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Comparison of Adaptive Behavior in Children With Heavy Prenatal Alcohol Exposure or Attention-Deficit/Hyperactivity Disorder

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Abstract

Background—Adaptive behavior, the ability to respond successfully to everyday demands, may be especially sensitive to the effects of heavy prenatal alcohol exposure. Similar adaptive dysfunction is common in other developmental disorders including attention-deficit/hyperactivity disorder (ADHD). ADHD is frequently present in alcohol-exposed children and this overlap in clinical presentation makes identification of alcohol-exposed children difficult. Direct comparison of children with prenatal alcohol exposure and ADHD may yield distinct patterns of cognitive and behavioral performance and add to growing knowledge of the neuropsychological and behavioral profile of prenatal alcohol exposure. Therefore, the aim of the current study was to compare adaptive behavior in children with histories of heavy prenatal alcohol exposure (ALC), nonexposed children with ADHD (ADHD), and typically developing controls (CON).

Methods—Sixty-five children (ALC = 22, ADHD = 23, CON = 20) were selected from a larger ongoing study of the behavioral teratogenicity of alcohol. Alcohol-exposed and control participants were selected to match the ADHD subjects on age, sex, socioeconomic status, and race/ethnicity. Caregivers were administered the Vineland Adaptive Behavior Scales, a semi-structured interview, and were asked to rate their child's behavior on 3 domains of adaptive function. Data were analyzed using regression techniques.

Results—Relative to controls, children in both the ALC and ADHD groups showed adaptive behavior deficits on all 3 domains and children in the ALC group were significantly more impaired than the ADHD group on the daily living skills domain. Within the ALC group, socialization standard scores were lower at older ages. This negative relationship between age and standard scores in the ALC group was also observed on the communication domain, a finding not previously reported.

Conclusions—This study suggests that both children with prenatal alcohol exposure and children with ADHD show impairments in adaptive function relative to controls, but that the pattern of impairment differs between these clinical groups. Adaptive ability in children with prenatal alcohol exposure is characterized by an arrest in development, as evidenced by a lack of improvement with age in socialization and communication scores. In contrast, children with ADHD exhibit a developmental delay in adaptive ability as their scores continued to improve with age, albeit not to the level of control children. Continued research focused on elucidating the patterns of deficits that exist in alcohol-exposed children ultimately will lead to improved differential diagnosis and effective interventions.

Keywords

Fetal Alcohol Spectrum Disorders; Fetal Alcohol Syndrome; Adaptive Behavior; ADHD; Differential Diagnosis; Neurobehavioral Profile

Behavioral and cognitive deficits are among the most devastating consequences of heavy prenatal alcohol exposure. Primary effects of this exposure can cause significant and permanent changes in brain structure and cognitive function (Archibald et al., 2001; Streissguth, 2007); secondary effects include difficulty in meeting demands of everyday life, i.e., adaptive behavior (Whaley et al., 2001). Behavioral and neuropsychological effects are seen in children with fetal alcohol syndrome (FAS) as well as those with heavy prenatal alcohol exposure, even if they lack the physical features required for an FAS diagnosis (Mattson and Riley, 2000; Mattson et al., 1997). The term fetal alcohol spectrum disorders (FASD) has been adopted to convey that the effects of prenatal alcohol exposure occur on a continuum (Bertrand et al., 2005). Individuals along the spectrum of effects have been noted to have deficits in behavior and adaptive function (Streissguth et al., 2004).

Clinically, children with heavy prenatal alcohol exposure often meet diagnostic criteria for attention-deficit/hyperactivity disorder (ADHD) (Fryer et al., 2007; Steinhausen et al., 1993). Attention deficits, hyperactivity, and impulsivity are among the behavioral symptoms shared with ADHD. Given the heterogeneity of outcomes following prenatal alcohol exposure, the overlap in presentation with other clinical groups, and the lack of a definitive biomarker of prenatal alcohol exposure, accurate identification of children prenatally exposed to alcohol is often difficult, especially without confirmed maternal history of alcohol exposure. A distinct neurobehavioral profile of FASD would aid in distinguishing children prenatally exposed to alcohol from nonexposed children displaying similar behavioral characteristics. Direct comparison of individuals with FASD and those with ADHD but without a history of prenatal alcohol exposure will assist in the clarification of this profile. In addition, elucidating strengths and weaknesses within these groups may improve differential diagnosis and lead to earlier and more effective interventions for both populations.

