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SHORT COMMUNICATION

Sluggish cognitive tempo: longitudinal stability and validity

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Abstract

Emerging research has identified sluggish cognitive tempo (SCT) as a construct separate from ADHD predominately inattentive presentation. The present study explores the longitudinal stability of SCT over a period of 7 years, specifically the independent effects of SCT on behavioural and academic outcomes concurrently over a 3-year period. A sample of 639 twins, aged 6–12 years, participating in the Western Reserve Reading and Math Project (WRRMP) were assessed at seven annual home visits. The WRRMP sample is an unselected sample of twins representative of the general population of typically developing school-age children. The current investigation will focus on parent and teacher reports which assess attention deficit hyperactive/impulsive disorder (ADHD) and standardized achievement measures which assess academic outcomes. Over periods longer than 1 or 2 years, SCT does not display good longitudinal stability ($r < .60$). SCT also does not have consistent significant independent effects on academic outcomes once the effects of ADHD were controlled for. Over a 7-year period, SCT does not demonstrate consistent longitudinal stability. SCT significantly predicts social problems, internalizing behaviours, and anxious/depressive behaviours after the effects of ADHD are controlled for. SCT has no significant independent effects on cognitive or educational outcomes after the effects of inattentive ADHD are controlled for.

Keywords Sluggish cognitive tempo · ADHD · Stability · Validity

Introduction

ADHD and sluggish cognitive tempo

The DSM V defines three diagnostic presentations of attention deficit hyperactivity/impulsive disorder (American Psychiatric Association 2013); inattentive (ADHD-I), hyperactive/impulsive (ADHD-H), and combined (ADHD-C). Each presentation is defined by the presence of inattention and hyperactive-impulsivity symptoms. Notably, within those diagnosed with ADHD, a significant portion rate high for symptoms that reflect slow or sluggish physical activity, mental confusion, daydreaming or staring blankly, and a general lack of mental alertness, a finding that has been replicated consistently (e.g., Barkley et al. 1990; Hynd et al. 1989; Lahey and Carlson 1991; Hartman et al. 2004; Bauermeister et al. 2012). These symptoms make up the construct of Sluggish Cognitive Tempo or SCT.

Though the symptoms of SCT are highly comorbid with symptoms of the ADHD inattentive presentation, the classification of SCT as a separate and distinct construct from ADHD has strong support in the research literature. Early SCT research, using factor analysis, found that a three factor

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model of ADHD consisting of the hyperactive/impulsive, inattentive, and sluggish tempo factors emerged from the data (Lahey et al. 1988), a finding which has been consistent, with more recent studies also displaying that SCT consistently loads on a third factor distinct from both inattention and hyperactive/impulsive factors (Hartman et al. 2004; Barkley 2012a, b). In particular, a recent meta-analysis (Becker et al. 2016a, b) on SCT provides much support for the internal validity of SCT; this meta-analysis, consisting of over 19,000 participants in all, found 13 items which loaded consistently on an SCT factor, as opposed to ADHD inattentive or hyperactive/impulsive factors. Given that there appears to be a unique subset of the ADHD population that has yet to be fully acknowledged by the DSM-V, either as a subset of ADHD or as a distinct behavioural disorder, further research into SCT may improve the identification and diagnosis of ADHD presentations and refine our understanding of ADHD as a construct.

Though there is no commonly agreed upon measure for SCT, across measures, high levels of SCT have been shown to have a variety of negative effects, independent of ADHD; in particular, numerous studies have found a strong negative effect of SCT on social functioning independent of the effects of ADHD (Becker et al. 2014a, b; Barkley 2014), as well as an association with a greater prevalence of internalizing behaviours and lower aggression (Penny et al. 2009; Garner et al. 2010; Barkley 2014; Becker et al. 2014a, b) and a greater prevalence of depression (Barkley 2012a, b; Becker and Langberg 2013). In particular, a recent study found that higher levels of SCT uniquely predicted increased levels of anxiety, depression, and social impairment over a 2-year period (del Mar Bernad et al. 2016).

