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## Prenatal Alcohol Exposure, ADHD, and Sluggish Cognitive Tempo

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### Abstract

**Background**—Children with heavy prenatal alcohol exposure often meet criteria for attention-deficit/hyperactivity disorder (ADHD). ADHD research has examined subtype differences in symptomology, including sluggish cognitive tempo (SCT). This construct is defined by behavioral symptoms including, hypoactivity and daydreaming, and has been linked to increased internalizing behaviors. The current study examined if similar findings are displayed in children with prenatal alcohol exposure.

**Methods**—As part of a multisite study, caregivers of 272 children (8–16y) completed the SCT scale and Child Behavior Checklist (CBCL). Four groups were included: alcohol-exposed children with ADHD (ALC+; n=75), alcohol-exposed children without ADHD (ALC–; n=35), non-exposed children with ADHD (ADHD; n=60), and non-exposed children without ADHD (CON; n=102). SCT and CBCL scores were analyzed using 2 (exposure) × 2 (ADHD) ANOVAs. Pearson

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correlations measured the relations between SCT, CBCL, and FSIQ. Discriminant function analysis (DFA) examined if SCT items could accurately classify groups.

**Results**—Analyses revealed significant main effects of Exposure and ADHD on SCT, internalizing, and externalizing scores, and significant interaction effects on SCT and internalizing scores. SCT significantly correlated with internalizing, externalizing, and attention ratings in all groups and with FSIQ in ALC+. DFA indicated that specific SCT items could distinguish ALC– from CON.

**Conclusions**—Alcohol-exposed children exhibited elevated SCT scores. Elevations were related to increased parent ratings of internalizing and externalizing behaviors and attention. These findings occurred in alcohol-exposed children regardless of ADHD symptoms and specific SCT items proved useful in distinguishing exposed children suggesting clinical utility for this measure in further defining the neurobehavioral profile related to prenatal alcohol exposure.

### Keywords

fetal alcohol spectrum disorder; fetal alcohol syndrome; attention deficit/hyperactivity disorder; sluggish cognitive tempo; neurobehavioral profile

## Introduction

Fetal alcohol spectrum disorders (FASD) include fetal alcohol syndrome (FAS) and other alcohol-related disorders, such as alcohol-related neurodevelopmental disorder (ARND) (Bertrand et al., 2005; Hoyme et al., 2005; Jones and Smith, 1973; Stratton et al., 1996). In the U.S., recent estimates range from 2–7 cases of FAS per 1000 births (May and Gossage, 2001a, 2001b; May et al., 2009). Estimates of FASD prevalence are more difficult to ascertain, however current estimates suggest rates in the U.S. of 10–50 per 1,000 (May et al., 2009; Sampson et al., 1997) and prevalence in isolated Aboriginal communities at 25–190 per 1,000 (Carr et al., 2010; Chudley et al., 2005).

Children with FASD exhibit a large range of neurobehavioral deficits (for review, see Mattson et al., 2011) and often meet diagnostic criteria for psychiatric conditions, particularly attention-deficit/hyperactivity disorder (ADHD). The presence of ADHD in alcohol-exposed children has been reported in over 70% of subjects with FAS or FASD (Burd et al., 2003; Fryer et al., 2007), although the rate is likely lower in prospective, longitudinal studies. In 2006, Nash and colleagues (Nash et al., 2006) used 12 items from the Child Behavior Checklist (CBCL) (Achenbach, 1991) to determine whether distinct symptoms of FASD and ADHD could discriminate the clinical groups. However, only a small number of items were found to distinguish the two, supporting substantial commonalities in their behavioral phenotype. In part due to the overlapping symptoms between FASD and ADHD, there has been an increase in the number of studies comparing these two clinical groups on multiple behavioral factors, including memory, attention, executive functioning, and adaptive functioning (e.g., Coles et al., 1997; Crocker et al., 2009; Greenbaum et al., 2009; Vaurio et al., 2008).

Current diagnostic guidelines (American Psychiatric Association, 2000) provide criteria for three subtypes of ADHD: predominantly inattentive type (ADHD-PI), predominantly hyperactive-impulsive type (ADHD-HI), and combined type (ADHD-C). Studies comparing ADHD-PI and ADHD-C types show that these groups can be distinguished using continuous performance tasks (CPT) with delayed reactions and omission errors displayed in ADHD-PI and higher rates of inhibition and commission errors displayed in ADHD-C (Collings, 2003). A novel construct known as sluggish cognitive tempo (SCT) has successfully discriminated ADHD-PI from ADHD-C and ADHD-HI (McBurnett et al., 2001) and is

correlated with sustained attention, reflected by omission errors (Wåhlstedt and Bohlin, 2010). Individuals with SCT have been characterized as having varying alertness and orientation, sluggishness, hypoactivity, and apparent daydreaming (McBurnett et al., 2001). ADHD subjects with high SCT scores have higher rates of internalizing behaviors such as depression, generalized anxiety, social phobia, and obsessions, compared to those with low SCT scores (Harrington and Waldman, 2010).

While SCT emerged from the ADHD literature, recent research suggests that SCT represents a construct independent of ADHD (Barkley, 2011). For example, in a recent study examining a clinical group of subjects with learning disorders (without ADHD), it was found that high SCT scores were positively associated with both internalizing behaviors and externalizing behaviors. Additionally, factor analysis supported a three-factor model in which SCT symptoms formed an independent factor that simply shared a high amount of variance with inattention, overlapping with that of ADHD (Garner et al., 2010). Other studies indicate that SCT relates to neuropsychological factors other than inattention, including academic achievement and impaired intellectual functioning (Reeves et al., 2007). These findings suggest that SCT is separate from ADHD and more related to generalized behavior problems and cognitive impairment.

