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Fredrick, J. W., Burns, G. L., Langberg, J. M., & Becker, S. P. (2021). Examining the structural and external validity of the Adult Concentration Inventory for assessing sluggish cognitive tempo in adults. *Assessment.* Advance online publication. https://doi.org/10.1177%2F10731911211027224

Examining the structural and external validity of the Adult Concentration Inventory for assessing sluggish cognitive tempo in adults

Joseph W. Fredrick[a,b], G. Leonard Burns[c], Joshua M. Langberg[d], & Stephen P. Becker[b,e]

Affiliations: [a] Department of Psychology, Miami University, Oxford, Ohio, USA; [b] Division of Behavioral Medicine and Clinical Psychology, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio, USA; [c] Department of Psychology, Washington State University, Pullman, Washington, USA; [d] Department of Psychology, Virginia Commonwealth University, Richmond, VA, USA; [e] Department of Pediatrics, University of Cincinnati College of Medicine, Cincinnati, Ohio, USA

Corresponding author information: Joseph W. Fredrick, PhD, Division of Behavioral Medicine and Clinical Psychology, Cincinnati Children's Hospital Medical Center, 3333 Burnet Avenue, Cincinnati, Ohio, 45229 USA, joseph.fredrick@cchmc.org, 513-803-0068

Funding Source. This research was supported by award number R305A160126 from the Institute of Education Sciences (IES), U.S. Department of Education. The content is solely the responsibility of the authors and does not necessarily represent the official views of the IES.

Conflict of Interest. The authors declare no potential conflicts of interest with respect to the research, authorship, or publication of this article.

Abstract

The Adult Concentration Inventory (ACI) is an adult self-report measure of sluggish cognitive tempo (SCT) developed following a meta-analysis identifying items distinguishing SCT from ADHD inattention. To date, only one study conducted in college students has examined the structural and external validity of the ACI. The current study evaluated the convergent and discriminative validity of the ACI in a community sample of adults, in addition to testing unique associations with internalizing symptoms, daily life executive functions, and sleep. Adults (N = 286; M_{age} = 44.45; 83.6% female) completed ratings of SCT, ADHD symptom dimensions, and external correlates. An a priori two-factor model with cross-loadings found 10 of the 16 SCT items to have high loadings on the SCT factor and low loadings on the ADHD inattention factor. SCT was uniquely associated with higher internalizing symptoms, time management and self-organization difficulties, poorer sleep quality, shorter sleep duration, lower sleep efficiency, and more daytime sleepiness. These findings replicate and extend support for the ACI in assessing SCT in adults.

Keywords: ADHD; anxiety; depression; executive functions; factor analysis; sleep; sluggish cognitive tempo

Examining the structural and external validity of the Adult Concentration Inventory for assessing sluggish cognitive tempo in adults

Sluggish cognitive tempo (SCT) represents a collection of behaviors characterized by excessive daydreaming, mind-wandering, staring or zoning out, drowsiness, and slowed thinking/moving (Barkley, 2012; Becker et al., 2016b). Although initially considered a potential specifier for identifying individuals with pure attention-deficit/hyperactivity disorder (ADHD) predominately inattentive type (ADHD-IN), studies consistently find SCT symptoms to be empirically distinct from ADHD-IN symptoms across community and clinical populations (Becker et al., 2016b). Additionally, above and beyond ADHD-IN, SCT symptoms remains associated with academic, emotional, and social impairments (Becker & Barkley, 2018). Further, although the etiology of ADHD is largely genetic, initial research suggests that SCT symptoms are less heritable and may be impacted by environmental characteristics (Moruzzi et al., 2014), including forms of psychosocial adversity (Barkley, 2012; Fredrick et al., 2019; Fredrick, Becker, & Lanberg, in press; Musicaro et al., 2020) or shortened sleep (Becker et al., 2019). Despite advancements in the study of SCT, several limitations remain. As noted in a recent review on the measurement of SCT, variability exists in the items and measures used to evaluate SCT, which makes it difficult to compare findings across studies (Becker, 2020). Second, the majority of studies examining the internal and external validity of SCT comprise child, adolescent, or college student samples, with far fewer being conducted in non-college sample of adults (Barkley, 2012). Accordingly, the current study examines the structural validity of the Adult Concentration Inventory (ACI), an adult self-report measure of SCT, and the unique associations between SCT and domains of functioning in a community sample of adults.

Assessing SCT in Adults

As SCT research has advanced, far more work has been done to develop and evaluate rating scales to assess SCT in children and adolescents compared to adults (Becker, 2020). The Barkley ADHD Adult Rating Scale-IV (BAARS-IV) was the first measure to assess the structural validity of self-reported SCT in adults (Barkley, 2012). In a nationally representative sample of adults, Barkley found support for nine SCT items that were empirically distinct from ADHD symptoms (Barkley, 2012), and a subsequent study replicated the structural validity of the SCT factor on the BAARS-IV from ADHD symptom dimensions in college students (Becker et al., 2014a). However, a study of adults in Japan found only five of the nine BAARS-IV SCT items to be distinct from ADHD inattention items (Takeda et al., 2019), suggesting possible variability in the differentiation of SCT from ADHD-IN across samples of adults.

More recently, the Adult Concentration Inventory (ACI) (Becker et al., 2018a) was developed following a meta-analysis that identified SCT items that were optimal for differentiating the construct from ADHD-IN (Becker et al., 2016b). The ACI includes the 13 items identified in the meta-analysis, in addition to three items capturing mental confusion that were also found to be specific to SCT (McBurnett et al., 2014). An initial validation conducted in a sample of over 3,000 undergraduate students (M_{age} = 19 years) found 10 of the 16 ACI items to be empirically distinct from ADHD-IN and internalizing symptoms; additionally, self-reported SCT symptoms were uniquely related to higher internalizing symptoms, emotion dysregulation, and lowered self-esteem (Becker et al., 2018a). However, the ACI has yet to be examined beyond college student samples, limiting its potential validity and utility for assessing SCT in adults.

External Correlates of SCT in Adults

Studies have repeatedly shown SCT to be distinct from not only ADHD symptoms, but also anxiety, depression, and daytime sleepiness in young adult (Becker et al., 2018a; Becker et al., 2014a; Langberg et al., 2014) and adult samples (Barkley, 2011a). Yet though distinct, studies

examining the external validity of SCT in adults have consistently found SCT symptoms to be associated with internalizing symptoms and related domains (Becker et al., 2016b). In college students, self-reported SCT symptoms are associated with higher anxiety and depression symptoms (Becker et al., 2018a; Becker et al., 2014a; Jarrett et al., 2017; Wood et al., 2017) above and beyond ADHD symptoms (Becker et al., 2018a; Becker et al., 2014a). Studies have also found SCT to be uniquely related to college students' emotion regulation difficulties (Flannery et al., 2016; Wood et al., 2017), rumination (Fredrick et al., 2020), loneliness (Becker et al., 2018), and lower self-esteem (Becker et al., 2018). We are aware of only one study that has examined SCT symptoms in relation to internalizing symptoms in a sample of adults not comprised fully of college students. In a sample of 429 adults in Japan (322 of whom were university students), Takeda et al. (2019) found SCT symptoms to be more strongly associated than ADHD-IN symptoms with internalizing symptoms.