However, research on the independent effects of SCT on academic achievement is relatively inconsistent. A study of 652 children aged 6–14, using an 8 item measure of SCT, did not find that SCT uniquely predicted academic impairment once the effects of ADHD-IN were controlled for (Belmar et al. 2015). A study examining SCT's relation to the Math, Reading, Spelling, and Writing subtests of the Wechsler Individual Achievement Test found no significant independent effects once the effects of ADHD were controlled for (Becker and Langberg 2013), but in another study by the same authors, SCT showed significant independent effects on academic functioning (Langberg et al. 2014). In addition, studies have found that scores on the Reading and Math sections of the Peabody Individual Achievement Test are negatively correlated with an increase in SCT symptoms (Hartman et al. 2004). Therefore, the role of SCT as a predictor of concurrent academic achievement is still unclear, and there is room for more research to be conducted in this area. In addition, questions of developmental stability remain, as well as questions about the independent effects of SCT on academic outcomes over longer periods of time.

Research looking at the longitudinal stability of SCT, and the independent effects of SCT over time, is also as of yet a relatively unexplored area of study. One of the earliest longitudinal studies of SCT supports SCT as a unique predictor of increased social impairment (Becker 2014a, b). A study using a 3 item measure of SCT has found promising evidence for SCT's construct validity over a 1-year period, finding that longitudinally, SCT uniquely predicts academic impairment over the effects of ADHD-IN alone (del Mar Bernad et al. 2014). Higher levels of SCT have also been found to uniquely predict increased levels of anxiety, depression, and social impairment over a 2-year period (del Mar Bernad et al. 2016). Furthermore, a recent longitudinal study of SCT (Leopold et al. 2016) has found evidence of high stability in SCT over the course of 3 years, as well as results which suggest that SCT and ADHD have different developmental outcomes. This finding supports the hypothesis that SCT may also have developmental stability over a longer period of time; however, more longitudinal research, particularly on SCT's predictive effects on academic impairment, is necessary to support these findings.

Aims of the present study

Additional research on SCT's relation to academic and behavioural outcomes is necessary to identify possible additional areas for intervention, as well as to further determine whether SCT has validity as a distinct construct from ADHD. More longitudinal research on SCT is an important area of study as well, as whether or not SCT has effects throughout the developmental pathway can also help refine future academic or behavioural intervention, and provide further evidence in determining SCT's distinctness from ADHD. Therefore, the present study has two main aims:

1. Test for the stability in individual differences in SCT over a 7-year span.
2. Examine the predictive validity of SCT measures for different academic and behavioural outcomes, independent from the effects of Inattentive ADHD, using hierarchical regression analyses, concurrently over a period of 7 years.

The information attained in the current study may improve treatment outcomes for ADHD, may improve the identification and diagnosis of ADHD presentations, and may lead to improved intervention plans aimed at improving academic performance.

Methods

Subjects were taken from a sample of twins in the Western Reserve Reading and Math Project (WRRMP), led by researchers from the Ohio State University and Case Western Reserve University (Petrill et al. 2006). Ethical approval was given by both the Ohio State and Case Western Reserve University Institutional Review Board (Buck-IRB and CWRU-IRB, respectively). The WRRMP is a longitudinal project, studying a population of twin pairs from ages 4 to 18, with longitudinal data collected from a total of 816 individuals. The present study made use of this data. Participants in this study were separated into "waves", corresponding to test administration sessions. For the stability analyses of SCT, individuals in the present study were taken from waves 1 through 7, representing an overall period of 7 years with test sessions occurring roughly a year apart. Characteristics of the 7 waves are shown in Table 1.

Measures

A Sluggish Cognitive Tempo (SCT) composite was created from 5 items on the Teacher Report Form (TRF; Achenbach and Rescorla 2001; Hartman et al. 2004) based on the Child Behaviour Checklist (CBCL; Achenbach and Edelbrock 1991). The TRF asks teachers to describe the behaviour of individuals as observed in a school environment. The TRF consists of 113 items which cover a wide range of behaviours as well as measure the individual's functioning in the classroom and has been used as a measure (in conjunction with others) for identifying various syndromes including mood, anxiety, and internalizing symptoms (Achenbach and Rescorla 2001; Becker and Langberg 2013).