The current study examined whether children with heavy prenatal alcohol exposure exhibited elevated SCT symptoms, similar to ADHD-PI, and to further determine if SCT was associated with internalizing and/or externalizing behaviors, both of which are elevated in children with prenatal alcohol exposure (Fryer et al., 2007; O'Connor and Kasari, 2000; O'Connor and Paley, 2006, 2009). In two recent studies, children with prenatal alcohol exposure demonstrated slowed reaction times that were similar to those in children with ADHD-PI (Kooistra et al., 2011; Kooistra et al., 2010). As mentioned, SCT relates to sustained attention (Wåhlstedt and Bohlin, 2010) and the presence of such deficits suggest that this population may also display elevations in SCT symptoms including apathy, lack of persistence, and daydreaming (Bauermeister et al., 2005). Based on previous studies, we hypothesized that SCT would correlate with both internalizing and externalizing behaviors in the alcohol-exposed groups. In addition to the studies described above demonstrating similar relations in other developmental populations, indirect support for the relation between SCT and externalizing behaviors exists. For example, externalizing behaviors are strongly influenced by the presence of inattention and academic underachievement (Kim and Deater-Deckard, 2011), which both relate to SCT (Reeves et al., 2007; Wåhlstedt and Bohlin, 2010) and occur in children with FASD (Mattson et al., 2011).

The present study included two alcohol-exposed groups, with and without diagnoses of ADHD. This study design allowed independent examination of the effects of prenatal alcohol exposure and ADHD symptomology on SCT symptoms. By including an alcohol-exposed group without ADHD, we tested whether SCT is elevated in the absence of ADHD, supporting previous studies suggesting the separability of these constructs. Given previous studies of sustained attention deficits and behavior disorders (Bauermeister et al., 2005; Fryer et al., 2007; Garner et al., 2010; Kooistra et al., 2010, 2011; O'Connor and Kasari, 2000), we hypothesized that SCT would be elevated in the alcohol-exposed groups and that SCT would be related to both internalizing and externalizing behaviors.

## Materials and Methods

### General Methods

The data used in this study were collected as part of the Collaborative Initiative on Fetal Alcohol Spectrum Disorders (CIFASD), a multi-site project with a goal of specifying neurobehavioral diagnostic criteria for FASD (for details about the methodology of the

CIFASD clinical projects, see Mattson et al., 2010). The CIFASD involves standardized neuropsychological and behavioral testing of children with FASD and comparison groups across multiple sites.

## Subjects

The current study consisted of 272 children (162 male and 110 female) between the ages of 8–16 years old ( $M=12.18$ ,  $SD=2.546$ ) with ( $n=110$ ) or without ( $n=162$ ) histories of heavy prenatal alcohol exposure. In addition, both groups included children with ( $n=135$ ) and without ( $n=137$ ) diagnoses of ADHD. Thus, four subject groups were used for analysis: (1) alcohol-exposed children with ADHD (ALC+,  $n=75$ ), (2) alcohol-exposed children without ADHD (ALC-,  $n=35$ ), (3) children without prenatal alcohol exposure, but with ADHD (ADHD,  $n=60$ ), and (4) typically developing children without either prenatal alcohol exposure or ADHD (CON,  $n=102$ ).

Subjects were recruited from five different sites: (1) Center for Behavioral Teratology, San Diego State University, San Diego, CA, (2) Emory University, Atlanta, GA, (3) Seven Northern Plains communities, including six Indian reservations, (4) University of New Mexico Center on Alcoholism, Substance Abuse and Addictions, and (5) University of California, Los Angeles Fetal Alcohol and Related Disorders Clinic. Subjects were recruited through distribution of flyers, word of mouth, clinical recommendation, and in-school studies. Details about each site including specific recruitment methods have been described previously (Mattson et al., 2010). Subjects were excluded if they had previously suffered a significant head injury that involved loss of consciousness, were not primary English speakers, were adopted from abroad after the age of 5 years (or less than 2 years before assessment), had other known causes of mental deficiency, or any other significant physical or psychiatric disabilities that precluded involvement in the study. Subjects were excluded from the comparison groups if greater than minimal alcohol exposure was documented on screening questionnaires or if exposure was unknown. Minimal alcohol exposure was defined as an average of no more than one drink per week and never more than two drinks per occasion during pregnancy. Children in the alcohol-exposed group were considered heavily exposed if mothers consumed  $> 4$  drinks per occasion at least once/week or  $> 13$  drinks/week during pregnancy. Unknown exposure was acceptable in the alcohol-exposed groups if FAS criteria were met, as defined below. Comparison groups were matched, according to site, to alcohol-exposed subjects based on age, race, ethnicity, and sex. Full Scale IQ (FSIQ) was measured using the Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV) (Wechsler, 2004).

All children were evaluated using a standardized dysmorphology examination conducted by a member of the CIFASD Dysmorphology Core (for details, see Jones et al., 2006; Mattson et al., 2010). Diagnosis of FAS was based on the presence of two or more key facial features (short palpebral fissures, smooth philtrum, thin vermilion), and either microcephaly (head circumference  $< 10^{\text{th}}$  percentile), or growth deficiency ( $< 10^{\text{th}}$  percentile for height or weight).

ADHD diagnoses were determined using the Computerized Diagnostic Interview Schedule for Children-Fourth Edition (C-DISC-4.0) (Shaffer et al., 2000). The C-DISC-4.0 is a structured, clinical interview completed by caregivers. It is based on current Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) (American Psychiatric Association, 2000) criteria for ADHD. The parent interview of the C-DISC-4.0 has demonstrated high reliability ( $\kappa = .79$ ) for sensitivity of detecting the presence of ADHD symptoms (Shaffer et al., 2000).

## Measures

**Sluggish Cognitive Tempo Scale (SCT-S)**—The SCT-S (McBurnett and Pfiffner, 2005; Pfiffner et al., 2007) is a parent-reported questionnaire measuring the occurrence of SCT symptoms. The SCT-S has demonstrated excellent internal consistency ( $\alpha = .90$ ), proving high reliability amongst items (Pfiffner et al., 2007). Each caregiver completed a questionnaire for his or her child. The questionnaire includes 15 items on which the caregiver is able to mark, (0) “never” (1), “sometimes,” (2), “often,” (3), or “very often.” Data from the SCT-S was combined to generate an average SCT score for each child, ranging from 0 (lowest) – 3 (highest).

**Child Behavior Checklist (CBCL)**—The CBCL (Achenbach, 1991) is a parent-reported questionnaire that evaluates emotional and behavioral problems. Ratings on 113 items result in eight syndrome scales, including the Attention Problems scale and three summary scales (Internalizing, Externalizing, and Total). Reliability was high ( $\alpha = .87$ ) among CBCL items based on data in the current study. Variables used for this study were the internalizing and externalizing summary T-scores and the attention problems T-score.

