolescence (Leopold et al., 2016), but no longitudinal study of SCT has considered the developmental trajectory of specific SCT dimensions, making this another important direction for research. Empirical data supporting these various possibilities would lend support for the utility of conceptualizing SCT as a multidimensional construct.

Despite the appeal and promise of these possibilities, it remains possible that SCT will ultimately be best conceptualized as unidimensional, particularly given the low reliability of the specific SCT dimensions found in the current and Becker, Luebbe, et al. (2015) studies. It should also be noted that some studies have found support for a one-factor model of SCT (Barkley, 2013; Lee et al., 2014; Willcutt et al., 2014). As research advances, if compelling evidence is not found for specific SCT factors having different etiologies, developmental trajectories, clinical correlates, and/or treatment implications, it may be most parsimonious to conceptualize and measure SCT unidimensionally. As noted by Ebesutani, McLeish, Luberto, Young, and Maack (2014), "although it may be sometimes tempting to want to report and interpret scores at the finest 'subscale' level" (p. 462), such decisions should be based on theory and the accumulation of empirical findings that support the use of more fine-grained measurement. Clearly, much more research is needed before determining the optimal way for conceptualizing the SCT construct and its dimensions.

Rater Agreement

It was also valuable to examine the degree to which raters agreed on the latent SCT construct. We found that adolescents and their parents exhibited a low degree of agreement when rating symptoms of SCT, with the exception of moderate agreement on the specific Daydreamer factor. It is not immediately clear why low, nonsignificant agreement was found between youth and parents for the general SCT factor and specific Slow and Sleepy factors but significant, moderate agreement was found for the specific SCT Daydreamer factor. It will be important for future research to replicate our finding for stronger youth–parent agreement for the cognitive alertness aspect of SCT (daydreaming, getting lost in one's thoughts) in comparison with the slow/sleepy behavioral aspects of SCT. Given that the general and specific factors of SCT were mainly nonoverlapping across informants, it will be important to assess ratings from both parents and youth, as informants may differentially predict outcomes or have incremental validity. As some SCT items reflect internalizing states, youth self-report may add incremental validity to predicting internalizing problems, while parent report may add to impairment and more observable outcomes, such as academic impairment.

Since there is some indication that SCT may fall along the internalizing rather than externalizing domain of psychopathology (Becker, Luebbe, Fite, Stoppelbein, & Greening, 2014; Lee et al., 2015), low parent and youth agreement would be expected since these raters generally have lower agreement for internal constructs and states such as internalizing symptoms (Salbach-Andrae, Lenz, & Lehmkuhl, 2009). Consistent with best-practice recommendations for evaluating internalizing conditions (Klein et al., 2005; Silverman & Ollendick, 2005), the lack of agreement observed in the current study may suggest a need to include self-report in addition to parent-report when examining SCT, which is notably in contrast to best-practice recommendations for assessing ADHD (Willcutt et al., 2014). As observed previously (Barkley, 2014; Becker, 2013; Becker, Leopold, et al., 2016), this finding also supports the need to move beyond samples of ADHD in thinking about SCT as it may be that SCT is equally if not more common in samples of youth with internalizing conditions (Barkley, 2013; Becker, Luebbe, Fite, Stoppelbein, & Greening, 2014; Capdevila-Brophy et al., 2014; Willcutt et al., 2014).

Limitations

The present study should be interpreted in light of several limitations. Although the use of a clinical sample of young adolescents with ADHD builds on prior work, it is important to note that these findings may not generalize to younger children or to adults with ADHD. There is some evidence that these findings will generalize to non-ADHD samples as Becker, Luebbe, et al. (2015) reported similar results in a school sample of elementary-aged children. However, although studying SCT in an ADHD sample remains important because SCT may be more common in clinical samples, there may be different etiology and outcomes for individuals with ADHD and SCT symptoms. Given this, it will be important to examine SCT in non-ADHD clinical and community samples to assess generalizability of this study's measurement findings. An additional limitation is that only parent and self-report were collected. Becker, Luebbe, et al. (2015) revealed a moderate

correlation between child self-report and teacher-report of SCT, so including three reporters may be helpful in better understanding the utility of self-reports. Future studies measuring SCT should examine the agreement between teachers, parents, and children. Finally, an important limitation was that the Penny et al. (2009) measurement scale only includes 14 items, which may suggest the need for further item development, especially since the parent-reported SCT CFA was not confirmed in this study. This is a widely used scale of SCT, and although they used a larger item pool to create this scale, it may be important to reexamine the original pool of 26 (Penny et al., 2009) or include items from previous studies (e.g., McBurnett et al., 2014 who included 44 SCT items in original EFA).