Additionally, due to the executive functioning deficits commonly present in adults with ADHD (Barkley & Murphy, 2011), studies have examined whether SCT symptoms account for unique variance in aspects of daily life executive functioning. Using the BAARS-IV, studies have found SCT and ADHD-IN symptoms to be independently related to deficits in overall daily life executive functioning (Flannery et al., 2017; Jarrett et al., 2017; Leikauf & Solanto, 2017; Wood et al., 2017). Preliminary evidence also suggests differences across specific executive functioning domains. For instance, ADHD-IN symptoms are more strongly related to difficulties in self-motivation and time-management domains, whereas SCT might be more related to poor self-regulation of emotion and self-organization/problem-solving in college student (Jarrett et al., 2017; Wood et al., 2017), ADHD-referred (Leikauf & Solanto, 2017), and nationally representative (Barkley, 2012) samples of adults. More recently, in the initial validation study of the ACI, SCT symptoms remained uniquely associated across daily life executive functioning

domains controlling for ADHD symptoms, though ADHD-IN symptoms were more strongly associated with self-organization, time-management, self-restraint, and motivation and equally associated as SCT with self-regulation of emotion (Becker et al., 2018a). Taken together, executive functioning may be one important domain where ADHD and SCT diverge.

Finally, although far less examined compared to internalizing symptoms and daily life executive functioning, several studies suggest that SCT negatively impacts adults' sleep functioning. On the surface, these findings are expected given some overlap of SCT behaviors and poor sleep (e.g., drowsiness, lethargy), and both SCT and sleep problems are elevated in ADHD populations (Becker & Barkley, 2018; Becker et al., 2016b). In college students, Langberg et al. (2014) found SCT symptoms to be moderately correlated with daytime sleepiness and uniquely associated with greater sleepiness over and above ADHD and internalizing symptoms. Another study with college students found SCT symptoms to be uniquely associated with worsened sleep quality, greater sleep disturbances (dreams, waking in the middle of the night), and daytime dysfunction, whereas ADHD-IN symptoms were only uniquely related to daytime dysfunction (Becker et al., 2014b). Finally, a recent study indicated that greater self-reported eveningness preference was uniquely associated with higher SCT symptoms among adult outpatients presenting for an ADHD evaluation (Lunsford-Avery et al., 2020). Thus, research to date suggests a potential unique association of SCT with sleep problems, though no study has utilized the ACI or a community sample of adults to examine associations between SCT and sleep.

Current Study

To advance the measurement and understanding of SCT in adults, the current study examined the structural validity and external validity of the ACI in a community sample of adults. The current study had two primary objectives:

1) To identify the ACI SCT items that demonstrated convergent and discriminative validity with the ADHD-IN items (i.e., high factor loadings on the SCT factor and low loadings on the ADHD-IN factor). Although the initial ACI validation study in college students identified 10 of the 16 items to exhibit strong factor loadings, we included all 16 items since no other study has examined the structural validity of the ACI in adults and there is evidence that the structural validity of SCT measures may differ in different types of adult samples (Takeda et al., 2019). Still, similar to results from the initial ACI validation study (Becker et al., 2018a), we anticipated that most, but not all, of the SCT items to exhibit strong convergent and discriminative validity from the nine ADHD-IN items.
2) To evaluate SCT in relation to internalizing symptoms, daily life executive functioning, and sleep behaviors. We examined both bivariate correlations as well as partial regression coefficients to evaluate the unique associations of SCT and ADHD symptom dimensions with these external correlates. Based on prior research, we hypothesized that self-reported SCT symptoms would be significantly associated with internalizing symptoms (Becker et al., 2018a; Becker et al., 2014a), organization/problem-solving and self-regulation of emotion domains of executive functions (Becker et al., 2018a; Jarrett et al., 2017; Leikauf & Solanto, 2017; Wood et al., 2017), and sleep problems and daytime sleepiness (Becker et al., 2014b; Langberg et al., 2014; Lunsford-Avery et al., 2020).

Methods

Participants

Participants were 286 adults ages 31-68 years ($M \pm SD_{age}$ = 44.45±6.04 years). Participants were mostly female (83.6%; 13.7% male, 2.7% unknown) and non-Hispanic White (69.6%; 4.5% Black, 4.2% Asian, 1.0% Other, 0.7% Native American, 19.6% unknown; 3.5% Hispanic, 20.6% unknown ethnicity). All participants were primary caregivers who were recruited as part of a

larger study of adolescents with and without ADHD (see Becker, Langberg et al., 2019). Regarding household income, 8.9% of adults reported making a household income of $40,000 or less, 30.9% of adults reported an income of $90,000 or less, and 60.2% of adults reported a household income over $120,000. Most participants reported attaining a college/university or graduate degree (79.8%), while the remaining reported attaining a partial college/vocational training or high school degree (20.2%). Finally, 30 participants (10.5%) reported receiving some form of government support (e.g., food stamps, Medicaid).

Procedures

This study was approved by the institutional review boards (IRB) at both study sites. Written informed consent was obtained from all participants. Data in the current study were collected in 2017-2018 at the second timepoint of a broader prospective study of adolescents with and without ADHD (Becker, Langberg et al., 2019). For recruitment for the broader study from which the current data were drawn, potential families were recruited via distribution of a recruitment flyer and letter to all eighth-grade families by e-mail, within an information packet, or at events attended by eighth-grade parents. Primary adult caregivers contacted the research staff in response to these recruitment materials/methods and were administered a phone screen to determine eligibility for the study. Families meeting screening criteria were invited to an in-person research visit to confirm eligibility. To be eligible for the broader study, caregivers were required to have a child with or without ADHD enrolled in eighth grade, with an estimated full scale intelligence score ≥ 80. Of the 302 participants in the broader study, 286 adults completed rating scales at the second timepoint, when parents provided ratings of their own symptoms and functioning.

Measures

Adult Concentration Inventory (ACI)

The ACI is an adult self-report measure of SCT. Consisting of 16 items, the ACI was developed following a meta-analysis examining the internal validity of SCT and the items that most consistently represent the SCT construct as distinct from ADHD-IN (Becker et al., 2016b). Items are rated on a four-point scale (0 = *not at all,* 3 = *very often*), with higher scores representing greater SCT symptoms. Previous studies have demonstrated high reliability of scores on the ACI in college student samples (e.g., Becker et al., 2018a; Fredrick et al., 2020).