Only 3 published studies have compared neuropsychological function of children with FASD directly to children with ADHD or attention deficit disorder (ADD) (Coles et al., 1997; Nanson and Hiscock, 1990; Vaurio et al., 2008), and, in part, they have yielded contradictory results. The first investigation found no differences between the alcohol-exposed and ADD groups on parent-rated measures of behavior, or on computerized measures of attention (Nanson and Hiscock, 1990). The second study found that children with ADHD were best identified using behavior checklists and tasks designed to measure focused and sustained attention, while children with FASD were impaired on measures of visual spatial skills, and had decreased ability to encode new information and use it in problem solving (Coles et al., 1997). The most recent study compared children with heavy prenatal alcohol exposure to children with ADHD on measures of executive function. Both groups displayed deficits on the Wisconsin Card Sorting Test and a relative weakness on letter over category fluency. However, only the alcohol-exposed group displayed overall deficits on letter fluency and a relative weakness on the Trail Making Test–Part B over the Trail Making Test–Part A (Vaurio et al., 2008).

To complement the few existing comparisons of neurobehavioral performance in children with ADHD and children with FASD, the current study focused on adaptive behavior, which is affected both in children with heavy prenatal alcohol exposure (Streissguth et al., 1991; Thomas et al., 1998) and in children with ADHD (Roizen et al., 1994; Stein et al., 1995).

Adaptive function refers to an individual's ability to meet developmentally appropriate expectations of personal independence and social responsibility (Sparrow et al., 1984) and includes the ability to perform everyday tasks (e.g., grooming and dressing) and adapt to changes in the environment. Management of everyday stressors and completion of basic tasks necessary for daily living are dependent on intact adaptive functioning. Despite the importance of adaptive function and the overlap in deficits found in FASD and ADHD, the 2 populations have not been compared directly on this domain.

The Vineland Adaptive Behavior Scales (VABS) (Sparrow et al., 1984) is a semi-structured interview given to the child's primary caregiver that assesses 3 aspects of adaptive behavior: communication, daily living skills, and socialization. Studies that have used the VABS have shown consistent deficits in individuals with prenatal alcohol exposure (LaDue et al., 1992; Streissguth et al., 1991). In one investigation of individuals with FASD (Streissguth et al., 1991), the average adaptive behavior scores were at the 7-year level although the mean age of the sample was 17 years. Highest scores were obtained on the daily living skills domain, with average scores at the 9-year level; lowest scores were on the socialization domain, with average scores at the 6-year level. Although a few subjects in the aforementioned sample obtained age appropriate scores on the daily living skills domain of the VABS, none obtained age appropriate scores on the communication or socialization domains.

Socialization may be particularly affected in alcohol-exposed individuals. Specifically, as alcohol-exposed children age, their socialization abilities fail to develop at the expected rate, suggesting that these children have increasing difficulty with meeting the greater demands in social functioning that come with age (Thomas et al., 1998; Whaley et al., 2001). In a study comparing children with prenatal alcohol exposure to a clinic-referred sample of nonexposed children, investigators found that both groups were impaired on the VABS across all domains (Whaley et al., 2001). Although the 2 groups did not differ from each other on adaptive behavior scores, the alcohol-exposed group showed a greater decline in socialization standard scores with increasing age than did the nonexposed clinically referred controls. These results suggest that age-related deficits in socialization skills (i.e., greater impairment with increasing age) may be characteristic of children with prenatal alcohol exposure.

Despite converging evidence suggesting a deficit in adaptive behavior in children with prenatal alcohol exposure, one study of prospectively identified children did not find differences in adaptive behavior in alcohol-exposed children relative to controls at age 6; scores for all groups fell within the average range (Coles et al., 1991). Because the participants included in this investigation were relatively young, the between group comparison may not have captured the more pronounced deficits that have been observed with increasing age. There is other evidence that adaptive impairments persist into adulthood and relate to adverse life outcomes such as disrupted school experiences, trouble with the law, and substance abuse problems (Streissguth et al., 2004).

Children with ADHD also have deficits in adaptive behavior compared to controls as measured by the VABS (Clark et al., 2002; Roizen et al., 1994; Stein et al., 1995; Wilson and Marcotte, 1996). As in children with FASD, children with ADHD have clear deficits in socialization skills (Campbell, 1994; Greene et al., 1996). Adaptive function is lower than would be expected based on IQ in children with ADHD (Roizen et al., 1994) and there is evidence that for some, adaptive difficulties persist into adulthood (Barkley et al., 2006). It is not clear whether these deficits reflect a developmental delay or arrest, as the direct relationship between adaptive behavior scores and age has not been reported. However, there is evidence that deficits in ADHD become less pronounced over time (Faraone et al., 2006).