## Statistical Analyses

Statistical analyses were conducted using the SPSS statistical package version 19.0 (SPSS, 2010). An alpha level of  $p < .05$  was used to determine statistical significance. Alpha levels of  $p = .05$ – $.08$  were considered to be marginally significant and those greater than  $.08$  were considered to be not statistically significant. Demographic variables were analyzed using Chi-square (ethnicity, race, sex, and handedness) and one-way analysis of variance (ANOVA) (age and FSIQ) techniques. With the exception of FSIQ, demographic variables were tested as covariates. FSIQ was not included as a covariate as low IQ is a hallmark deficit of children with prenatal alcohol exposure and cogent arguments against covarying IQ in neurodevelopmental populations exist (Dennis et al., 2009).

Data from the SCT and CBCL were analyzed using three (SCT, internalizing, and externalizing) separate  $2 \times 2$  factorial ANOVAs with alcohol exposure (exposed vs. non-exposed) and ADHD (ADHD vs. non-ADHD) serving as the between subjects factors. Significant interactions were followed up using pair-wise comparisons. The relationships between SCT scores and all other measures (internalizing, externalizing, attention problems, and FSIQ scores) were analyzed using within-group Pearson correlations. Finally, discriminant function analyses examined whether individual SCT item scores could be used to accurately predict group membership.

To verify that there were no significant differences on any of the measures due to site, individual one-way ANOVAs were conducted. There were no significant effects of site on SCT, internalizing behavior, or externalizing behavior scores ( $p > .10$ ).

## Results

### Demographic Data

Groups did not show statistically significant differences on handedness [ $\chi^2$  (df = 6) = 10.88,  $p = .092$ ], or ethnicity [ $\chi^2$  (df = 6) = 10.62,  $p = .101$ ]. However, significant group differences were found on sex [ $\chi^2$  (df = 3) = 8.58,  $p = .035$ ], race [ $\chi^2$  (df = 18) = 33.91,  $p = .013$ ], age [ $F(3, 268) = 4.74$ ,  $p = .003$ ], and FSIQ [ $F(3, 268) = 49.42$ ,  $p < .001$ ]. Pairwise comparisons showed that the CON group had a significantly higher FSIQ score than all other groups ( $p < .001$ ), while ALC+ had a significantly lower FSIQ than the ADHD group ( $p < .001$ ). The ALC groups were not significantly different on FSIQ ( $p = .213$ ). The ADHD group was significantly younger compared to ALC+ ( $p = .011$ ), ALC- ( $p = .026$ ) and CON



( $p = .005$ ) groups, which did not differ significantly from each other ( $p > .10$ ). Demographic data are presented in Table 1.

### Between-Subjects SCT Analysis

The mean total SCT scores and mean item SCT scores are presented in Table 2. No demographic variables were significantly related to SCT scores ( $p > .20$ ); therefore, SCT analyses were continued without covariates. There was a significant main effect of Exposure [ $F(1, 268) = 13.82, p < .001$ ] (exposed > non-exposed) and ADHD [ $F(1, 268) = 177.17, p < .001$ ] (ADHD > non-ADHD). There was also a significant Exposure  $\times$  ADHD interaction [ $F(1, 258) = 9.04, p = .003$ ] (see Figure 1). Pairwise comparisons revealed that ALC+ had significantly higher SCT scores than ALC- ( $p < .001$ ), and both ALC- and ADHD had significantly higher SCT scores than CON ( $p < .001$ ). The ALC+ and ADHD groups had similar SCT scores ( $p = .422$ ). These results indicate that while ADHD showed a strong influence on SCT score, alcohol exposure alone (without ADHD) also resulted in a significant elevation of SCT symptoms. In contrast, in the presence of ADHD, alcohol exposure did not further elevate SCT scores at a significant level.

### Between-Subjects CBCL Analyses

For CBCL problem scales, handedness was a significant covariate for internalizing behaviors [ $F(1, 163) = 6.39, p = .012$ ] only and was included in the model for internalizing score analyses. Age was included as a covariate for both CBCL behavior measures since past studies have shown changes in internalizing and externalizing behaviors throughout development (Gilliom and Shaw, 2004). With covariates, there was a significant main effect of Exposure on internalizing [ $F(1, 266) = 17.83, p < .001$ ] and externalizing [ $F(1, 267) = 55.52, p < .001$ ] scores (exposed > non-exposed). There was also a significant main effect of ADHD on internalizing [ $F(1, 266) = 38.52, p < .001$ ], and externalizing [ $F(1, 267) = 100.27, p < .001$ ] scores (ADHD > non-ADHD). See Figures 2 and 3. In addition, there was a significant Exposure  $\times$  ADHD interaction for internalizing [ $F(1, 266) = 10.68, p = .001$ ], but not for externalizing [ $F(1, 267) = .298, p = .086$ ] behavior scores. Pairwise comparisons revealed that for internalizing behaviors scores: ADHD and ALC- had significantly higher scores than CON ( $p < .001$ ). The ALC+ and ADHD groups did not significantly differ ( $p = .469$ ) while ALC+ and ALC- groups showed marginally significant differences ( $p = .058$ ). Similar to SCT, these results indicate that both ADHD and alcohol exposure significantly increased the presence of internalizing and externalizing behaviors.

### Relation of SCT to CBCL Behavior Scores, Attention, and IQ

To examine the relation between SCT and internalizing and externalizing behaviors, Pearson correlations were conducted within each group. Results revealed that all groups had significant, positive correlations between SCT and internalizing behaviors, and between SCT and externalizing behaviors (Table 3).

To help determine the role of SCT as an independent factor, Pearson correlations were also used to examine the relations between SCT with measures inattention and cognitive ability (Reeves et al., 2007; Wählstedt and Bohlin, 2010). Correlations between SCT and CBCL Attention Problems and FSIQ revealed positive correlations between SCT and inattention in all groups and between SCT and FSIQ in the ALC+ group (Table 4).