Barkley Adult ADHD Rating Scale – IV (BAARS-IV)

The BAARS-IV (Barkley, 2011a) an adult self-report measure that includes the 18 *DSM-5* (American Psychiatric Association, 2013) symptoms of ADHD-IN and hyperactivity/impulsivity (ADHD-HI). Participants respond to each item using a four-point scale (1 = *not at all*, 4 = *very often* changed to *0 = not at all, 3 = very often* for this study to match anchors on the ACI). The factor structure of this measure has been established in a nationally representative sample of adults and the scales demonstrate satisfactory internal consistency and test-retest reliability over a two- to three-week period (Barkley, 2011a, 2012). In the current study, αs = .86 and .75 for ADHD-IN and ADHD-HI, respectively.

Depression, Anxiety, and Stress Scales – 21 (DASS-21)

The DASS-21 (Antony et al., 1998) measures self-reported depression (e.g., "I could not seem to experience any positive feeling at all"), anxiety (e.g., "I felt scared without any good reason"), and stress (e.g., "I found it hard to wind down"). In reference to the past week, participants rate each item using a four-point scale (1 = *did not apply to me at all*, 4 = *applied to me very much or most of the time*). The DASS-21 demonstrates acceptable internal consistency and concurrent validity with other measures of anxiety and depression (Antony et al., 1998;

Lovibond & Lovibond, 1995). In the current study, αs = .86, .81, and .67 for depression, anxiety, and stress, respectively.

Barkley Deficits in Executive Functioning Scale, Short Version (BDEFS-S)

The BDEFS-SF (Barkley, 2011b) is a 20-item short form version of the 89-item BDEFS. The BDEFS is a self-report measurement assessing the frequency in which adults experience difficulties in EF and includes multiple EF domains, including Self-Management to Time, Self-Organization/Problem Solving, Self-Restraint, Self-Motivation, and Self-Regulation of Emotion. Participants respond on a four-point scale (1 = *never or rarely*, 4 = *very often*). The subscales of the BDEFS-SF have shown to correlate highly with their respective counterparts of the BDEFS (Barkley, 2011b) and the five factor structure of the BDEFS-S has recently been replicated (Lace et al., 2020). In the current study, scores for each subscale were as follows: Self-Management to Time (α = .85), Self-Organization/Problem Solving (α = .83), Self-Restraint (α = .79), Self-Motivation (α = .70), and Self-Regulation of Emotion (α = .87).

Pittsburgh Sleep Quality Index (PSQI)

The PSQI is an adult self-report measure of sleep quality and disturbance (Buysse et al., 1989). The PSQI assesses seven well-validated components of sleep: subjective sleep quality, sleep onset latency, sleep duration, sleep efficiency, sleep disturbance, use of sleep medication, and daytime dysfunction. Scoring is based on a four-point scale with higher scores reflecting poorer sleep functioning over the past month. Four items (e.g., assessing sleep duration; sleep latency) are open-ended responses that, based on participants' answers, are converted to the four-point scale. The PSQI is internally consistent (Buysse et al., 1989), is reliable across four weeks (Lund et al., 2010), and correlates with other measures of sleep disturbance and daily diaries of sleep activity (Buysse et al., 2008). Most domains are assessed with one or two items, whereas the sleep disturbance domain is assessed with 10 items (α = .72).

Epworth Sleepiness Scale (ESS)

The ESS (Johns, 1991) is a widely used adult self-report measure of daytime sleepiness. Participants rate the likelihood of dozing or falling asleep across eight different situations commonly encountered in daily life (e.g., sitting and reading, watching TV, as a passenger in a car for an hour without a break). Each item is rated on a four-point scale (0 = *no chance of dozing*, 3 = *high chance of dozing*), and a mean score of the items is calculated as an overall index of daytime sleepiness. Previous studies using scores from the ESS have demonstrated adequate internal consistency and test-retest reliability in adults with and without sleep disorders (Buysse et al., 2008; Moul et al., 2004). In the current sample, α = .76.

Analytic Strategy

First, an a priori two-factor model with cross-loadings was applied to the 16 SCT and nine ADHD-IN items to identify SCT items with convergent validity (high loadings on the SCT factor) and discriminant validity (low loadings on the ADHD-IN factor). An SCT item was determined to load onto a factor if the SCT loading was > .50 and the ADHD-IN loading was < .30. SCT and ADHD-IN items were treated as categorical indicators with the robust weighted least squares estimator used for the analyses (WLSMV). Second (assuming some of the SCT items would fail to show convergent and discriminant validity in the first analysis), an a priori two-factor model with cross-loadings was then applied to the SCT items with convergent and discriminant validity from the first analysis and the nine ADHD-IN items.

The global fit of the model from this second factor analysis was evaluated with the comparative fit index (CFI, acceptable fit > .90, close fit > .95), the Tucker-Lewis Index (TLI, acceptable fit > .90, close fit > .95), the standardized root-mean-square residual (SRMR, acceptable fit < .08, close fit < .05), and the root-mean-square error of approximation (RMSEA, acceptable fit < .08, close fit < .05, see Little, 2013). The factor analyses used the geomin rotation

procedure. The localized ill-fit of the second model was also evaluated with an inspection of the residual matrix. Standardized residuals greater than 0.10 were considered to suggest localized ill-fit (Kline, 2016). Finally, the correlation of the SCT and ADHD-IN factors was inspected to determine if the two factors had sufficient discriminant validity (i.e., factor correlations less than .85 are considered necessary for discriminant validity, Brown, 2015, p. 116). These analyses were thus designed to identify SCT items with good convergent validity as well as discriminant validity with the ADHD-IN factor. Such was a necessary first step for a meaningful evaluation of the external correlates of SCT and ADHD-IN.

For the determination of the external correlates of SCT and ADHD-IN, the analyses used manifest variables (summary scores on each measure) given the sample size was not large enough for the use of latent variables. The first step here involved the calculation of correlations of SCT, ADHD-IN, and ADHD-HI with demographic variables. The second step involved the determination of the correlations of the SCT, ADHD-IN, and ADHD-HI dimensions with internalizing symptoms, daily life executive functioning, and sleep. The third step used regression analyses to determine if SCT, ADHD-IN, and ADHD-HI were uniquely associated with the internalizing symptoms, daily life executive functioning, and sleep. The regression analyses were repeated controlling for groups status (0 = adults of adolescents without ADHD, 1 = adults of adolescents with ADHD), age, household income, and education level. The Mplus model constraint procedure was used to determine if the SCT and ADHD-IN correlations and partial regression coefficients with the external correlates differed significantly.