A current aim of fetal alcohol research is to focus on cognitive and behavioral outcomes, and to better delineate neurobehavioral strengths and weaknesses on several domains of function in order to improve identification (Riley et al., 2003). Delineation of such profiles requires assessment of their specificity by comparing alcohol-exposed individuals to similar clinical groups, rather than outlining deficits only in relation to typically developing children. Such dual comparisons (to both typical and clinical comparison groups) will elucidate differential patterns of performance, add to the growing knowledge of neuropsychological and behavioral profiles associated with prenatal alcohol exposure, and ultimately improve differential diagnosis. Therefore, the current study compared adaptive behavior in children with histories of heavy prenatal alcohol exposure, nonexposed children with ADHD, and typically developing controls.

The hypotheses of this study were as follows: (1) Children with heavy prenatal alcohol exposure and nonexposed children with ADHD would show deficits in adaptive function relative to controls, and (2) there would be a differential effect of age on socialization scores among groups; for alcohol-exposed children, standard scores would decrease with age, however, standard scores would be unrelated to age in children with ADHD and controls.

MATERIALS AND METHODS

General Method

Three groups of children were included in this study: children with heavy prenatal alcohol exposure (the ALC group), children with ADHD without prenatal alcohol exposure (the ADHD group), and a control group of typically developing children with neither prenatal alcohol exposure nor ADHD (the CON group). All subjects were children recruited as part of a larger ongoing study of the behavioral teratogenicity of alcohol. Alcohol-exposed children were recruited into this larger study via several mechanisms, including professional referral (50%) or self-referral. The subset of alcohol-exposed children included in this investigation was selected so that all subjects in this group met *DSM-IV* criteria for ADHD, which is highly prevalent (90%) in our exposed sample (Fryer et al., 2007). Groups were matched on age, sex, socioeconomic status (SES) and race/ethnicity. Nonexposed participants were recruited from the community via advertising at various agencies and child-related venues. While children with ADHD were not specifically recruited for the current investigation, all children were screened for *DSM-IV* diagnoses and children included in the ADHD group met diagnostic criteria as detailed below. Mothers of children in the ALC group consumed at least 4 drinks per occasion at least once per week or consumed 14 drinks per week throughout pregnancy. Teratogenic exposure history was determined through multi-source collateral report, including review of available medical, social service and adoption agency records, and maternal report, when available. Direct maternal report generally was unavailable, as many children with heavy prenatal alcohol exposure no longer reside with their biological families. The majority of control children and children with ADHD in our sample reside with their biological mothers. Therefore, screening for exposure to alcohol or other teratogens in these groups was determined through direct maternal report. Mothers of ADHD and control children included in the study reported little (i.e., <1oz AA/day prior to pregnancy recognition), if any, alcohol use during pregnancy. These procedures are in agreement with normative standards for retrospective confirmation of maternal alcohol use within the field of clinical behavioral teratology.

Children included in the alcohol-exposed group were evaluated by a dysmorphologist with expertise in alcohol teratogenesis. Exams were based on physical measurements (e.g., pre and/or postnatal growth measures), craniofacial structure analysis (e.g., evaluation of palpebral fissures, philtrum, vermillion), alcohol exposure history, and historical record review. The ALC group included children who met criteria for FAS and children with

confirmed heavy prenatal alcohol exposure but who did not have all physical features associated with the disorder.

ADHD diagnoses were determined using the computerized National Institute of Mental Health Diagnostic Interview Schedule for Children (DISC) (Shaffer et al., 2000). Many children with prenatal alcohol exposure who participate in our ongoing research program have comorbid ADHD diagnoses (Fryer et al., 2007), but as mentioned, children were excluded from the ALC group if they did not have a diagnosis of ADHD. Children were not included in the CON group if they met criteria for ADHD, or if their parents reported any concerning behavioral problems upon initial enrollment in the larger study. Data on child medication use were not collected at the time of the parent interview. However, in our recently published study, which used a similar sample, parents reported stimulant use at the time of recruitment in 25% of the ADHD group and 35% of the FASD group (Vaurio et al., 2008).

Following informed consent and assent, children were administered a battery of neuropsychological tests, including measures of general intelligence, language, learning, memory, visual spatial and visual motor ability, motor performance, academic performance, and executive function and parents completed questionnaires and interviews about their child (cf. Mattson and Roebuck, 2002; Mattson et al., 2006). The measure used in the current study, the VABS, is described below. The Institutional Review Board at San Diego State University approved all procedures.