### Discriminant Function Analyses of SCT Items

Discriminant function analyses were conducted to determine if SCT items could be used to distinguish groups. Three analyses were conducted: (1) ALC- vs. CON, (2) ALC- vs. all ADHD, and (3) ADHD (without prenatal alcohol exposure) vs. CON. For the second

analysis, the ADHD groups (exposed and non-exposed) were combined because they demonstrated very similar responses on the SCT items. These analyses test whether SCT items can distinguish alcohol-exposed subjects *without* ADHD from typically developing children and from children with ADHD, respectively. The third analysis was included in order to determine the specificity of the discriminating items in the first analysis. For these analyses, the 15 SCT items were entered as the predictor variables. Using an alpha level of .001 to evaluate homogeneity of covariance matrices assumption, Box's M test was significant for all analyses. For all analyses, one function was tested at an alpha level of .05 and each proved to be statistically significant: (1)  $\chi^2(15) = 46.70, p < .001, \eta^2 = .305$ ; (2)  $\chi^2(15) = 46.76, p < .001, \eta^2 = .264$ ; (3)  $\chi^2(15) = 172.51, p < .001, \eta^2 = .689$ .

For the first analysis, items significantly distinguished the ALC- group ( $M = 1.134$ ) from the CON group ( $M = -.382$ ). The standardized discriminant function coefficients (Table 5) suggested that there were four SCT items that best distinguished the alcohol-exposed children without ADHD from typically developing children: (1) forgets details (.437), (2) confused (.322), (3) forgetful (.666), and (4) drowsy (.558). These items had standardized discriminant function coefficients  $> .30$  and the ALC- group had significantly ( $p < .05$ ) higher mean scores on these items than the CON group, as indicated by the positive values of these items' coefficients and the positive group centroid for the ALC- group. Classification accuracy was 77.8% overall with 61.8% of subjects from the ALC- and 83.2% of subjects from the CON group classified correctly.

In the second analysis, items significantly distinguished the ALC- group ( $M = -1.155$ ) from the combined ADHD group (ALC+ plus ADHD groups) ( $M = .307$ ). The standardized discriminant function coefficients (Table 5) suggested that there were three SCT items that best distinguished the two groups: (1) lack of persistence (.494), (2) leaves things behind (.343), and (3) forgets instructions (.355). These items had standardized discriminant function coefficients  $> .30$  with the combined ADHD group demonstrating higher mean scores on all items than the ALC- group, as indicated by the positive values of these items' coefficients and the positive group centroid for the ADHD group. Classification accuracy was 76.5% overall with 79.4% of subjects from the ALC- and 75.8% of subjects from the ADHD group classified correctly.

In the third analysis, items significantly distinguished the ADHD only group ( $M = 1.988$ ) from the CON group ( $M = -1.103$ ). The standardized discriminant function coefficients (Table 5) suggested that there were two SCT items that successfully distinguished the two groups: (1) lack of persistence (.380) and (2) forgets details (.521). These items had standardized discriminant function coefficients  $> .30$  with the ADHD group demonstrating higher mean scores on all items than the CON group, as indicated by the positive values of these items' coefficients and the positive group centroid for the ADHD group. Classification accuracy was 91.7% overall with 91.1% of subjects from the ADHD group and 92.1% of subjects from the CON group classified correctly.

## Discussion

This is the first study to evaluate elevations of SCT in children with FASD. Alcohol-exposed children with and without ADHD were compared to non-exposed children with ADHD and typically developing children on measures of SCT, internalizing behaviors, and externalizing behaviors. As predicted, all three clinical groups (alcohol-exposed with and without ADHD and non-exposed with ADHD) showed elevated scores on measures of SCT, internalizing behaviors, and externalizing behaviors compared to typically developing children. Furthermore, the two alcohol-exposed groups, with and without ADHD, were found to have significantly higher mean SCT scores compared to non-exposed children

without ADHD. The alcohol-exposed group with ADHD did not significantly differ from the ADHD group, both showing significantly higher scores than the alcohol-exposed group without ADHD.

The current study supported the hypothesis that prenatal alcohol exposure is related to elevations of SCT. Both alcohol-exposed groups demonstrated elevations in SCT relative to non-exposed controls. However, contrary to expectations, the alcohol-exposed group without ADHD had significantly lower SCT scores than the alcohol-exposed group with ADHD. Retrospectively, these results make sense given the relationship shown between SCT and ADHD in previous research. Results support the similar behavioral phenotypes caused by ADHD and heavy prenatal alcohol exposure, creating difficulties in accurate identification of alcohol-exposed children, in the presence of ADHD.

Despite the fact that ADHD children with and without exposure demonstrated higher SCT elevations, empirical evidence still suggests that SCT symptoms may be distinct from ADHD. The main effect of ADHD confirmed the prominent influence such symptoms have on SCT. However, the Exposure  $\times$  ADHD interaction also demonstrated ADHD was not necessary for elevations in SCT symptoms as evidenced by the SCT increases in alcohol-exposed children without ADHD. Consistent with our findings, clinical populations without ADHD have consistently demonstrated SCT elevations (Barkley, 2011; Garner et al., 2010; Reeves et al., 2007). Furthermore, SCT displayed different associations among IQ depending on group, with significant correlations between SCT and IQ only in the ALC+ group. The lack of correlation in the other groups was not related to restriction of range, given similar variability of FSIQ across groups, particularly in the ADHD and ALC+ groups. However, average FSIQ scores were lower in the ALC+ group than in the ADHD group suggesting that lower cognitive function may be an additional risk factor for SCT in the sense that the lower IQ is, the more intense SCT symptoms may become. Moreover, it was previously stated that SCT appears to be an independent set of symptoms, unrelated to ADHD, that are more strongly related to attention deficits. The relation between SCT and IQ in the current study extends previous findings suggesting that SCT may not simply underlie ADHD, but independently relate to specific neuropsychological deficits such as inattention and IQ.”

Both internalizing and externalizing behavior scores were elevated and related to SCT in both alcohol-exposed groups, which supported the previous study by Garner and colleagues (Garner et al., 2010). These findings are expected given that clinical populations generally display a strong relationship between measures of internalizing and externalizing behaviors (Gould et al., 1993). Additionally, internalizing and externalizing behaviors have shown patterns of codevelopment, with the existence of one increasing chances for the existence of the other (Gilliom and Shaw, 2004). The current findings for children with prenatal alcohol exposure suggest that the implications of SCT are more far reaching than previously reported.