Results

Weighted Least Square Mean and Variance Adjusted Exploratory Structural Equation Modelling of the ACI Items

As presented in Table 1, 10 of the 16 SCT items (ACI items 3, 5, 6, 8, 10, 11, 13, 14, 15, 16; α with these 10 items = .91) demonstrated strong convergent and discriminative validity. The six items with poor factor loadings were removed, and an a priori two-factor model with cross-loadings was applied to the 10 SCT and nine ADHD-IN items. The two-factor model provided an acceptable to close fit $\chi^2(134) = 297.069$, $p < .001$, CFI = .974, TLI = .967, SRMR = .055, and RMSEA = .065 (90% CI: .055, .075) An inspection of the correlational residuals presented in the residual matrix found 14 slightly greater than absolute value of .10 out of a total of 190 residuals; thus, there was no major-localized ill-fit. The average loading of the 10 SCT items on the SCT factor was .80 (range = .54 - 1.03), whereas the average loading on the ADHD-IN factor was .08 (range = .00 - .20). Additionally, the average loading of the nine ADHD-IN items on the ADHD-IN factor was .56 (range = .51 - .81), whereas the average loading on the SCT factor was .16 (range = -.00 - .43). Although three of the nine ADHD-IN items had loadings greater than .30 on the SCT factor and less than .50 on the ADHD-IN factor (i.e., “lose things necessary for tasks,” “easily distracted,” “forgetful”), all subsequent analyses retained the nine ADHD-IN symptoms given that they are established as the nine items for assessing and diagnosing ADHD in the DSM-5. The SCT and ADHD-IN factor correlation of the two-factor model with cross loadings was .64 (SE = .06, $p < .001$).

Correlations of SCT and ADHD-IN with Demographics and External Correlates

Table 2 present intercorrelations, means, standard deviations, and range of SCT, ADHD symptom dimensions, internalizing symptoms, daily life executive functions, and sleep functioning. The mean score on the ACI SCT measure was .53, whereas the mean for ADHD-IN and ADHD-HI was .40 and .30, respectively. Paired-samples *t*-tests indicated a pattern of SCT > ADHD-IN > ADHD-HI (all *ps* < .001). Study site, age, and sex (coded as 0 = female, 1 = male) were unrelated to all psychopathology dimensions. However, SCT ($r = -.28$, $p < .001$) and ADHD-

IN ($r = -.14$, $p = .02$) were each significantly associated with lower family income; additionally, SCT and ADHD-HI symptoms were both significantly associated with greater self-reported government support (ps < .01).

Table 3 presents bivariate associations of SCT, ADHD-IN, and ADHD-HI with external correlates, in addition to superscripts indicating significant differences between the magnitudes of the bivariate correlations with each external correlate. With the exception of sleep medication use, SCT and ADHD symptom domains were significantly correlated with the external correlate domains. In considering differences in magnitudes of bivariate correlations, SCT was more strongly associated than ADHD-HI (but not ADHD-IN) with depression and anxiety. SCT symptoms were more strongly related than ADHD-IN (but not ADHD-HI) to higher stress ($p < .001$). For daily life executive functioning, ADHD-IN was more strongly associated than SCT with poorer time-management, self-restraint, self-motivation, and self-regulation of emotion (ps < .05), whereas ADHD-IN and SCT were similarly related to self-organization. SCT symptoms were more strongly associated than ADHD-HI with poorer time-management, organization/problem-solving, and self-motivation (ps < .01). Finally, with regard to sleep functioning, SCT symptoms were more strongly associated than ADHD-IN (but not ADHD-HI) with shorter sleep duration ($p < .01$) and daytime sleepiness ($p = .014$).

Unique Associations of SCT and ADHD-IN with External Correlates

Figures 1 and 2 present partial standardized regression coefficients for the unique associations of SCT, ADHD-IN, and ADHD-HI with external correlates. SCT remained associated (all ps < .001) with higher depression, anxiety, and stress when controlling for ADHD symptoms. Additionally, ADHD-IN remained associated with higher depression and anxiety (ps < .01), but not stress ($p > .05$), whereas ADHD-HI was uniquely related to higher anxiety and stress (ps < .01). When comparing the magnitude of the unique associations, SCT and ADHD-IN did not

differ on associations with depression, though both SCT and ADHD-IN were more strongly related than ADHD-HI to depression. SCT and ADHD symptom dimensions did not differ on associations with anxiety, and both SCT and ADHD-HI were more strongly associated than ADHD-IN with higher stress.

As expected, ADHD-IN remained uniquely associated with all facets of daily life executive functioning domains (*p*s < .001) and was more strongly associated than SCT and ADHD-HI symptoms with time-management, self-motivation, and self-regulation of emotions. SCT was also uniquely associated with higher ratings of poor time management and organization/problem-solving (*p*s < .001) and did not differ from ADHD-IN symptoms on associations with organization/problem-solving. ADHD-HI ratings were uniquely related only to poor self-restraint and regulation of emotion.

Finally, regarding sleep functioning, SCT was uniquely associated with poorer sleep quality, sleep duration, sleep efficiency, and daytime sleepiness (*p*s < .05), and was more strongly associated than ADHD dimensions with shorter sleep duration (*p*s < .01). SCT symptoms were also more strongly associated than ADHD-IN symptoms with higher daytime sleepiness ($p < .01$) but, surprisingly, not ADHD-HI symptoms. SCT symptoms did not differ from ADHD dimensions on strength of associations with sleep quality, efficiency, disturbance, or use of sleep medications. In contrast to SCT, ADHD-IN was only uniquely associated with greater daytime dysfunction ($p < .001$), and ADHD-IN was more strongly related than ADHD-HI symptoms with daytime dysfunction. Across sleep domains, ADHD-HI was only uniquely associated with higher daytime sleepiness.

Discussion

The current study is the first to evaluate the structural and external validity of the Adult Concentration Inventory (ACI) (Becker et al., 2018a) for assessing SCT symptoms in a

community sample of adults. Findings showed that 10 of the 16 ACI items had strong convergent and discriminant validity from the ADHD-IN items (i.e., high loadings on the SCT factor and low loadings on the ADHD-IN factor). Additionally, controlling for ADHD symptom dimensions, SCT symptoms remained associated with higher self-reported internalizing symptoms, poor time management and organization/problem-solving, poorer sleep quality and efficiency, shorter sleep duration, and greater daytime sleepiness. These findings provide important evidence for using the ACI to assess SCT symptoms and evaluate associations with functional outcomes in adults.

Structural Validity of the ACI

Findings from the factor analyses found 10 of the 16 SCT items demonstrated both convergent and discriminative validity in relation to ADHD-IN items. These results are the first to provide evidence for the structural validity of the ACI in a community sample of adults and add to the small body of research using the ACI to evaluate SCT in college student samples (Becker et al., 2018a; Becker et al., 2018b; Fredrick et al., 2019, 2020; Swope et al., 2020). When comparing items loading on the SCT factor in the current study with those observed in the initial ACI validation study with college students (Becker et al., 2018a), a few similarities and differences emerged. First, items reflecting cognitive (e.g., “daydreaming”, “staring into space”, “losing train of thought”, “lost in own thoughts”, “feel confused”, “zoning or spacing out”, “thinking is slow”) and mental confusion (e.g., “forget what I was going to say”, “mind gets mixed up”) aspects of SCT were found to have structural validity across both studies. In contrast to the college student validation study (Becker et al., 2018a), items reflecting the behavioral/motoric component of SCT (e.g., “sleepy or drowsy”, “tired easily”) did not demonstrate discriminant validity from ADHD-IN in the current study. Although these results should be considered preliminary until a larger body of research has examined the SCT item set in adults, findings suggest that the motoric items for assessing SCT may vary across development, be specific to college student or youth sample, or

need further evaluation as to the optimal items for assessing SCT in adults (Barkley, 2012; Becker, 2020). Additionally, it may be that these SCT items are too general and overlap with the ADHD-IN construct in adult samples. Finally, in the current study the SCT and ADHD-IN bivariate correlations were strongly correlated (.64) and similar to the magnitude of associations between SCT and ADHD-IN reported in the ACI college student study (.73) (Becker et al., 2018a) and SCT meta-analysis (.72) (Becker et al., 2016b).