The TRF items used to construct the scale for Cognitive Sluggish Tempo measured levels of mental awareness, daydreaming, slow or sluggish physical activity, and mental confusion. Each item is scored from 0 to 2, with 0 being a lack of a particular behaviour as observed in the student, while a 2 signified a high level of the particular behaviour in the student. The five items as presented on the TRF were: "Stares Blankly", "Underactive/Slow Moving", "Daydreams", "Apathetic", and "Confused or Seems to be in a fog". The sum of these five items was combined into a composite. Higher scores indicated a greater presence of SCT symptoms. The raw composite scores were corrected for age, age squared, and sex using regression. The alpha reliability of the five-item SCT measure was acceptable (Cronbach 1951), with a value above .70 in all Waves except Wave 4 (.63) and Wave 7 (.68), as shown in Table 2.

We then assessed the SCT composite for normality. Skewness and kurtosis values for the SCT composites in waves 1 through 7 indicated that the distribution of SCT was significantly non-normal. SCT composite scores were transformed with a log transformation which achieved sufficient levels of normality and were then used for all subsequent analyses.

ADHD

The presence of ADHD symptoms was created from items on the TRF. A measure for both inattentive and hyperactivity symptoms was created from the TRF, a total of 7 items, with 3 of these items measuring the presence of inattention symptoms ("Fails to finish things", "Cannot concentrate or pay attention", "Inattentive, easily distracted"), and 4 of these items measuring the presence of hyperactivity symptoms ("Cannot sit still; is restless or hyperactive", "Is impulsive or acts without thinking", "Talks too much", "Is unusually loud").

Academic achievement

The Woodcock-Johnson (WJ) Calculation subtest, WJ Math Fluency subtest, WJ Applied Problems subtest, and the WJ Quantitative Concepts subtest (Woodcock et al. 2001) were combined into a WJ Mathematics composite, which

Table 1 Sample size and age for twins with SCT scores

	N (total sample)	*N* (with SCT data)	Male	Female	Mean age (SD)
Wave 1	639	491	205	286	6.11 (.67)
Wave 2	560	426	180	245	7.15 (.66)
Wave 3	612	360	185	203	8.19 (.82)
Wave 4	288	141	57	84	8.33 (.50)
Wave 5	582	146	63	83	9.76 (1.02)
Wave 6	528	219	85	132	10.89 (1.06)
Wave 7	532	242	101	141	12.03 (1.23)

N is the number of individual participants, not twin pairs

Table 2 Alpha reliability of the SCT measure in each wave

Testing year	*N* (total sample)	*N* (with all 5 questions answered)	Alpha
Wave 1	639	491	.79
Wave 2	560	426	.82
Wave 3	406	360	.75
Wave 4	164	141	.68
Wave 5	582	146	.82
Wave 6	528	219	.81
Wave 7	532	242	.73

was used as a measure of mathematics achievement. These mathematics measures were administered in Waves 5 and 6.

The Woodcock-Johnson Word Identification and Passage Comprehension test (Woodcock et al. 2001) were combined into a WJ Reading composite, which was used as a measure for verbal and reading ability. These reading measures were administered in Waves 1, 2, 3, 5, 6, and 7.

Behavioural problems

The presence of social problems, internalizing behaviours, and anxious and depressive symptoms was created from items on the TRF, for a total of 60 items. Waves 1 through 7 were used in the analysis of social problems, internalizing behaviours, and anxious and depressive symptoms with SCT. These measures were administered in Waves 1–7.

Data analysis

The present study examines SCT's longitudinal stability and independent effects on academic and behavioural outcomes. Stability analyses were conducted using bivariate correlations of the log-transformed SCT Composite between Waves 1–7.

Hierarchical regression models were used to analyse the effects of SCT on academic and behavioural outcomes, independent from the effects of ADHD. The Sluggish Cognitive Tempo composite was analysed with the Woodcock-Johnson Mathematics composite, made up of the WJ Calculation, Math Fluency, Applied Problems, and Quantitative Concepts measures, to test for independent effects of SCT on Math achievement. In addition, the SCT composite was analysed with the Woodcock-Johnson Reading composite, made up of the WJ Word Identification and Passage Comprehension, to test for independent effects of SCT on measures of reading achievement. The SCT Composite was also analysed with the social problems, internalizing behaviours, and anxious/depressive symptoms measures from the CBCL.