Participants

Sixty-five children (ages 6 to 13) were included in this study, distributed as follows: ALC, $n = 22$; ADHD, $n = 23$; and CON, $n = 20$. Alcohol-exposed and control participants were selected to match the ADHD subjects on age, sex, SES and race/ethnicity.

Measure

The Vineland Adaptive Behavior Scales—Interview Edition (VABS) (Sparrow et al., 1984), a semi-structured interview, was administered to each child's caregiver. The VABS consists of 261 items that fall into 1 of 3 adaptive behavior domains: (1) communication, (2) daily living skills, and (3) socialization. For each item in the appropriate age range, caregivers are asked to judge whether their child consistently displays the indicated behavior. Responses are scored to yield an overall adaptive behavior composite score and standard scores (mean = 100, SD = 15), as well as age equivalent scores for each domain. Reliability and validity have been demonstrated in typically developing children and adolescents (Sparrow et al., 1984) as well as pediatric clinical populations (de Bildt et al., 2005; Perry and Factor, 1989).

Statistical Analyses

All data were analyzed using SPSS version 13 statistical software package (SPSS, Inc., Chicago, IL).

Demographic Information—Demographic data were analyzed using chi-square (sex, race/ethnicity, and handedness) and standard analysis of variance (ANOVA) techniques [age, full scale IQ (FSIQ), and SES as measured by Hollingshead]. Significant group differences were followed up by examining individual group z -scores (for chi-square analyses) and unadjusted pairwise comparisons (for ANOVA analyses).

Regression Analyses of Adaptive Behavior Data—Data from the 3 adaptive domains of interest (communication, daily living skills, and socialization) were analyzed separately using hierarchical multiple regression with the categorical variable Group (ALC,

ADHD, CON) and the continuous variable Age entered as predictors on step 1. A dummy coded system was used to analyze the Group variable. Group $\times$ Age interaction terms also were computed and entered into the analyses on step 2. Significant interactions were probed by running a separate bivariate regression for each group with age as the predictor and adaptive domain score as the dependent variable.

Analysis of Categorized Adaptive Behavior Data—Results documenting reported levels of impairment were examined as follows. Adaptive behavior standard scores for each domain were dichotomized, according to the VABS manual, as “adequate” (scores 1 standard deviation below the mean or greater, i.e., standard score of 85 or higher) or “less than adequate” (scores lower than one standard deviation below the mean, i.e., standard score less than 85) and compared using chi-square analyses. Significant findings were followed up by examining individual *z*-scores for each group.

Analysis of IQ-Matched Groups—Given the well-established deficit of IQ in individuals with FASD (e.g., Mattson et al., 1997; Streissguth et al., 1990), it is possible that group differences in the dependent variable of interest (adaptive behavior) may relate to differences in IQ. Therefore, to examine whether group differences in adaptive function are explained by IQ differences, we also compared adaptive behavior, as described previously, in a subsample of 27 individuals (9 per group) with similar FSIQ scores.

RESULTS

Demographic Information

The groups were similar on age [$F(2, 62) = 0.358, p = 0.700$], SES [$F(2, 62) = 2.905, p = 0.062$], sex [$\chi^2(df = 2) = 0.887, p = 0.642$], handedness [$\chi^2(df = 2) = 1.453, p = 0.483$], race [$\chi^2(df = 2) = 0.289, p = 0.865$], and ethnicity [$\chi^2(df = 2) = 1.474, p = 0.479$], but differed on FSIQ [$F(2, 62) = 16.552, p < 0.001$]. Pairwise comparisons indicated that for FSIQ scores, the CON and ADHD groups, who did not differ from each other, had significantly higher FSIQ scores than the ALC group. Demographic information is detailed in Table 1.

Regression Analyses of Adaptive Behavior Data

Average adaptive behavior scores for the 3 groups are presented in Table 2. Separate hierarchical multiple regression analyses were conducted to evaluate the effect of Group (ALC, ADHD, CON) and Age on each of the VABS domains (communication, daily living skills, and socialization). Regression results are summarized in Table 3 and scatterplots illustrating the relationship between age and adaptive scores on each domain are presented in Fig. 1.

Communication Domain—On step one, Group and Age accounted for a significant amount of the variance in communication scores. Both the ALC and the ADHD groups had significantly lower scores than the CON group, however, there were no differences in scores between the ALC and the ADHD group. Age was not significantly associated with communication standard scores. When entered on step two the interaction terms accounted for a significant increase in explained variance in communication scores. There was a significant interaction between age and the comparison between the ALC and the CON groups and between age and the comparison between the ADHD and the ALC groups. Thus, differences in the relationship between communication scores and age exist within these groups.