External Validity of the ACI

In addition to providing evidence for the structural validity of the ACI, findings indicated external validity of the ACI with several domains of functioning.

Internalizing Symptoms

Consistent evidence was found for SCT symptoms being uniquely associated with increased depression, anxiety, and stress. These findings replicate a number of studies in college students (Becker et al., 2018a; Becker et al., 2014a; Swope et al., 2020) and a few in community and clinical adult samples (Leikauf & Solanto, 2017; Takeda et al., 2019). However, this study is the first to document unique relations between SCT and internalizing symptoms using the ACI in a community sample of adults. Additionally, results showed that SCT and ADHD-IN symptoms were similarly related to higher depression and anxiety. This finding is consistent with one study showing both SCT and ADHD-IN to be uniquely associated with higher depression and anxiety (Becker et a., 2018a), though contrasts with another study which found SCT to be more strongly associated than ADHD-IN with these internalizing domains (Takeda et al., 2019). Although additional studies are needed to determine whether SCT has similar or stronger associations than ADHD-IN with internalizing domains, findings from the current study add to the limited body of research in adults linking SCT to higher anxiety and depression symptoms.

Although SCT and ADHD-IN were both uniquely associated with higher depression and anxiety, SCT was more strongly related than ADHD-IN to stress. This finding is consistent with another study that found a three-item measure of SCT symptoms to be uniquely related to perceived stress in a community sample of adults (Combs et al., 2015). Potentially, symptoms of daydreaming, mind-wandering, and mental confusion interfere an individual's ability to cope and respond to ongoing stressors (Combs et al., 2015). Or, given findings that SCT was associated with lower self-reported annual income and more government support, consistent with studies linking SCT to psychosocial adversity (Barkley, 2012; Fredrick et al., in press), individuals with elevated SCT may experience more frequent or intense daily life stressors.

Daily Life Executive Functioning

Across daily life executive functioning domains, SCT was uniquely associated with deficits in time-management and self-organization/problem solving, whereas ADHD-IN symptoms remained associated with all domains and was more strongly associated than SCT with deficits in time-management, self-restraint, self-motivation, and self-regulation of emotion. The degree to which our findings align with previous research depends on the specific domain of executive functioning being examined. Collectively, our findings are consistent with prior studies finding ADHD-IN symptoms to be more strongly associated than SCT with nearly all daily life executive functioning domains (Barkley, 2012; Becker et al., 2018a; Leikauf & Solanto, 2017), whereas SCT symptoms are more consistently associated with only a few of these domains. Regarding deficits in time-management, the majority of previous research has also shown SCT and ADHD-IN symptoms to both be independently associated, with the latter accounting for more variance (Barkley, 2012; Becker et al., 2018a; Jarrett et al., 2017; Wood et al., 2017). However, one study in ADHD-referred adults reported ADHD-IN, but not SCT symptoms, to be uniquely associated with self-reported time management deficits (Leikauf & Solanto, 2017). In addition to

time-management, SCT symptoms were also uniquely related to deficits in self-organization/problem-solving in the current study. Previous studies have reported mixed findings as to whether SCT (Barkley, 2012; Jarrett et al., 2017; Wood et al., 2017) or ADHD-IN (Becker et al., 2018a; Leikauf & Solanto, 2017) is more strongly associated with self-organization/problem solving, though each of these studies consistently observe SCT to provide unique variance. Our findings add to this body of research suggesting that time-management and self-organization/problem-solving are domains of daily life executive functions likely related to SCT symptoms.

Further, our findings showed that SCT symptoms were unrelated to self-motivation, self-restraint, or self-regulation of emotion above and beyond ADHD symptoms. These findings generally converge with prior research showing ADHD symptom dimensions be more related than SCT to self-restraint deficits (Barkley, 2012; Becker et al., 2018a; Jarrett et al., 2017; Leikauf & Solanto, 2017), which is consistent with theoretical and empirical evidence highlighting poor impulse control/self-restraint as core features of ADHD (Barkley & Murphy, 2011) as well as studies showing SCT to be associated with lower impulsivity (Marshall et al., 2014). Our finding that SCT was not uniquely associated with self-motivation (which encompasses aspects of self-control) when controlling for ADHD symptoms is consistent with a few past studies (Barkley, 2012; Becker et al., 2018a; Leikauf & Solanto, 2017), though others have found SCT to be uniquely related to scores on this subscale (Jarrett et al., 2017; Wood et al., 2017). Finally, our findings for self-regulation of emotion differs from previous studies. Whereas previous studies have reported SCT symptoms to be uniquely (Becker et al., 2018a; Wood et al., 2017) or even more strongly than ADHD-IN (Barkley, 2012; Jarrett et al., 2017) related to self-regulation of emotion, SCT symptoms were not uniquely related to self-regulation of emotion in the current study. Although it is unclear why these different findings emerged, it is important to note that the

self-regulation of emotion scale is multifaceted and comprises difficulties with impulsive emotional reactions and depression/withdrawal (Becker et al., 2018a), with the latter representing a strong correlate of SCT (Becker et al., 2016b). Thus, future research is needed to unpack the relation between SCT and bottom-up (e.g., reactivity) and top-down (e.g., cognitive control) emotion regulation processes in adults. Finally, it is important to be cautious when solely relying on rating scales to measure executive functioning, given recent findings of performance-based tasks having superior predictive validity (Soto et al., 2021) and overlap of executive functioning rating scales with psychopathology symptoms or other domains of executive functioning (e.g., self-motivation subscale including items reflecting poor self-control).

Sleep Functioning

Findings showed SCT symptoms to be more strongly associated than ADHD symptom dimensions with sleep domains. Specifically, SCT was uniquely related to worsened sleep quality, shorter sleep duration, lower sleep efficiency, and higher daytime sleepiness. SCT symptoms were also more strongly associated than ADHD-IN symptoms with shorter sleep duration and greater daytime sleepiness. The degree to which these findings converge with prior studies depends on the type of sleep domain being examined. First, our finding for SCT being linked to poorer sleep quality is consistent with a study in college students reporting SCT symptoms, but not ADHD-IN symptoms, to be uniquely associated with poorer self-reported sleep quality (Becker et al., 2014b). However, Becker et al. (2014b) also found SCT to be uniquely related to nighttime sleep disturbances and daytime functioning in a sample of 244 college students, which we did not find in the current study. Conversely, SCT was uniquely associated with shorter sleep duration in the current study but not in the Becker et al. (2014b) study. One possibility for these discrepant findings reflects measurement differences or, given evidence documenting higher rates of SCT in college students compared to other adult samples using the BAARS-IV (Barkley, 2012; Flannery

et al., 2016; Wood et al., 2017), SCT may evince differential patterns of associations with components of sleep in college student compared to other adult samples.