Results

Stability of SCT over time

The stability of individual differences in SCT was explored across Waves 1 through 7, representing an overall time period of 7 years. Wave 1 ($N = 491$) consists of participants age 4–7, Wave 2 ($N = 425$) aged 5–8, Wave 3 ($N = 361$) aged 6–9, Wave 4 ($N = 141$) aged 7–10, Wave 5 ($N = 146$) aged 8–11, Wave 6 ($N = 219$) aged 9–12, Wave 7 ($N = 242$) aged 10–13.

Bivariate phenotypic correlations were conducted between log-transformed SCT composite scores in Waves 1 through 7 and are presented in Table 3. Correlations reveal a weak relationship between Waves. Modest correlations occur between adjacent Waves (Cohen 1988). A strong correlation exists between Wave 4 and Wave 5, with an r value of .59. In general, Table 3 depicts a simplex pattern with higher correlations resulting between measurement occasions closer together in time. To account for possible measurement error between Waves, a correction for attenuation was applied (Nunnally and Bernstein 1994) and using the alpha reliability values displayed in Table 2. The corrected correlations are presented in Table 4. These corrected correlations are somewhat stronger than their uncorrected counterparts, but in general do not change the interpretation of the data, showing weak relationships between Waves, and modest correlations between adjacent Waves.

It is important to note that Wave 3 and Wave 4 occur within a significantly shorter period of time than other Waves, with a mean difference in age between the two of .14 years (almost 2 months). Because of the relatively small amount of time between the occurrences of testing of Wave 3 and 4, the correlation between Waves 3 and 4 can be considered a measure of test–retest reliability for the SCT and ADHD measures (Tables 3, 4, 5, 6, 7, 8).

Table 3 Bivariate correlations among SCT composite from wave 1 through 7

Subscale	1	2	3	4	5	6	7
Wave 1	–	.46** (369)	.23** (262)	.13 (122)	.34** (81)	.16 (133)	.12 (147)
Wave 2		–	.33** (259)	.14 (109)	.22 (74)	.31** (113)	.11 (140)
Wave 3			–	.49** (88)	.44** (78)	.29** (105)	.18* (130)
Wave 4				–	.59** (25)	.40* (32)	.09 (51)
Wave 5					–	.48** (55)	.16 (61)
Wave 6						–	.20* (105)
Wave 7							–

N of each correlation is displayed in parentheses. Correlations marked with an asterisk (*) were significant at $p < .05$. Correlations marked with two asterisks (**) were significant at $p < .01$

Table 4 Corrected bivariate correlations among SCT composite from wave 1 through 7

Subscale	1	2	3	4	5	6	7
Wave 1	–	.57** (369)	.27** (262)	.18* (122)	.42** (81)	.20* (133)	.16 (147)
Wave 2		–	.42** (259)	.19* (109)	.27* (74)	.38** (113)	.14 (140)
Wave 3			–	.69** (88)	.56** (78)	.37** (105)	.24** (130)
Wave 4				–	.79** (25)	.54** (32)	.13 (51)
Wave 5					–	.59** (55)	.21 (61)
Wave 6						–	.26** (105)
Wave 7							–

N of each correlation is displayed in parentheses. Correlations marked with an asterisk (*) were significant at $p < .05$. Correlations marked with two asterisks (**) were significant at $p < .01$

Table 5 Bivariate correlations among hyperactive/impulsive symptoms from waves 1 through 7

Subscale	1	2	3	4	5	6	7
Wave 1	–	.46** (190)	.38** (136)	.61** (62)	.30 (40)	.37** (55)	.27* (72)
Wave 2		–	.59** (132)	.70** (55)	.41* (37)	.34** (50)	.32** (69)
Wave 3			–	.51** (45)	.53** (42)	.25 (52)	.37** (66)
Wave 4				–	− .37 (12)	.32 (15)	.40* (26)
Wave 5					–	.57** (25)	.27 (26)
Wave 6						–	.44** (53)
Wave 7							–

Correlations marked with an asterisk (*) were significant at $p < .05$. Correlations marked with two asterisks (**) were significant at $p < .01$

Table 6 Corrected bivariate correlations among hyperactive/impulsive symptoms from wave 1 through 7

Subscale	1	2	3	4	5	6	7
Wave 1	–	.60** (190)	.51** (136)	.78** (62)	.38* (40)	.47** (55)	.34** (72)
Wave 2		–	.80** (132)	.90** (55)	.51** (37)	.43** (50)	.41** (69)
Wave 3			–	.68** (45)	.69** (42)	.33* (52)	.49** (66)
Wave 4				–	− .45 (12)	.46 (15)	.50* (26)
Wave 5					–	.70** (25)	.33 (26)
Wave 6						–	.55** (53)
Wave 7							–