To explore the interactions further, simple bivariate regressions were conducted to evaluate the relationship between communication scores and age for each group. In the ALC group, age was significantly negatively associated with communication standard scores. Older alcohol-exposed children in this sample had lower communication standard scores than younger children. There was no significant relationship between age and communication scores in the ADHD group or CON group.

Daily Living Skills Domain—On step one, Group and Age accounted for a significant amount of the variance in daily living skills scores. Both the ALC and the ADHD groups had significantly lower scores than the CON group. In addition, the ALC group had significantly lower daily living skills scores than the ADHD group. Age was significantly associated with daily living skills standard scores. However, when entered on step two, the interaction terms did not account for a significant increase in explained variance in daily living skills scores.

Socialization Domain—On step one, Group and Age accounted for a significant amount of the variance in socialization scores. Both the ALC and ADHD groups had significantly lower scores than the CON group, but did not differ from each other. Age also was significantly associated with socialization standard scores. When entered on step two, the interaction terms accounted for a significant increase in explained variance in socialization scores. The regression coefficient reflecting the interaction of age and the comparison between the ADHD and the ALC groups was statistically significant, suggesting that differences in the relationship between socialization scores and age exist between those 2 groups.

To explore the interaction between age and ADHD versus ALC further, simple bivariate regressions were conducted to evaluate the relationship between socialization scores and age in the ALC and ADHD groups. In the ALC group, age was significantly, negatively associated with socialization standard scores. Thus, as children in the ALC group age, their socialization standard scores decrease. In the ADHD group, there was no significant relationship between age and socialization scores.

Analysis of Categorized Adaptive Behavior Data

Data (adequate vs. less than adequate as defined above) for each of the 3 adaptive behavior domains were examined using chi-square analysis. Within each group, z-scores were examined to further characterize significant overall group differences. On the communication [χ^2 (df = 2) = 11.428, p = 0.001] and daily living skills [χ^2 (df = 2) = 14.534, p = 0.001] domains, children in the ALC group were more likely to be rated as having inadequate adaptive skills, while children in the CON group were more likely to be rated as having adequate abilities. Children in the ADHD group were equally as likely to be rated as having adequate or inadequate communication and daily living skills. However, on the socialization domain [χ^2 (df = 2) = 11.688, p = 0.003], children in both the ALC and ADHD groups were equally as likely to be rated as adequate or inadequate, while children in the control group were more likely to be rated as having adequate socialization abilities (Table 4).

Analysis of IQ-Matched Groups

To determine whether deficits in adaptive function in children with FASD are independent of IQ, the above analyses were repeated with a small subsample of 27 participants (n = 9/group) matched on FSIQ. This subsample had IQ scores ranging from 84 to 112 [mean (SD) FSIQ: ALC = 98.56 (6.80); ADHD = 99.11 (7.82); CON = 102.89 (8.22)] and there were no differences in IQ between the groups or on any demographic variables, except for sex. There

were significantly more ($p = 0.049$) females in the control group than in the other 2 groups. On all 3 domains a similar pattern emerged; the CON group had significantly higher scores than both clinical groups who did not differ from each other. However, there were no significant Group $\times$ Age interactions. Regression results are summarized in Table 5.

DISCUSSION

We compared adaptive behavior in children with histories of heavy prenatal alcohol exposure, children with ADHD, and typically developing controls. As hypothesized, on all 3 domains, children in both the ALC group and the ADHD group showed deficits in adaptive behavior relative to controls. In addition, children in the ALC group were significantly more impaired on daily living skills than were children with ADHD. These findings are consistent with previous reports of impaired adaptive function in children with FASD and ADHD (Roizen et al., 1994; Stein et al., 1995; Thomas et al., 1998). While overall adaptive dysfunction was not unique to alcohol exposure, the pattern of impairment differed across groups. The alcohol-exposed children in this sample were more severely impaired on the daily living skills domain than children in the ADHD group. Furthermore, children in the ALC group were more likely to be classified as having inadequate communication and daily living skills than were children with ADHD and controls. It is unlikely that adaptive deficits in alcohol-exposed children are solely a result of diminished cognitive ability, as significant impairment in adaptive function was observed when the analyses were conducted on a subset of participants matched on IQ.