Finally, we found SCT, but not ADHD-IN, to be uniquely associated with greater daytime sleepiness. This finding aligns with a small but consistent body of research linking SCT to daytime sleepiness in children (Becker et al., 2016a), adolescents (Smith et al., 2019), and college student samples (Langberg et al., 2014). Despite the clear overlap in behavioral aspects of SCT (e.g., tired, sleepy) and daytime sleepiness, it has also been established that these constructs are distinct (Langberg et al., 2014; Smith et al., 2019). Further, as described above, several of the behavioral/motoric features of SCT did not evidence discriminant validity from ADHD-IN items in the current study (including the “I get tired easily” and “I feel sleepy or drowsy during the day” items), and these items were therefore not part of the SCT composite used in the regression analyses, providing further confidence that the overlap of SCT and daytime sleepiness is not merely a result of shared item content. Potentially, given a recent study linking greater diurnal preference for eveningness to SCT behaviors in adults (Lunsford-Avery et al., 2020), adults reporting SCT symptoms might have a propensity for to stay up late (e.g., delayed circadian rhythm), resulting in shorter sleep duration and daytime sleepiness. Given the cross-sectional nature of the data and most previous studies, it is unclear whether SCT represents a manifestation of poor sleep or is a predictor of sleep impairments. Importantly, there is evidence from experimental research that shortened sleep worsens SCT in adolescents (Becker et al., 2019; Garner et al., 2017). Yet the magnitude of associations between insufficient/poor sleep and SCT also indicates that these are not redundant constructs (Becker et al., 2016a; Langberg et al., 2014; Smith et al., 2019). Additional research is needed to further disentangle the interrelations of SCT and sleep. Longitudinal studies that incorporate multi-method assessment of sleep (e.g., actigraphy, sleep diaries) are especially needed.

Limitations and Future Directions

Several limitations are important to note and point to key directions for future research. First, the cross-sectional design prevented us from evaluating the test-retest reliability of the ACI or predictive validity in relation to domains of functioning. Investigating the ACI over multiple time points will bolster confidence in the validity and reliability of this measure for assessing the nature and correlates of SCT. Second, consistent with many studies to date on SCT in adults (e.g., Barkley, 2012; Becker et al., 2014; Becker et al., 2018; Langberg et al., 2014; Takeda et al., 2019), only self-report rating scales were used, though it is important to note a few studies have examined informant ratings of SCT symptoms in college students (Leopold et al., 2015) and adult outpatients seeking an ADHD evaluation (Lunsford-Avery et al., 2021; Mitchell et al., 2020). These studies documented low to moderate correlations between self and parent-report (Leopold et al., 2015) and collateral-report (Lunsford-Avery et al., 2021) of SCT, in addition to finding collateral-report of SCT symptoms being uniquely associated with functional impairment across settings above and beyond ADHD symptoms (Lunsford-Avery et al., 2021). Thus, future research should incorporate multiple reports (e.g., partners/spouses) to capture behaviors and impairments that may be present across contexts (e.g., relationship quality, occupational functioning). Similarly, future research would benefit from incorporating performance-based tests (e.g., working memory, processing speed) and objective methods of functioning (e.g., actigraphy) to examine correlates of SCT and augment criterion validity of the ACI, particularly following research suggesting that performance-based tests demonstrate superior validity in predicting academic and behavioral functioning compared to executive functioning rating scales (Soto et al., 2020). In addition, we did not have clinical information regarding ADHD or other psychiatric diagnoses for study participants, and it will be important to further examine the ACI in adults with ADHD in addition to other clinical samples. Relatedly, there has been long-standing interest in how to best

capture the heterogeneity in ADHD, including the possibility of a restrictive (“pure”) inattentive presentation (Adams et al., 2010; Diamond, 2005; Milich et al., 2001). Although we did not group participants in our study based on SCT or ADHD symptoms, and studies clearly show SCT to be distinct from ADHD-IN (Becker et al., 2016b), it would be useful for future work to examine whether SCT symptoms are important as markers of a restrictive inattentive phenotype (Becker & Willcutt, 2019; Nigg et al., 2010) or are otherwise useful for understanding ADHD heterogeneity (Nigg et al., 2020).

Third, our study solely tested associations of SCT with internalizing, executive functioning, and sleep domains, and future research should examine whether adult SCT symptoms contribute to additional domains of functioning considered relevant in adulthood, such as romantic partner and/or parent-child relationship quality, alcohol/substance use, and occupational functioning which are clearly impacted by adult ADHD symptoms (Barkley, 2012; Park et al., 2017). Similarly, due to the smaller sample size and relatively fewer males in the current study, we were unable to test for sex differences on the SCT or in relation to outcome measures. Future factor analytic studies with a larger and more representative sample are needed to enhance results from structural equation modeling techniques, which would also permit testing factor structure of SCT when including additional psychopathology symptoms (e.g., internalizing symptoms) and other domains of functioning (e.g., executive functioning, sleep). Finally, although community-based recruitment was used, our sample consisted of parents of adolescents with and without ADHD who were predominately female, White, middle-upper SES adults, restricting generalizability of findings to clinical samples or adults with diverse racial/ethnic identities or SES backgrounds. Future research is needed to use other sampling approaches to recruit a more representative sample of adults when examining the ACI. Although assessment of SCT is slowly garnering increased evidence in diverse racial/ethnic samples (Becker, 2020), it is important to

note that nearly all of these studies comprise youth samples. Further, although not a focus of the present study, SCT was uniquely associated with lower self-reported annual income and more government support, consistent with studies linking SCT to indices of socioeconomic status (Barkley, 2012). Clearly, an important next step will be more thorough investigation of how cultural, social, and economic factors influence the presentation and correlates of adult SCT.

Conclusion

This study provides evidence for the structural and external validity of the Adult Concentration Inventory (ACI) for assessing SCT symptoms in a community sample of adults. Further, SCT symptoms were uniquely associated with internalizing symptoms, daily life executive functioning domains, and poorer sleep functioning, with SCT symptoms being more strongly associated than ADHD-IN with higher stress, shorter sleep duration, and greater daytime sleepiness. As the field aims to determine the clinical utility of SCT, either as a transdiagnostic construct, diagnostic specifier, or distinct clinical entity (Becker & Willcutt, 2019; Nigg et al., 2020), measures with sound psychometric properties are essential for the field to advance. Findings provide further support for the ACI as an adult self-report rating scale assessing SCT which may prove useful for clinical assessment and treatment delivery.