Due to the significant findings between groups on SCT scores, we examined whether SCT items could successfully differentiate the ALC- group from the CON and combined ADHD groups using discriminant function analysis. Three of the 15 SCT items were found to significantly distinguish the ALC- from the combined ADHD groups. These items were not clinically meaningful because the ADHD subjects (regardless of alcohol exposure) already showed significantly higher scores on these items, only serving to emphasize what was demonstrated by the initial analyses. Four of the 15 SCT items (forgets details, confused, forgetful, drowsy) successfully discriminated ALC- from CON, while only two (forgets details and lack of persistence) were found to discriminate non-exposed ADHD from CON subjects. Of clinical importance is the fact that three of four SCT items that could



significantly discriminate between ALC- and CON did not overlap with those that discriminated ADHD from CON, suggesting that these items may be able to provide information important for differential diagnosis between alcohol-exposed and ADHD children. This finding can aid in the identification of children with prenatal alcohol exposure that do not meet diagnostic criteria for ADHD. Findings suggest that the SCT scale can be utilized by clinicians to distinguish between alcohol-exposed children without ADHD and typically developing children, and may help in the development of future intervention services.

Children with prenatal alcohol exposure can display elevations in SCT symptoms, even in the absence of ADHD. Based on the relationship between inattention and SCT, it is possible that alcohol-exposed children have attention deficits that should be addressed even when ADHD-related symptoms are not clinically elevated. Early intervention on attention deficits (particularly inattention) may be beneficial for children with FASD that have elevated SCT symptoms and alleviate behavioral impairments in this population. A related intervention has been demonstrated in which subjects in an attention process training group that focused specifically on sustained attention showed an increase in the number of correct responses, decreased omission and commission errors, and improved reaction on attention tasks times in children with FASD compared to children without a structured intervention program (Vernescu, 2010). Attention deficits overall can lead to poor functioning within school and work environments throughout life (Connor and Streissguth, 1996). Since inattention is only one of the neuropsychological shortfalls shown in FASD (Mattson et al., 2011), this population will have multiple factors interfering with their ability to adjust to daily challenges. Early intervention can therefore provide the opportunity for improved productivity in everyday environments. The findings from the present study provide further knowledge regarding a neurobehavioral profile of children prenatally exposed to alcohol and support the need for these interventions, aiding in the establishment of more distinct diagnostic criteria for FASD.

### Limitations

While the overall sample size was large, group sizes were unequal, which may have affected the outcome of our discriminant function analyses. A matched-IQ group was also not included nor was IQ included as a covariate. As mentioned earlier, IQ is not a proper covariate for neurodevelopmental populations. Controlling for IQ can result in unrepresentative samples and are not an accurate assessment of the role of IQ in the target behavior (Dennis et al., 2009). Regardless, the difference in IQ between control subjects and clinical groups may have influenced the discriminant function analyses. With the risk of dramatically decreasing the sample size in the current study, the subjects with ADHD were not dichotomized into ADHD-PI and ADHD-C subtypes as in past SCT studies, which may have affected the resulting SCT scores as ADHD-PI subjects alone may exhibit the highest rates of SCT symptoms. Thus inclusion of all ADHD subjects combined could have reduced overall mean scores. The results also relied on parent reports of behavior. This subjective reporting of data could have been influenced by the parents' knowledge of their child's exposure or diagnosis status and could have influenced our results. To address this, we compared parent reports of SCT with a limited number of teacher reports ( $n=122$ ) and average scores were significantly correlated ( $p < .001$ ). Also of note is that the rates of FAS in the two exposed groups were very similar (39.2% vs. 40.0%), reducing the risk that the presence or knowledge of FAS diagnosis did not influence parent ratings of ADHD.

### Future Directions

As additional risk factors for SCT are identified, a more specific examination of the relation between prenatal alcohol exposure and SCT will be possible. Similarly, larger sample sizes

that allow for the separation of alcohol-exposed groups into ADHD subtypes would also result in more detailed examination of SCT in alcohol-exposed children. Thus, determining if ADHD subtype is an important factor for understanding the relationship between alcohol exposure and SCT. The current study employed a parent measure of attention problems; future research should utilize a more objective measure of attention to evaluate if SCT symptoms are associated with attention deficits. Fundamentally, understanding to what degree SCT affects children with prenatal alcohol exposure and the long-term consequences of these symptoms would be beneficial for the development of a neurobehavioral profile. Likewise, it could result in advantageous treatments that may thwart the development of increased problem behaviors. Overall, the similarities between the two ADHD groups highlights the importance of measures that distinguish between prenatally exposed children and other clinical populations, like ADHD, to help prevent misdiagnosis. Studies, such as the current one, can have important implications on improved neuropsychological assessments and treatments as they add to the understanding of deficits in FASD.