Correlations marked with an asterisk (*) were significant at $p < .05$. Correlations marked with two asterisks (**) were significant at $p < .01$

Table 7 Bivariate correlations among inattentive symptoms from waves 1 through 7

Subscale	1	2	3	4	5	6	7
Wave 1	–	.47** (188)	.48** (134)	.41** (61)	.30 (40)	.43** (55)	.14 (74)
Wave 2		–	.39** (129)	.46** (54)	.24 (37)	.25 (50)	.42** (69)
Wave 3			–	.65** (44)	.21 (41)	.68** (53)	.37* (66)
Wave 4				–	.00 (12)	.37 (15)	.26 (26)
Wave 5					–	.79** (26)	.34 (27)
Wave 6						–	.52** (54)
Wave 7							–

N of each correlation is displayed in parentheses. Correlations marked with an asterisk (*) were significant at $p < .05$. Correlations marked with two asterisks (**) were significant at $p < .01$

Table 8 Corrected bivariate correlations among inattentive symptoms from waves 1 through 7

Subscale	1	2	3	4	5	6	7
Wave 1	–	.57** (188)	.58** (134)	.53** (61)	.35* (40)	.52** (55)	.17 (74)
Wave 2		–	.46** (129)	.58** (54)	.27 (37)	.30* (50)	.51** (69)
Wave 3			–	.82** (44)	.24 (41)	.81** (53)	.45** (66)
Wave 4				–	.00 (12)	.47 (15)	.34 (26)
Wave 5					–	.79** (26)	.34 (27)
Wave 6						–	.63** (54)
Wave 7							–

N of each correlation is displayed in parentheses. Correlations marked with an asterisk (*) were significant at $p < .05$. Correlations marked with two asterisks (**) were significant at $p < .01$

Independent effects of sluggish cognitive tempo

The second aim of this study was to explore whether SCT has independent effects on academic and behavioural outcomes, separate from those of Inattentive ADHD. For the hierarchical regression analyses of the independent effects of SCT on reading ability, participants with both completed SCT and inattentive scores were taken from Wave 1 ($N = 489$), Wave 2 ($N = 422$), Wave 3 ($N = 357$), Wave 5 ($N = 146$), Wave 6 ($N = 216$), and Wave 7 ($N = 241$). For analyses of the independent effects of SCT on mathematics ability, participants with both completed SCT and Inattentive scores were taken from Wave 5 ($N = 146$) and Wave 6 ($N = 216$); Waves 1, 2, 3, 4, and 7 were not included in the mathematics analyses because the WJ mathematics measures were not administered in these waves. Wave 4 was not included in either reading or mathematics analyses, as academic measures were not administered in this instance of testing. Both hyperactive/impulsive and inattention symptoms are generally stable over a 7-year period from Wave 1 to Wave 7, as shown in Tables 5 and 7, respectively. As a correction for attenuation was done for the bivariate correlations among SCT symptoms in each Wave, corrected correlations for hyperactive/impulsive and inattention symptoms are also presented in Tables 6 and 8, respectively. The alpha reliabilities used for hyperactive/impulsive and inattention symptoms are presented in Table 9.

Hierarchical regressions did not show significant independent effects of SCT on mathematics or reading outcomes, beyond the effects of inattentive ADHD, in any Waves ($p > .05$). Hierarchical regressions found a significant independent effect of SCT on social problems, internalizing behaviours, and anxious/depressive behaviours, once the effects of Inattentive ADHD were controlled for, in all Waves ($p < .05$) with the exception of social problems in Wave 3 ($p = .43$), Wave 4 ($p = .76$), and Wave 5 ($p = .88$).