Future Directions

This study did not examine the external validity of the general factor or three specific factors of SCT, which will be important in determining how best to use the measure in research and clinical settings. Now that the three-factor structure has been supported in multiple studies, it will be important to study how each factor, as well as the general factor of SCT, is related to functional impairment. It will be especially important for studies seeking to examine this question to be sure to include measures (e.g., school grades, academic achievement scores, neuropsychological test performance) that eliminate shared method variance that could account in part for results obtained. In addition to providing insight into the optimal way for conceptualizing and assessing SCT, such studies may clarify the nature of SCT, namely whether it is a distinct disorder (Barkley, 2014; Saxbe & Barkley, 2014), an identifier of a unique subset of ADHD (Carlson & Mann, 2002; Marshall et al., 2014), or a transdiagnostic qualifier (Becker, Leopold, et al., 2016).

Perhaps most important in terms of future directions is to evaluate the utility of self-report of SCT as conclusions about the clinical utility cannot be made from this study. Additional work is needed to examine how to best incorporate self-report into clinical practice (e.g., use of total score vs. subscale scores), and which set of raters most comprehensively captures the full SCT presentation. An important next step is to evaluate which rater (self, parent, teacher) of SCT is most strongly associated with functional impairment. It would be beneficial for studies evaluating this issue to use a range of sample types, including community- and population-based samples as well as clinical samples. Given the strong association between SCT and internalizing symptoms and daytime sleepiness, it would be especially valuable to examine self-reported SCT in samples of youth with anxiety, depression, or sleep disorders/hypersomnias (Becker, Leopold, et al., 2016). Extant studies conducted with children indicate that SCT is distinct from these domains (Becker, Garner, & Byars, 2016; Becker, Leopold, et al., 2016; Lee et al., 2014; Willcutt et al., 2014). However, only one study has examined whether child-rated SCT is distinct from child-rated anxiety and depression (Becker, Luebbe, et al., 2015), making this a clear area for additional research examining the factor structure and clinical utility of youth-reported SCT symptoms. If it were the case that self-report of SCT best predicted functional impairment, it would be wise to consider self-report primary and parent and teacher reports secondary.

Finally, additional research should identify an item set that best describes SCT (see Becker, Leopold, et al., 2016). Studies currently use SCT scales with varying numbers of items (e.g., Marshall et al., 2014 used 3 SCT items; Capdevila-Brophy et al., 2014 used 4 SCT items; Willcutt et al., 2014 used 6 SCT items; Fenollar Cortés et al., 2014 used 8 SCT items; and Barkley, 2013 used 12 SCT items). The Penny et al. (2009) scale evaluated in this study includes 14 items and although not all 14 items may be necessary (and some may not be as useful for identifying a SCT construct separate from ADHD; Jacobson et al., 2012; Penny et al., 2009), it is likely that more than 3 or 4 items will be needed to adequately capture the multidimensional nature of SCT. Future research should employ a consistent number of items in measuring SCT. This is because a factor structure may change depending on the number of items used and it is important not to leave out items that may differentially predict impairment. Given the general lack of agreement between raters, there may be a need to refine SCT measurement. The Daydreamer factor only includes three items, suggesting that a larger item pool may be needed to measure SCT, and that the Penny et al. (2009) items may not be ideal for conceptualizing SCT. We recommend further measurement development of SCT including larger item pools tested with both clinical and community samples, especially for parent-report measures.

Conclusions

This study provides additional evidence for validity of one of the most frequently used measures of SCT and furthers our understanding of the structure and dimensionality of SCT. Some studies have found SCT to be unidimensional (Barkley, 2012; Lee et al., 2014; Willcutt et al., 2014), whereas others have reported SCT to be multidimensional (Barkley, 2013; Fenollar Cortés et al., 2014; McBurnett et al., 2014; Penny et al., 2009). Our results indicate that SCT is best conceptualized as multidimensional, with a general factor of SCT and three specific, lower order factors. However, it is important to note that the specific factors contain too little reliable variance to be viewed as specific measures of the SCT construct, independent of the general SCT factor. It is common in psychological research to observe strong evidence for a single factor, while also uncovering multiple factors that fit the data (Reise et al.,

2010). Our findings suggest that the subscale structure of SCT is complex and hierarchical, and is best conceptualized using a bifactor structure. It will be especially important for researchers to examine the general and specific factors in relation to impairment (e.g., academic, social, neuropsychological), as well as other psychopathologies. Another important next step is to evaluate the clinical utility of self-report of SCT.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This research was supported by a grant awarded to Dr. Langberg from the Institute of Education Sciences (R305A130011).

Note

1. Since M*plus* estimates covariance rather than factor correlations by default, phantom factors for the latent factors, which standardize the latent factors, must typically be created. In our analyses, latent factors were identified by fixing the variances of latent variable to 1, thereby standardizing latent variables (Kline, 2011). The advantage of this approach is that it eliminates the need to create phantom factors in order to estimate the correlation between latent variables.

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