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Table 1

Factor Loadings of the Adult Concentration Inventory (ACI) SCT Items on the SCT and ADHD-IN Factors

SCT Item	SCT	ADHD-IN
1.) I am slow at doing things.	.11	.65
2.) My mind feels like it is in a fog.	.47	.42
3.) I stare off into space.	**.74**	.10
4.) I feel sleepy or drowsy during the day.	.04	.73
5.) I daydream.	**.54**	.19
6.) I lose my train of thought.	**.86**	.00
7.) I am not very active.	-.08	.69
8.) I get lost in my own thoughts.	**.66**	.15
9.) I get tired easily.	-.02	.82
10.) I forget what I was going to say.	**.84**	-.05
11.) I feel confused.	**.80**	.08
12.) I am not motivated to do things.	-.02	.78
13.) I zone out or space out.	**.95**	-.06
14.) My mind gets mixed up.	**.95**	-.08
15.) My thinking seems slow or slowed down.	**.69**	.20
16.) I have a hard time putting my thoughts into words.	**.67**	.13

Note. Items with a primary loading on the SCT factor are in bold. SCT = sluggish cognitive tempo; ADHD-IN = attention-deficit/hyperactivity disorder inattentive

Table 2

Intercorrelations and Descriptive Statistics of Study Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. SCT	--																		
2. ADHD-IN	.70***	--																	
3. ADHD-HI	.47***	.49***	--																
Internalizing																			
4. Depression	.48***	.46***	.24***	--															
5. Anxiety	.50***	.47***	.38***	.44***	--														
6. Stress	.57***	.48***	.49***	.57***	.58***	--													
Daily life EF																			
7. Time	.63***	.74***	.33***	.54***	.41***	.48***	-												
8. Organize	.66***	.72***	.37***	.42***	.37***	.39***	.61***	--											
9. Restraint	.47***	.56***	.47***	.30***	.36***	.48***	.47***	.48***	--										
10. Motivation	.48***	.65***	.35***	.37***	.40***	.29***	.59***	.54***	.39***	--									
11. Emotion	.39***	.50***	.34***	.47***	.47***	.53***	.51***	.40***	.46***	.36***	--								
Sleep																			
12. Quality	.29***	.21***	.18**	.25***	.18**	.21***	.24***	.17**	.12*	.15**	.17**	--							
13. Latency	.17**	.19**	.12*	.31***	.22***	.30***	.20**	.18**	.12*	.17**	.24***	.41***	--						
14. Duration	.31***	.18**	.21***	.27***	.17**	.26***	.20**	.19**	.18**	.18**	.10	.47***	.28***	--					
15. Efficiency	.22***	.16**	.12*	.26***	.05	.15**	.21***	.16**	.07	.17**	.10	.40***	.33***	.49***	--				
16. Disturb	.19**	.21***	.14*	.22***	.24***	.19**	.17**	.20***	.16**	.21**	.17**	.30***	.27***	.17**	.26***	--			
17. Med Use	.13*	.07	.09	.13*	.20***	.17**	.06	.07	.10	.05	.05	.17**	.26***	.15*	.21***	.10	--		
18. Dysfunct	.39***	.09	.30***	.48**	.27***	.34***	.50***	.36***	.33***	.32***	.29***	.35***	.15*	.31***	.18***	.19**	.13*	--	
19. Sleepiness	.39***	.28***	.29***	.23***	.24***	.33***	.25***	.29***	.29***	.22***	.20**	.06	.01	.20**	.06	.15**	-.01	.35***	---
M	.53	.40	.30	.31	.20	.55	7.47	5.31	5.00	4.80	5.31	2.10	1.58	1.10	.37	2.18	1.28	1.88	1.86
SD	.49	.41	.33	.40	.29	.46	2.45	1.84	1.54	1.27	1.96	.67	.76	.85	.73	.53	.62	.64	.49
Range	0-3.00	0-2.56	0-1.78	0-2.29	0-1.71	0-2.43	4.00-16.00	4.00-15.00	4.00-13.00	4.00-12.00	4.00-15.00	1.00-3.00	1.00-3.00	0-3.00	0-3.00	1.00-3.00	1.00-3.00	1.00-3.00	1.00-3.38

Note. SCT = sluggish cognitive tempo; ADHD = attention-deficit/hyperactivity disorder; IN = inattention; HI = hyperactivity/impulsivity; EF = executive functioning; Time = time management; Organize = self-organization/problem-solving; Restraint = self-restraint; Motivation = self-motivation; Emotion = self-regulation of emotion; Med Use = sleep medication use = Dysfunct = sleep dysfunction

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

Table 3

Correlations (Standard Errors) of Sluggish Cognitive Tempo and ADHD Symptoms with Internalizing Symptoms, Daily Life Executive Functioning, and Sleep Functioning