Table 9 Alpha reliability of ADHD measures in each wave

Testing year	*N* (total sample)	Hyperactivity/impulsivity alpha	Inattention alpha
Wave 1	639	.77	.82
Wave 2	560	.76	.84
Wave 3	406	.71	.84
Wave 4	164	.79	.74
Wave 5	582	.83	.92
Wave 6	528	.81	.83
Wave 7	532	.80	.81

Discussion

The first aim of the current study was to explore the stability of the SCT construct over time. As shown in Table 3, the highest correlation value for SCT occurs between Wave 4 and Wave 5 with a value of .59, a strong correlation. The same pattern is true when looking at the corrected correlation values for SCT. The highest correlation occurs between Waves 4 and 5 with a value of .79 despite the fact that we would expect the correlation between Waves 3 and 4 to be the highest correlation of all, as the correlation between Waves 3 and 4 SCT should represent the most valid estimate of our measure's overall reliability due to the relatively short time period between the testing of Waves 3 and 4 (almost 2 months).

All other uncorrected correlations between Waves have a value of less than .5, and the correlations between Waves more than 1 year apart are particularly weak. In general, the results suggest that while SCT may be relatively stable across a 1- or 2-year time span, when examined across a greater time span little evidence of stability is found. While the corrected correlations, as would be expected, show stronger stability in SCT across Waves, these correlations still display a pattern consistent with the

uncorrected correlations. The majority of corrected correlations have a value of less than .5 and are particularly weak between Waves more than 1 year apart, indicating a lack of stability over time. Compared to SCT, ADHD symptoms in the present study are more strongly correlated across waves displaying higher stability over time; this is true when comparing both the uncorrected and corrected correlations of SCT and ADHD symptoms across Waves. This finding is supported by previous longitudinal research on ADHD symptoms (Larsson et al. 2004). Both hyperactive/impulsive and inattention symptoms are in general significantly stable, with consistent moderate correlations above .50 (Cohen 1988). However, of note is the low correlations of Waves 1–4 with Wave 5 in both hyperactive/impulsive and inattention symptoms, as shown in Tables 5 and 7. This may be due to the relatively low sample size used for the correlations between Waves 1–4 and Wave 5. However, correlations between hyperactive/impulsive symptoms and inattention symptoms in Waves 5 through 7 are generally significant and strong to moderate (Cohen 1988) and remain much more robust relative to SCT's correlations in these same instances of testing.

With the SCT measure having generally acceptable to good internal consistency (as shown in Table 2), the lack of stability in the SCT measure between years of testing may indicate a lack of developmental continuity; as the participants developed, they experienced relatively short periods of high SCT symptoms which would no longer be present after about a year. There does not appear to be a significant gradual "ramp-up" of SCT symptoms over long periods of time (SCT mean values; Wave 1 = 1.73, Wave 2 = 1.82, Wave 3 = 1.80, Wave 4 = 1.78, Wave 5 = 1.83, Wave 6 = 1.81, Wave 7 = 1.77), at odds with the research findings of Leopold et al. (2016). In addition, these results suggest that the stability of SCT is independent of the stability of ADHD hyperactive/impulsive and inattention symptoms, as measured by the CBCL. SCT is much less stable over time than both inattentive and hyperactive/impulsive symptoms. The current literature on the longitudinal stability of SCT is at odds with these findings, with a recent longitudinal study of SCT finding that SCT has high longitudinal stability (Leopold et al. 2016), a finding which is not replicated in this study. However, SCT's instability in the present study suggests that as a construct, SCT is separate and independent from inattentive presentation ADHD, supporting previous literature on SCT's distinctiveness from other presentations of ADHD (Becker et al. 2016a, b). Much more research needs to be done exploring the apparent developmental discontinuity found in the present study.

The second aim of the present study was to explore whether the SCT composite had significant independent effects on academic achievement and behavioural outcomes, independent of the symptoms of ADHD. Alone, the inattentive measure significantly predicts the WJ Reading Composite and the WJ Mathematics Composite. However, SCT does not account for a significant amount of variance after controlling for the effects of inattentive ADHD. In addition, the effect sizes for each measure of each wave have values below .10, indicating that even where SCT does account for a significant amount of variance, the effect sizes are negligible. These results show that SCT has little to no effect on cognitive and academic outcomes within our sample and that where the Inattentive scale significantly predicts academic outcome measures, SCT adds no significant additional predictive value.