We also examined the association between age and group membership on adaptive behavior. The results indicated that age was a significant predictor that helped to characterize the differential pattern of deficits seen in the ALC and ADHD subjects on the communication and socialization domains. Younger alcohol-exposed subjects had performance that was similar to controls, however, the disparity in functioning between the groups became more pronounced with increasing age. It may be that the range of adaptive ability for younger children, in general, is more restricted than what is expected of older children and therefore it is more difficult to detect differences at younger ages. In other words, because young children are not expected to perform tasks such as prepare their own meals or do their own laundry, it is not until older ages that deficits in these abilities become apparent in children with heavy prenatal alcohol exposure. It also is likely that as children age the adaptive tasks expected of them are more difficult and involve more complex executive function. Executive function deficits are known to occur in children and adolescents with heavy prenatal alcohol exposure (Mattson et al., 1999; McGee et al., 2008b) and may help explain the results presented here. In previous studies of alcohol-exposed subjects, deficits in executive function predicted deficits in social skills and social problem solving (McGee et al., 2008a; Schonfeld et al., 2006). Although typically developing peers progress in executive function ability with increasing age, alcohol-exposed children do not achieve the same functional level, which in turn negatively impacts their capacity to effectively adapt to their environmental demands.

Taken together with previous literature, these findings support the interpretation that socialization deficits are not merely the result of a developmental delay in children with FASD, but rather, they represent an arrest in development of these skills (Streissguth et al., 1991; Thomas et al., 1998; Whaley et al., 2001) and further suggest a similar arrest in development of communication abilities. In contrast, children with ADHD appear to have a developmental delay in adaptive ability, as their raw scores improved with increasing age but their performance lagged behind that of controls at a consistent rate. Thus, distinct patterns of adaptive function performance existed across groups at different ages. Continued investigation, comparing third party report with standardized “within-child”

neuropsychological measures, will provide the most valid and reliable clinical profile for identification of children with prenatal alcohol exposure and distinguishing them from nonexposed children with ADHD. Though our sample size did not allow, future studies should examine differences between children with FASD and ADHD at specific age ranges (e.g., young vs. old). Additionally, longitudinal studies are needed to better characterize the developmental trajectory of adaptive behavior in alcohol-exposed children as they age.

In the subgroup comparison of IQ-matched subjects, the Group $\times$ Age interaction was not significant. Thus, it may be that age becomes a less important factor once IQ is taken into account, although because of the smaller sample size of these analyses, results should be considered preliminary. Based on the current findings, future investigations should consider the influence of general intellectual ability on adaptive function, and further examine the influence of age across the full range of IQ observed in the alcohol-exposed population.

Deficits in adaptive behavior in children with FASD are likely a result of multiple factors. The current study did not include a measure of home environment, however it is probable that differences on this variable exist among groups. Children with heavy prenatal alcohol exposure often do not reside with their biological family and may be more likely to have experienced multiple home placements and less stable home environments, putting them at increased risk for adaptive dysfunction. In addition, children of alcoholics are more likely to be exposed to family dysfunction and domestic violence (Jester et al., 2000) and the interaction of prenatal alcohol exposure and exposure to childhood trauma may result in more severe neurodevelopmental deficits (Henry et al., 2007). Therefore, in the instance that children with prenatal alcohol exposure are residing with their biological families, they are more likely to experience unfit home environments and increased risk for deficits in adaptive behavior. Adverse home environment of alcohol-exposed children has been associated with poorer outcomes on other domains of function such as language and social communication (Coggins et al., 2007); thus, it is plausible that deficits in adaptive function in children with FASD also are related to negative family environments of these children. However, one investigation of alcohol-exposed children did not find a significant effect of home placement on adaptive behavior (Whaley et al., 2001). Studies that more thoroughly assess the interaction of clinical syndromes and rearing environment on adaptive function are needed to better understand this relationship.

Limitations

Despite its significant findings, there are several limitations of this study that should be addressed. Although consistent with other studies of adaptive behavior in the alcohol-exposed population, the sample used was relatively small in size, and therefore results must be interpreted cautiously. Replications of these findings are critical to better understand the nature of adaptive deficits in both children with FASD and children with ADHD. Second, prenatal alcohol exposure was identified retrospectively, limiting information regarding quantity and frequency of exposure. Prospective studies may contribute to a better understanding of the relationship between dose and timing of prenatal alcohol exposure and adaptive function. However, retrospective studies, such as this one, allow for the examination of greater numbers of children with higher levels of prenatal alcohol exposure than is typical for prospective designs. Therefore, more severely affected children can be identified and characterized with this type of design. Similarly, precise information about possible confounding factors, such as maternal smoking and prenatal exposure to other substances, is unknown. Because children in the ADHD group were not recruited specifically based on ADHD diagnosis, it is possible that this sample is different from one that was clinically referred. Children with ADHD who participated in this study could have less severe symptoms than a sample drawn from a clinic setting, which may have impacted our results. Finally, the VABS is a brief parent report measure of adaptive behavior and thus