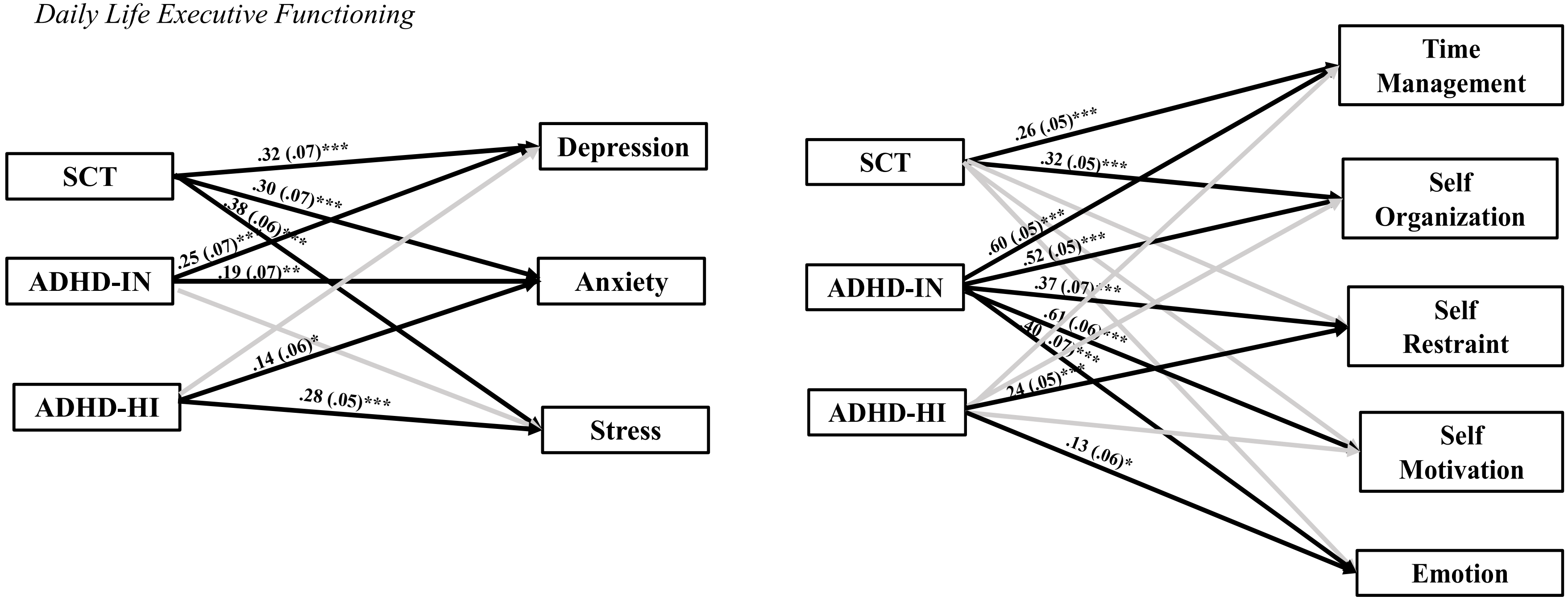
	Internalizing Symptoms			Daily Life Executive Functioning				
Variable	Depression	Anxiety	Stress	Time Management	Self-organize	Self-Restraint	Self-Motivation	Emotion
SCT	$.48^{a}$ (.05)	$.50^{a}$ (.04)	$.57^{a}$ (.04)	$.63^{b}$ (.04)	$.66^{a}$ (.03)	$.47^{c}$ (.05)	$.48^{b}$ (.05)	$.39^{b}$ (.05)
ADHD-IN	$.46^{a}$ (.05)	$.47^{ab}$ (.05)	$.48^{b}$ (.05)	$.74^{a}$ (.03)	$.72^{a}$ (.03)	$.56^{ab}$ (.04)	$.65^{a}$ (.05)	$.50^{a}$ (.04)
ADHD-HI	$.24^{b}$ (.06)	$.38^{bc}$ (.05)	$.49^{ab}$ (.04)	$.33^{c}$ (.05)	$.37^{b}$ (.05)	$.47^{bc}$ (.05)	$.35^{b}$ (.05)	$.34^{b}$ (.05)

	Sleep Functioning							
	Quality	Latency	Duration	Efficiency	Disturbance	Medication Use	Dysfunction	Daytime Sleepiness
SCT	$.29^{a}$ (.06)	$.17^{a}$ (.06)	$.31^{a}$ (.05)	$.22^{a}$ (.06)	$.19^{a}$ (.06)	$.13^{a}$ (.06)	$.39^{a}$ (.05)	$.39^{a}$ (.05)
ADHD-IN	$.21^{a}$ (.06)	$.19^{a}$ (.06)	$.18^{b}$ (.06)	$.16^{a}$ (.06)	$.21^{a}$ (.06)	$.07^{a}$ $(.06)^{ns}$	$.44^{ab}$ (.05)	$.28^{b}$ (.05)
ADHD-HI	$.18^{a}$ (.06)	$.12^{a}$ (.06)	$.21^{ab}$ (.06)	$.12^{a}$ (.06)	$.14^{a}$ (.06)	$.09^{a}$ $(.06)^{ns}$	$.30^{bc}$ (.06)	$.29^{ab}$ (.05)

Note. All correlations significant $p < .05$, with exception of ADHD-IN and ADHD-HI with sleep medication use. Correlation coefficients with different superscripts within a column for an outcome measure differ at $p < .05$. ADHD = attention-deficit/hyperactivity disorder; IN = inattention; HI = hyperactivity/impulsivity; SCT = sluggish cognitive tempo.

Figure 1

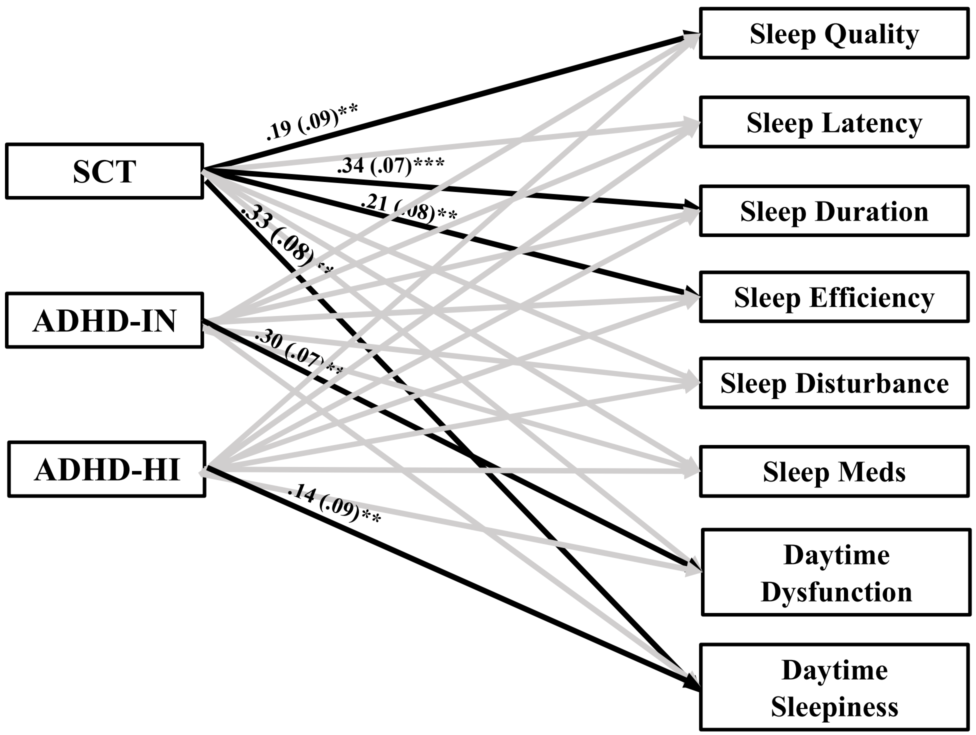
Standardized Unique Effects (Standard Errors) of Sluggish Cognitive Tempo and ADHD Symptoms on Internalizing Symptoms and Daily Life Executive Functioning



Note. Standardized estimates are reported outside parantheses; standard errors are reported inside parantheses. All other paths are nonsignificant ($p > .05$). SCT = sluggish cognitive tempo; ADHD = attention-deficit/hyperactivity disorder; IN = inattention; HI = hyperactivity/impulsivity; Emotion = self-regulation of emotion.
*** $p < .001$; ** $p < .01$; * $p < .05$

Figure 2

Standardized Unique Effects (Standard Errors) of Sluggish Cognitive Tempo and ADHD Symptoms on Sleep Functioning



Note. Standardized estimates are reported outside parantheses; standard errors are reported inside parantheses. All other paths are nonsignificant ($p > .05$). SCT = sluggish cognitive tempo; ADHD = attention-deficit/hyperactivity disorder; IN = inattention; HI = hyperactivity/impulsivity; Sleep Meds = sleep medication use.

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