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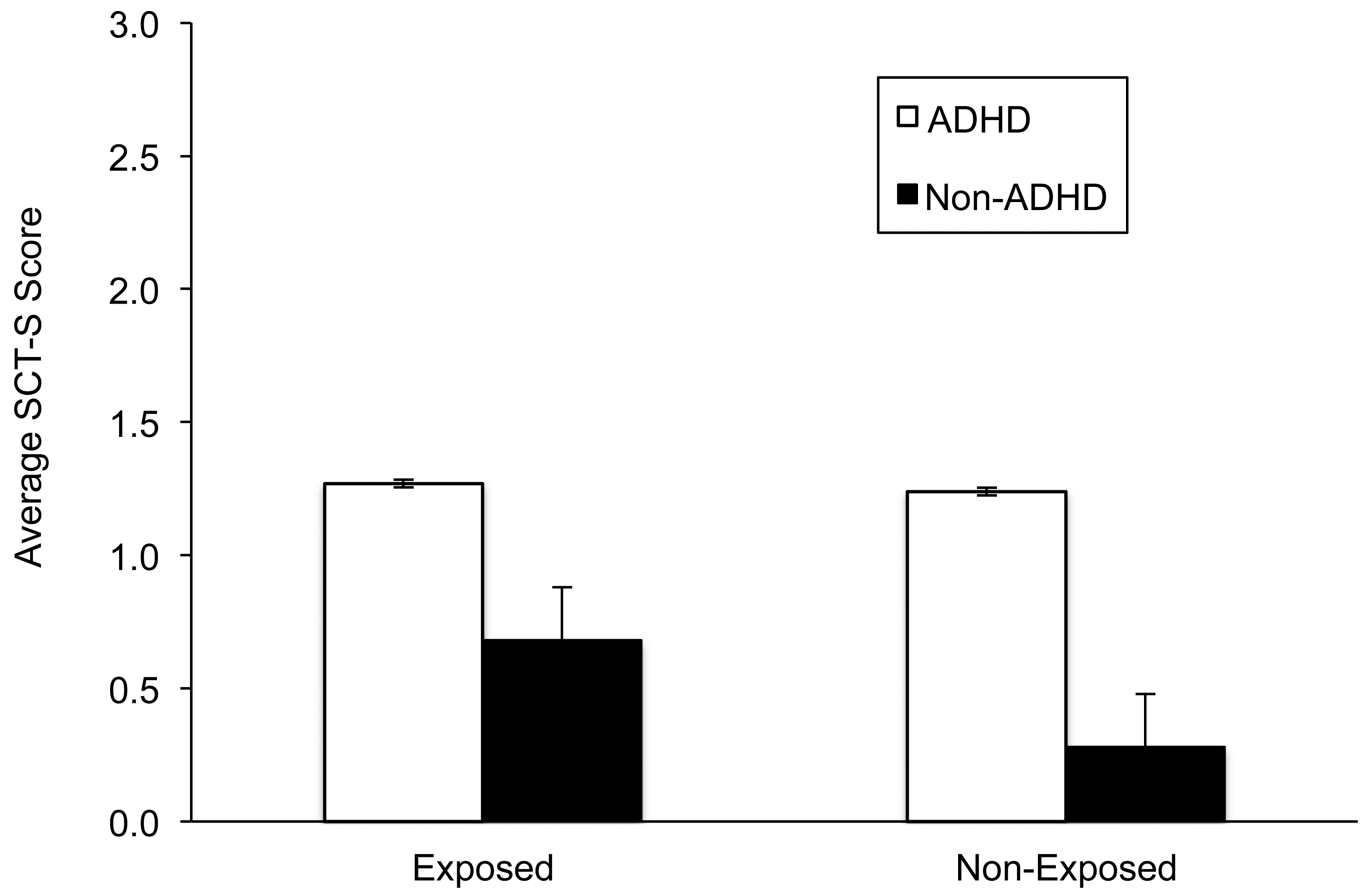
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