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Higher functioning children with prenatal alcohol exposure: Is there a specific neurocognitive profile?

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Abstract

Recent attempts to identify a neurocognitive profile of children with prenatal alcohol exposure (PAE) have led to an emerging "generalized deficit" conceptualization marked by diffuse information processing and integration difficulties as opposed to a specific profile. This study examines whether this conceptualization can be extended to higher functioning children with PAE who are without intellectual disability and addresses several limitations of previous research. One hundred twenty-five children aged 6–12 years with social skills deficits, 97 of whom met diagnostic criteria for a Fetal Alcohol Spectrum Disorder (FASD), underwent a comprehensive, multi-informant assessment of neurocognitive, emotional, social, behavioral, and adaptive functioning. Multivariate analyses of variance examined differences in functioning between the PAE group and a nonexposed comparison group with and without controlling for child IQ. Results indicated that the PAE group returned significantly poorer scores than the nonexposed group on every construct assessed, including executive functioning, attention, working/visuospatial memory, linguistic abstraction, adaptive behavior, emotional/behavioral functioning, and social cognition. These differences largely maintained after controlling for IQ and were similar regardless of informant, although teachers reported somewhat fewer group differences. Within the PAE group, no differences were found across FASD subtypes. These results provide evidence extending the emerging generalized deficit conceptualization of children with PAE to those higher functioning individuals without global intellectual disability.

Keywords

Fetal alcohol spectrum disorders; Prenatal alcohol exposure; Alcohol-related neurodevelopmental disorder; Neurodevelopment; Fetal alcohol syndrome

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For over 35 years, growing evidence regarding the impact of maternal alcohol consumption during pregnancy has prompted increased attention to the link between prenatal alcohol exposure (PAE) and a constellation of developmental disabilities that are characterized by physical, cognitive, and behavioral impairments. These disabilities include a continuum of

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disorders known as Fetal Alcohol Spectrum Disorders (FASD; Warren & Hewitt, 2009). On the most severe end of the spectrum are those individuals who meet full criteria for fetal alcohol syndrome (FAS). Also included in the spectrum are those individuals who were exposed to alcohol prenatally but who may or may not meet diagnostic criteria for full FAS. These individuals are diagnosed as having partial FAS (pFAS) or alcohol-related neurodevelopmental disorder (ARND) according to the diagnostic criteria proposed by the Institute of Medicine (IOM; Stratton, Howe, & Battaglia, 1996).

Prevalence and Impact

FASD prevalence rate estimations have varied (May et al., 2009) though most authors agree that previously reported rates are likely underestimations due to several factors: the absence of routine assessments by health practitioners for PAE, reluctance of mothers to disclose alcohol consumption during pregnancy due to stigma, and physicians' lack of awareness of, or confidence in, making a diagnosis of a developmental disability associated with PAE (Eyal & O'Connor, 2011). A comprehensive review of epidemio-logical studies of FASD recently concluded that the prevalence of FAS in the United States is 2 to 7 cases per 1,000 children and between 2% to 5% of the population for any FASD (May et al., 2009). These rates equate to an annual financial impact of up to $55.5 billion in the United States alone (Burd, 2011) and underscore the seriousness of PAE and its sequelae as a public health issue. For this reason, early identification of individuals affected by PAE is critical. Research shows that early identification and the provision of a stable environment reduces two- to fourfold the risk of maladaptive outcome associated with PAE, including disrupted school experience, trouble with the law, psychiatric and legal confinement, inappropriate sexual behavior, and developing alcohol/drug problems (Streissguth et al., 2004). Unfortunately, while individuals with FAS are more likely to be identified along the FASD spectrum, given their characteristic facial dysmorphology, small size, and increased likelihood for intellectual disability, the majority of individuals with PAE are often not diagnosed, despite having significant neurocognitive deficits, including overall intellectual deficits and more specific problems in executive functioning, social cognition, learning and memory, language, attention, visual-spatial ability, motor, and adaptive functioning (Kodituwakku, 2009; Mattson, Crocker, & Nguyen, 2011).