is subject to informant bias. In general, caregivers of children in the ALC and ADHD groups were aware of their child's diagnosis and as a result responses may be influenced by anticipation of poorer outcomes for these participants. Alternative assessments or validation of third-party reports could be useful in highlighting differential patterns of adaptive behavior across clinical groups.

Implications and Future Directions

The current study adds to the growing body of literature aimed at identifying a neurobehavioral profile of individuals with FASD by providing data on the specificity of adaptive deficits in this population. Determination of such a profile will aid in differential diagnosis and lead to more informed and effective interventions for alcohol-exposed children. In particular, interventions targeted at improving communication, daily living, and socialization abilities may prove beneficial. Though limited, there is evidence of positive outcomes for alcohol-exposed children who are diagnosed and treated early (Adnams et al., 2007; Streissguth and Kanter, 1997). However, interventions designed to improve adaptive behavior at older ages also could be important given the increase in severity of dysfunction as children with FASD age.

Future research should continue with the goal of elucidating patterns of adaptive function deficits in alcohol-exposed children. Longitudinal studies are needed to examine the course of adaptive behavior in these children over time, but studies that examine adaptive behavior differences between children with FASD and ADHD at specific age ranges also are important. In addition, investigations using multiple measures of adaptive function, including more objective observational measures, may better characterize the nature of adaptive function deficits in alcohol-exposed children.

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Fig. 1. Scatterplots illustrating the relationship between age and standard scores on the 3 adaptive behavior domains for children with heavy prenatal alcohol exposure (ALC), children with attention-deficit/hyperactivity disorder (ADHD), and typically developing controls (CON).

Table 1

Demographic Information for Children With Heavy Prenatal Alcohol Exposure (ALC), Children With Attention-Deficit/Hyperactivity Disorder (ADHD), and Typically Developing Controls (CON)

Variable	ALC	ADHD	CON
<i>N</i>	22	23	20
Sex [<i>N</i> (%) Female]	8 (36.4)	9 (39.1)	10 (50.0)
Race [<i>N</i> (%) White]	15 (68.2)	17 (73.9)	15 (75.0)
Ethnicity [<i>N</i> (%) Hispanic]	2 (9.1)	5 (21.7)	4 (20.0)
Handedness [<i>N</i> (%) Right]	17 (77.3)	20 (87.0)	18 (90.0)
Age in years [M (SD)]	10.32 (2.37)	9.78 (2.17)	9.96 (1.90)
SES [M (SD)] ^a	48.77 (11.48)	43.39 (11.01)	51.68 (12.05)
FSIQ [M (SD)] [*]	90.27 (10.79)	104.57 (15.78)	113.65 (12.73)

^aSocioeconomic status (SES) was measured using the Hollingshead Four Factor Index of Social Status.

^{*}Significant group differences were noted on FSIQ ($p < 0.001$).

Table 2

Mean ($\pm$ SD) Standard Scores on the Vineland Adaptive Behavior Scale for Children With Heavy Prenatal Alcohol Exposure (ALC), Children With Attention-Deficit/Hyperactivity Disorder (ADHD), and Typically Developing Controls (CON)

Domain	ALC	ADHD	CON
Communication	77.23 (22.89)	87.61 (18.79)	103.25 (11.73)
Daily living skills	69.41 (19.83)	81.13 (19.31)	98.15 (13.02)
Socialization	81.50 (20.85)	83.83 (16.14)	102.45 (10.75)

Table 3

Hierarchical Multiple Regression Results for Children With Heavy Prenatal Alcohol exposure (ALC), Children With Attention-Deficit/Hyperactivity Disorder (ADHD), and Typically Developing Controls (CON)