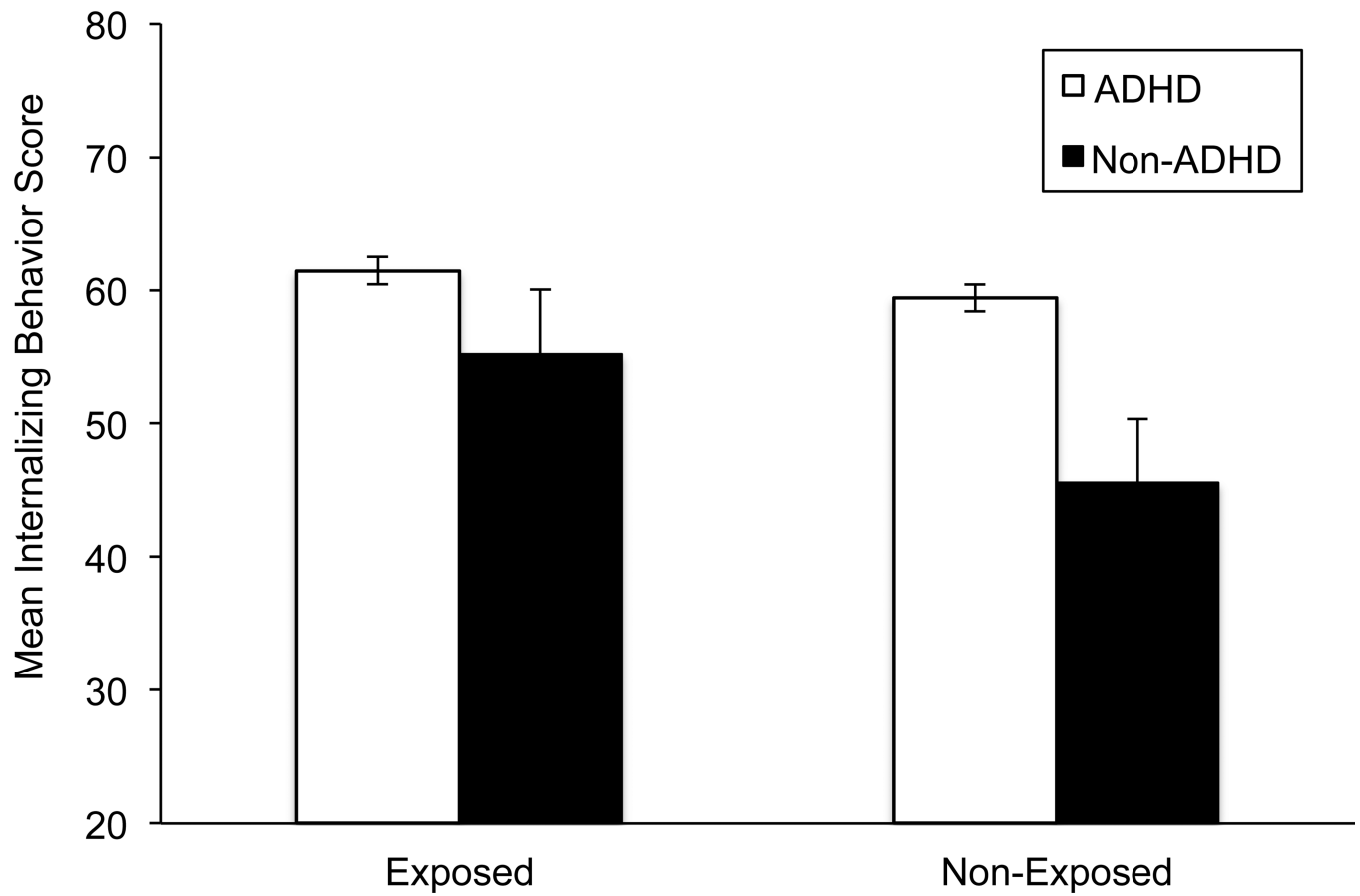
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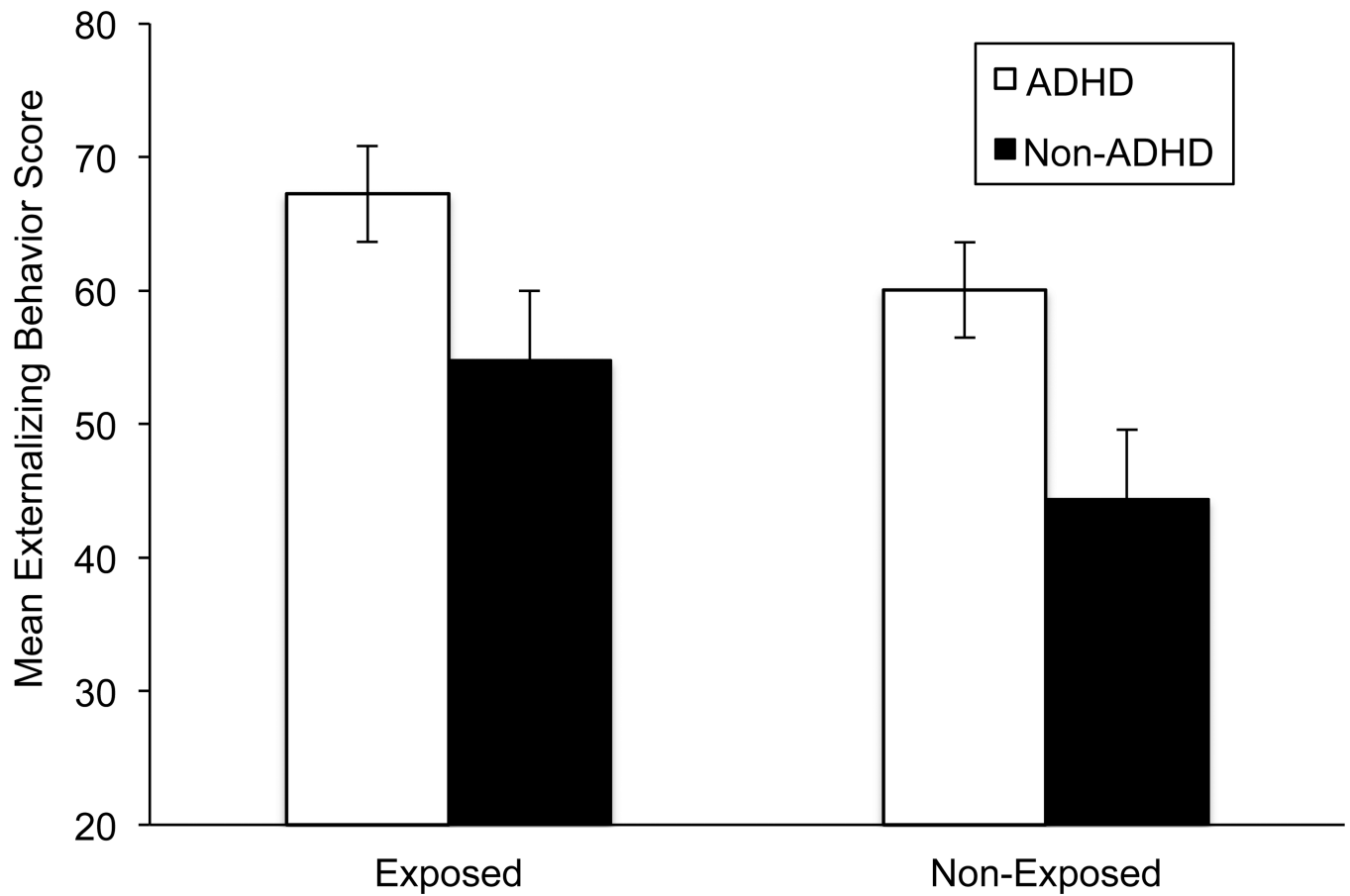