Neurocognitive Profile

Given the pervasiveness of FASD and the impact of its sequelae, efforts have been made to identify a neurocognitive profile to assist in the identification of children with PAE. Recently, a profile of the largest clinical sample of individuals with PAE (N = 1400; mean age = 9.0 years, SD = 6.2) concluded that individuals with FAS or pFAS returned significantly poorer scores on intellectual, visual-motor, executive functioning, and memory-oriented tasks when compared to those with ARND (Astley, 2010). Similar results were reported from a neurocognitive comparison of a clinical sample of 78 foster and adopted children (mean age: 8.99 – 9.66 years) diagnosed with FAS, pFAS, or ARND (Chasnoff, Wells, Telford, Schmidt, & Messer, 2010), with the FAS group generally performing more poorly than both the pFAS and ARND groups on indices of intelligence, executive functioning, achievement, memory, adaptive living skills, and behavioral functioning. Study limitations included the absence of a nonexposed comparison group and no control for IQ, which the authors noted may have accounted for group differences on the neurocognitive measures employed. Controlling for IQ differences, while methodologically controversial (e.g., Dennis et al., 2009) is relevant for PAE studies in order to identify whether or not there are unique characteristics of this population that cannot be explained simply by intellectual disability (e.g., Carmichael Olson, Feldman, Streissguth, Sampson, & Bookstein, 1998; Vaurio, Riley, & Mattson, 2011).

Several investigations have attempted to distinguish children with PAE from nonexposed children. A latent profile analysis of 22 neuropsychological variables and IQ from 139 individuals (7–21 years) with heavy PAE indicated that executive functioning and spatial processing were especially sensitive to PAE, and that the identified profile accurately distinguished children with heavy PAE who did not meet the physical criteria for FAS from nonexposed controls (Mattson et al., 2010)—an important contribution as children who do not meet criteria for full-blown FAS are less likely to be identified. A separate series of well-controlled studies indicated that children with heavy PAE evidenced different patterns of deficits on indices of executive functioning, verbal learning, memory, and adaptive behavior than nonexposed children with attention deficit/hyperactivity disorder (ADHD; Crocker, Vaurio, Riley, & Mattson, 2009, 2011; Vaurio, Riley, & Mattson, 2008).

These studies collectively illustrate the emergence of a theme in which individuals with PAE demonstrate impairments in multiple neurocognitive domains with little evidence of a specific profile. Two recent reviews of the neurocognitive and behavioral effects of PAE (Kodituwakku, Segall, & Beatty, 2011; Mattson et al., 2011) provide a more comprehensive discussion and a similar conclusion, with persuading support for a generalized deficit conceptualization in which children with PAE demonstrate diffuse information-processing difficulties that become more pronounced as task complexity increases (Kodituwakku et al., 2011). This conceptualization is supported by a growing body of structural and functional imaging studies indicating abnormalities in nearly every brain structure and region investigated in participants with PAE (for a review, see Lebel, Roussotte, & Sowell, 2011). Diffusion tensor imaging techniques have revealed that white matter appears especially vulnerable to alcohol, with reduced microstructural integrity found in children with PAE in areas associated with processing speed, nonverbal ability, and executive functioning (for a review, see Wozniak & Muetzel, 2011). The corpus callosum, the largest white fiber tract, and other commissural and temporal connections are all sensitive to the teratogenic influences of alcohol (Lebel et al., 2008) as are the deep gray matter structures (Nardelli, Lebel, Rasmussen, Andrew, & Beaulieu, 2011). Additionally, there is nascent evidence of reduced functional connectivity in the brains of individuals with PAE (Wozniak et al., 2011).