SCT in this sample was significantly related to social problems, internalizing behaviours, and anxious/depressive behaviours, consistent with prior research on SCT. In addition, in all Waves, SCT showed significant independent effects on social problems, internalizing behaviours, and anxious/depressive behaviours once the effects of Inattentive ADHD were controlled for, with the exception of Social Problems in Waves 3, 4, 5, and 6. It must be noted that the internalizing behaviours measure shares 2 items with the SCT Composite (Stares Blankly, Underactive/Slow Moving), so item overlap may be confounding the results on this measure. However, when these two overlapping items were removed from the internalizing behaviours measure and analyses were re-run, this did not change the results: SCT was still significantly related to internalizing behaviours in all Waves ($p < .05$). Though there was no item overlap between the SCT measure and the social problems and anxious/depressive behaviours measure, all three measures were taken from the Teacher Report form Child Behaviour Checklist (Achenbach and Edelbrock 1991).

Overall our results predicting social problems, internalizing behaviours, and anxious/depressive behaviours are consistent with previously reported studies. In contrast, our study finds weaker evidence for longitudinal stability in SCT and relatively weak relationships between SCT and academic outcomes. These findings may be explained in part because our sample was selected to be representative of the general population with relatively few children scoring high on SCT. Many previous studies of SCT selected for the presence of ADHD in their samples.

Prior research on SCT also varies widely in the measurement of SCT. Thirteen SCT items have been supported as the most valid and reliable measures of SCT (Becker et al. 2016a, b), 5 of which were used in the present study. Though previously published studies have used SCT measures of four items or less (del Mar Bernad et al. 2014; Becker et al. 2016a, b), the present study is still limited by the availability of SCT items used to make the SCT composite. Future research using a larger measure of SCT may yield more promising results.

Furthermore, the present study used log-transformed composite sums of the raw SCT scores in each Wave to create a measure of SCT for longitudinal analyses, using alpha reliabilities as a measure of stability. This method of comparison was necessitated by the availability and characteristics of our data and is done on the assumption that at each Wave, each item that makes up the SCT composite loads equally on our common variable of "SCT". However, this assumption may not necessarily be true and leaves open the possibility that across Waves, item loadings for SCT may vary over time, particularly as the participants are in such formative developmental stages. For example, the item of "Apathetic" may be more strongly indicative of SCT in earlier Waves, but may decrease in importance in later Waves as the participants get older. This may mean that SCT's stability over time is over- or under-represented depending on which Waves are being compared. Future studies may benefit from using more statistically powerful approaches such as structural equation modelling (SEM) methods like Latent Growth-Curve Modelling or Latent Change Modelling, to measure the longitudinal stability of SCT.

The present study was also limited by the method of data collection. The Teacher Report Form is filled out by outside observers (teachers) and may not accurately reflect the behaviour of the participants. In addition, there is no data on the same Attention Problems and SCT scale provided for the participants in different non-school settings, so behaviour observed at school may not accurately reflect overall behaviour of the participants. In addition, the TRF may not have been filled out consistently by the same teacher from year to year, adding an element of subjectivity. Future studies using multiple means of reporting may more accurately capture the behaviour of participants.

Despite the limitations of this study, as a twin sample, there is great potential to explore the heritability and environmental factors of SCT within each Wave, and over time. The results of these genetic analyses will be presented in a follow-up study examining the heritability of SCT and its longitudinal stability.

Conclusion

Our findings in this study show that SCT is not a particularly stable construct over a 7-year period. In addition, results show that SCT does not have any unique independent effects from Inattentive ADHD on academic outcomes. However, SCT has a significant independent effect on anxious/depressive symptoms and internalizing behaviours, and to a lesser extent, social problems, above and beyond the effects of inattentive ADHD symptoms. Future SCT research requires the development of a "gold standard" reliable and valid measure for SCT. The results are in agreement with previous literature supporting SCT as a distinct construct from ADHD, as SCT showed a distinct pattern of stability from the hyperactive/impulsive and inattentive ADHD as measured by the CBCL. However, as results from our study suggest, its independent effects from the effects of general inattentive ADHD on academic outcomes have been generally insignificant and inconsistent, suggesting that even though SCT appears to be distinct from both presentations of ADHD and has a strong independent effect on other behavioural outcomes, its effects on academic outcomes may not be meaningful.

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Compliance with ethical standards

Conflict of interest There are no conflicts of interest to report. This article has not been previously published in any form and has not been submitted or is being submitted to any other journal or publisher. This study was fully approved by the Case Western Reserve Institutional Review board and participants in this study gave informed consent, the forms for which are available upon request.

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