**Figure 1.** Average SCT-S scores for children with and without prenatal alcohol exposure and ADHD. Data are presented as mean (+/- standard error) SCT-S scores.





**Figure 2.** Average CBCL internalizing behavior scores for children with and without prenatal alcohol exposure and ADHD. Data are presented as mean (+/- standard error) internalizing scores.



**Figure 3.** Average CBCL externalizing behavior scores for children with and without prenatal alcohol exposure and ADHD. Data are presented as mean (+/- standard error) externalizing scores.

**Table 1**

Demographic data for children with heavy prenatal alcohol exposure, with (ALC+) and without (ALC-) ADHD, non-exposed children with ADHD (ADHD), and typically developing controls (CON).

Demographic Variable	ALC+ N = 75	ALC- N = 35	ADHD N = 60	CON N = 102
Site [N (%)]	32 (42.7)	8 (22.9)	31 (51.7)	42 (41.2)
San Diego	11 (14.7)	5 (14.3)	9 (15.0)	16 (15.7)
Plains States	15 (20.0)	12 (42.9)	15 (25.0)	18 (17.6)
Atlanta	14 (18.7)	8 (22.9)	1 (1.7)	11 (10.8)
Los Angeles	3 (4.0)	2 (5.7)	4 (6.7)	15 (14.7)
Albuquerque				
FAS [N (%)]	21 (28.0)	11 (31.4)	0 (0)	0 (0)
ADHD [N (%)]	75 (100.0)	0 (0)	60 (100.0)	0 (0)
Sex [N (%) Females] *	28 (37.3)	20 (57.1)	17 (28.3)	45 (44.1)
Race [N (%) White] *	51 (68.0)	13 (37.1)	36 (60.0)	73 (71.6)
Ethnicity [N (%) Hispanic]	6 (8.0)	4 (11.4)	13 (21.7)	19 (18.6)
Handedness [N (%) Right]	63 (84.0)	32 (91.4)	56 (93.3)	96 (94.1)
Age [M (SD)] *	12.42 (2.322)	12.58 (2.593)	11.11 (2.493)	12.49 (2.583)
FSIQ [M (SD)] *	82.55 (16.914)	88.77 (13.950)	93.98 (18.599)	110.04 (12.747)
Growth deficiency [N (%)]	25 (33.3)	12 (34.3)	10 (16.7)	12 (11.8)
Height 10%	21 (28.0)	9 (25.7)	7 (11.7)	8 (7.8)
Weight 10%	19 (25.3)	8 (22.9)	8 (13.3)	6 (5.9)
Microcephaly [N (%)] (OFC 10%)	25 (33.3)	10 (28.6)	6 (10.0)	2 (2.0)
Structural abnormality [N (%)]	31 (41.3)	15 (42.9)	8 (13.3)	6 (5.9)
PFL 10%	23 (30.7)	9 (25.7)	3 (5.0)	4 (3.9)
Smooth philtrum	32 (42.7)	18 (51.4)	12 (20.0)	11 (10.8)
Thin vermilion border	32 (42.7)	16 (45.7)	10 (16.7)	14 (13.7)

\* Significant group differences were noted

**Table 2**

Average scores by group for sluggish cognitive tempo (SCT) items, internalizing behaviors, and externalizing behavior CBCL Scores. Data are presented as Mean (Standard Deviation).

Variable	ALC+	ALC-	ADHD	CON
<b>SCT Item</b>				
1. Absent minded	1.73 (0.983)	0.89 (0.718)	1.57 (0.831)	0.48 (0.540)
2. Vague or preoccupied	1.30 (0.840)	0.80 (0.719)	1.38 (0.846)	0.37 (0.543)
3. Lack of persistence	1.60 (0.854)	0.80 (0.719)	1.63 (0.823)	0.32 (0.530)
4. Forgets details of daily routine	1.71 (1.075)	0.94 (1.056)	1.77 (0.831)	0.19 (0.416)
5. Forgets where things are normally kept	1.55 (1.044)	0.77 (0.808)	1.52 (0.965)	0.20 (0.446)
6. Leaves things behind	1.92 (0.912)	1.09 (0.612)	1.68 (0.748)	0.59 (0.603)
7. Confused or seems to be in a fog	1.05 (0.842)	0.26 (0.505)	0.78 (0.922)	0.05 (0.217)
8. Daydreams	1.17 (0.828)	0.57 (0.655)	1.24 (0.844)	0.29 (0.479)
9. Overtired	0.87 (0.890)	0.57 (0.608)	0.78 (0.846)	0.29 (0.519)
10. Apathetic	1.08 (0.955)	0.54 (0.611)	0.95 (1.061)	0.25 (0.539)
11. Stares Blankly	0.66 (0.668)	0.26 (0.443)	0.63 (0.863)	0.11 (0.312)
12. Lacks Energy	0.49 (0.707)	0.26 (0.448)	0.58 (0.894)	0.16 (0.416)
13. Forgetful	1.84 (0.916)	1.11 (0.900)	1.68 (0.899)	0.36 (0.523)
14. Sluggish/Drowsy	0.56 (0.702)	0.31 (0.471)	0.55 (0.872)	0.13 (0.335)
15. Forgets Instructions	1.89 (0.879)	1.06 (0.873)	1.78 (0.721)	0.46 (0.608)
<b>SCT Average Score *</b>	1.28 (0.550)	0.68 (0.453)	1.24 (0.516)	0.28 (0.288)
<b>Internalizing CBCL Score *</b>	60.48 (10.193)	55.91 (10.170)	58.98 (11.810)	45.76 (9.307)
<b>Externalizing CBCL Score *</b>	66.71 (9.115)	55.86 (10.353)	59.82 (11.253)	43.99 (9.391)

\* Significant main effects were noted (exposed>non-exposed and ADHD>non-ADHD)

**Table 3**

Within-group correlations (two-tailed) between SCT-S score and CBCL problem behaviors scores.

Group	CBCL Item			
	Internalizing Behaviors		Externalizing Behaviors	
	<i>r</i>	<i>p</i> -value	<i>r</i>	<i>p</i> -value
ALC+	.347	.002	.390	.001
ALC-	.411	.014	.430	.010
ADHD	.492	< .001	.348	.006
CON	.454	< .001	.542	< .001



**Table 4**

Within-group correlations (two-tailed) between SCT- S score and CBCL Attention Problems and FSIQ.

Group	Neuropsychological Factor			
	Inattention		FSIQ	
	<i>r</i>	<i>p</i> -value	<i>r</i>	<i>p</i> -value
ALC+	.597	<.001	.323	.003
ALC-	.420	.010	-.291	.080
ADHD	.584	<.001	-.083	.456
CON	.493	<.001	-.021	.812

**Table 5**

Standardized discriminant function coefficients per item on the SCT-S, for comparisons between alcohol-exposed children without ADHD (ALC-) and controls or children with ADHD (with and without ADHD).

SCT Item	Standardized Discriminant Function Coefficients		
	ALC- vs. CON	ALC- vs. ADHD	ADHD vs. CON
1. Absent Minded	- 0.077	0.234	0.178
2. Preoccupied	0.029	0.032	0.007
3. Lack of persistence	0.296	0.494 *	0.380 *
4. Forgets details	0.437 *	- 0.205	0.521 *
5. Forgets where things are kept	- 0.083	- 0.042	0.014
6. Leaves things behind	0.123	0.343 *	- 0.028
7. Confused	0.322 *	0.236 *	0.090
8. Daydreams	- 0.330	0.227	0.217
9. Overtired	- 0.177	- 0.103	- 0.080
10. Apathetic	- 0.211	- 0.089	- 0.040
11. Stares blankly	- 0.158	0.077	- 0.075
12. Lacks energy	- 0.396	0.139	- 0.024
13. Forgetful	0.666 *	- 0.202	- 0.053
14. Drowsy	0.558 *	- 0.151	0.055
15. Forgets instructions	- 0.084	0.355 *	0.233

\* Item significantly distinguished group membership