While these findings add support for a generalized deficit conceptualization (Kodituwakku et al., 2011), it is unknown whether higher functioning children with PAE demonstrate the same global impairments. Previous investigations have typically included a range of individuals having mild-to-severe intellectual deficits (e.g., Astley, 2010; Chasnoff et al., 2010; Crocker et al., 2009, 2011; Mattson et al., 2010; Vaurio et al., 2008) or were limited to only heavily exposed children (Vaurio et al., 2011). This prevents a focused examination of the great majority of children with PAE who are without global intellectual disability but who, nonetheless, demonstrate neurocognitive deficits that interfere with their overall functioning. A previous investigation estimated that 73% of individuals with FAS and 91% of individuals with partial FAS or ARND have IQs of 70 or above (Sampson, Streissguth, Bookstein, & Barr, 2000). These children are at comparatively greater risk for maladaptive outcomes than the more severely affected children with PAE, such as those with FAS and an intellectual disability (Streissguth, Barr, Kogan, & Bookstein, 1996). Thus, this study focused on higher functioning children with PAE given the high-prevalence rate and paucity of research on this at-risk group.

Study Aims

This study sought to investigate whether the emerging "generalized deficit" conceptualization of neurocognitive and behavioral functioning in children with PAE can be extended to higher functioning children, who were defined as having an IQ score of 70 or greater. Measures of social, emotional, behavioral, executive, and language functioning, as well as learning/memory, attention, adaptive behavior, and spatial ability were used. Multisource data were collected, with a mixture of performance, self-report, and informant-rated (i.e., parent, teacher) instruments. A nonexposed group of children with poor social functioning, a frequent diagnosis among children with PAE, was utilized as a comparison group. A second aim was to examine whether group differences remained after controlling for IQ. Finally, analyses considered whether there were distinguishable differences among children with different FASD classifications (FAS, pFAS, ARND).

METHODS

Participants

All study-related activities took place at a major university in Southern California. The university and the Centers for Disease Control and Prevention Institutional Review Boards approved all procedures and a Certificate of Confidentiality was obtained from the National Institute of Alcohol Abuse and Alcoholism prior to participant recruitment. Informed consent was obtained from the parent(s) and assent from children ≥ 7 years of age.

A sample of 129 children was originally recruited from February 2003 to June 2005 as part of an investigation of prenatal alcohol exposure and social skills deficits. Recruitment methods consisted of community-posted flyers and letters mailed to local health care providers, YMCAs, and schools. Flyers targeted parents of children with social skills problems and made no mention of alcohol exposure, which was assessed as part of an eligibility screening that occurred via telephone when interested families responded to the flyers. Children were eligible if they were between 6 and 12 years of age, had measurable social skills deficits (≤ −1 standard deviation below the mean) on the Socialization Domain of the Vineland Adaptive Behavior Scales (VABS; Sparrow, Balla, & Cicchetti, 1984) and had a composite IQ score of ≥ 70 (nonverbal IQ ≥ 70 for two cases recently adopted from Russia) on the Kaufman Brief Intelligence Test (K-BIT; Kaufman & Kaufman, 1990). Children were not admitted if they had major sensory or motor deficits or a past diagnosis of intellectual disability or pervasive developmental disorder.

FASD Diagnosis

Following the phone screening, participants were scheduled for a physical examination for FASD features according to the criteria set forth in the *Diagnostic Guide for Fetal Alcohol Spectrum Disorders* (Astley, 2004). The study physician was unaware of the PAE status of the participants. A comprehensive history of PAE was obtained from the biological mothers by means of the *Health Interview for Women* (O'Connor & Kasari, 2000). Among adopted or foster children, medical or legal record documentation, as well as reliable witness reports of PAE, were obtained. Children with unknown exposure were not included in the study.

Measures

General Intelligence.—The Kaufman Brief Intelligence Test (K-BIT; Kaufman & Kaufman, 1990) is a brief, individually administered measure of verbal and nonverbal intelligence. The instrument has a record of good psychometric features, including split-half (r = .79–.94) and test-retest reliabilities (r = .83–.92), as well as construct validity (WISC-III: r = .67–.89; Kaufman & Kaufman, 1990; Canivez, Neitzel, & Martin, 1995).