Step 1: Group & Age	Communication		Daily living skills		Socialization	
	<i>b</i>	<i>p</i>	<i>b</i>	<i>p</i>	<i>b</i>	<i>p</i>
ALC (1) vs. CON (0)	-25.398	<0.001	-27.990	<0.001	-19.989	<0.001
ADHD (1) vs. CON (0)	-15.954	0.006	-17.395	0.002	-19.105	<0.001
ADHD (1) vs. ALC (0)	9.444	0.091	10.594	0.046	0.884	0.851
Age	-1.738	0.111	-2.090	0.044	-2.674	0.005
Step 2: Group × Age interaction	$F(5, 59) = 6.921$, $p < 0.001$, $R^2 = 0.369$		$F(5, 59) = 6.565$, $p < 0.001$, $R^2 = 0.357$		$F(5, 59) = 7.853$, $p < 0.001$, $R^2 = 0.400$	
ΔR^2	$F(2, 59) = 4.110$, $p = 0.021$, $\Delta R^2 = 0.088$		$F(2, 59) = 0.274$, $p = 0.761$, $\Delta R^2 = 0.006$		$F(2, 59) = 3.160$, $p = 0.050$, $\Delta R^2 = 0.064$	
	<i>b</i>	<i>p</i>	<i>b</i>	<i>p</i>	<i>b</i>	<i>p</i>
Age × ALC vs. CON	-5.596	0.039	0.542	0.839	-2.567	0.268
Age × ADHD vs. CON	0.595	0.827	1.876	0.495	2.547	0.284
Age × ADHD vs. ALC	6.191	0.011	1.333	0.575	5.114	0.015

Dummy codes used for each analysis are included in parentheses.

Table 4

Number of Cases of Children With Heavy Prenatal Alcohol Exposure (ALC), Children With Attention-Deficit/Hyperactivity Disorder (ADHD), and Typically Developing Controls (CON) Classified as Having “Less Than Adequate” Adaptive Behavior on the 3 Domains of the Vineland Adaptive Behavior Scales

Domain	ALC	ADHD	CON
Communication	13 (59.1%) $z = 2.2$	11 (47.8%) $z = 1.0$	2 (10.0%) $z = -3.3$
Daily living skills	17 (77.3%) $z = 2.7$	14 (60.9%) $z = 0.8$	4 (20.0%) $z = -3.6$
Socialization	11 (50.0%) $z = 1.8$	11 (47.8%) $z = 1.6$	1 (5.0%) $z = -3.4$

Z-scores are presented to further characterize omnibus group effects.

Table 5

Hierarchical Multiple Regression Results for Children With Heavy Prenatal Alcohol Exposure (ALC), Children With Attention-Deficit/Hyperactivity Disorder (ADHD), and Typically Developing Controls (CON) Matched on IQ

	Communication		Daily living skills		Socialization	
	<i>b</i>	<i>p</i>	<i>b</i>	<i>p</i>	<i>b</i>	<i>p</i>
Step 1: Group & Age	<i>F</i> (3, 23) = 9.236, <i>p</i> < 0.001, <i>R</i> ² = 0.546		<i>F</i> (3, 23) = 10.017, <i>p</i> < 0.001, <i>R</i> ² = 0.566		<i>F</i> (3, 23) = 7.132, <i>p</i> = 0.001, <i>R</i> ² = 0.482	
ALC (1) vs. CON (0)	-27.335	<0.001	-27.630	<0.001	-20.373	0.008
ADHD (1) vs. CON (0)	-26.031	<0.001	-21.639	0.002	-28.130	0.001
ADHD (1) vs. ALC (0)	1.304	0.836	-5.991	0.358	-7.757	0.278
Age	-1.663	0.183	-3.150	0.016	-2.299	0.097
Step 2: Group × Age interaction	<i>F</i> (5, 21) = 5.600, <i>p</i> = 0.002, <i>R</i> ² = 0.571		<i>F</i> (5, 21) = 5.733, <i>p</i> = 0.002, <i>R</i> ² = 0.577		<i>F</i> (5, 21) = 4.757, <i>p</i> = 0.005, <i>R</i> ² = 0.531	
ΔR^2	<i>F</i> (2, 21) = 0.613, <i>p</i> = 0.551, ΔR^2 = 0.025		<i>F</i> (2, 21) = 0.267, <i>p</i> = 0.769, ΔR^2 = 0.011		<i>F</i> (2, 21) = 1.101, <i>p</i> = 0.351, ΔR^2 = 0.049	
	<i>b</i>	<i>p</i>	<i>b</i>	<i>p</i>	<i>b</i>	<i>p</i>
Age × ALC vs. CON	-0.326	0.917	1.975	0.547	-0.021	0.983
Age × ADHD vs. CON	2.571	0.422	2.242	0.500	4.035	0.254
Age × ADHD vs. ALC	2.897	0.311	0.267	0.928	4.106	0.193

Dummy codes used for each analysis are included in parentheses.