Executive Functioning.—The Behavior Rating Inventory of Executive Function (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000) is an 86-item informant-rated instrument assessing impairment of executive functioning in children aged 5–18 years. The instrument produces two nonoverlapping indices that were utilized for the current study: the Behavioral Regulation Index and the Metacognition Index. Higher T-scores represent poorer executive functioning. The Behavioral Regulation Index represents the ability to shift cognitive set and to modulate emotions and behavior via appropriate inhibitory control, which enables problem solving and appropriate self-regulation. The Metacognition Index represents the ability to initiate, to plan, to organize, and to sustain future-oriented problem solving in working memory and is interpreted as the ability to cognitively self-manage tasks and to monitor one's performance. Good psychometrics have been reported (Cronbach's α range = .94–.98; test-retest reliability (r = .80–.92), including convergent and divergent validity (Donders, 2002; Gioia et al., 2000). Parent and teacher ratings were obtained.

Children's Color Trails (CCT; Williams et al., 1995) is a timed measure of executive functioning consisting of two consecutive conditions: (a) the connecting of numbers 1–15 in sequence and (b) the same task conducted while adhering to an alternating color-dependent pattern in the presence of foils. The measure has good reliability (e.g., alternate form r = .85–.90) and validity characteristics (Williams et al., 1995) and has been used with PAE samples (Chasnoff et al., 2010). An overall standard score based on completion time was produced for each of the two conditions.

Working and Visuospatial Memory.—The Digit Span and Spatial Span subtests of the Wechsler Intelligence Scale for Children as Process Instrument (WISC-III PI; Kaplan, Fein, Kramer, Delis, & Morris, 1999) assess auditory and visuospatial working memory through the presentation and subsequent recall of numerical and spatial sequences of increasing difficulty. Both tests involve forward and backward recall conditions. Internal consistency is good (Cronbach's α range = .66–.80), and the tests demonstrate moderate to high correlations with similar instruments (Kaplan et al., 1999).

Language.—The Figurative Language subtest of the Test of Language Competence (Wiig & Secord, 1988) was administered to assess for verbal abstraction ability. This test consists of 17 figurative statements (e.g., "our teacher came apart at the seams") that participants were asked to interpret and then to choose one of four illustrations that best depicted the meaning. An overall scaled score was produced.

Adaptive/Emotional/Behavioral Functioning.—The Vineland Adaptive Behavior Scales, Survey Form (VABS; Sparrow et al., 1984) is a parent-completed assessment of adaptive functioning for individuals ages 0–19 years. Three scales yielding standard scores were used: Communication, Daily Living Skills, and Socialization. The Communication scale items assess what one understands, says, reads and writes. The Daily Living Skills scale items pertain to personal hygiene practices, how one eats/drinks, completion of household tasks, use of time/money/phone, and job skills. The Socialization scale items address how one interacts with others, plays/uses leisure time and demonstrates responsibility and sensitivity toward others. Psychometric data for these scales are good for internal consistency (Cronbach's α = .78–.95), test-retest reliability (r = .76–.93), and content, criterion, and construct validity (Sparrow et al., 1984).

The Personal Behaviors Checklist (PBCL), also known as the Fetal Alcohol Behavior Scale (Streissguth, Bookstein, Barr, Press, & Sampson, 1998), is a 36-item checklist designed to assess behaviors commonly found in children with PAE. Higher scores reflect a greater number of maladaptive behaviors. It demonstrates good internal consistency (Cronbach's α = .91) and test-retest reliability (r = .69) and is uncorrelated with IQ, sex, age, and race. Scores on the following scales are produced: Personal Manner, Emotions, Motor Skills and Activities, Academic/Work Performance, Social Skills and Interactions, and Bodily or Physiologic Functions. An overall score is also produced with a cutoff score of 11 distinguishing children with PAE from those without. Parent and teacher ratings were obtained.

The Swanson, Nolan, and Pelham Parent Rating Scale – Version IV (SNAP-IV; Swanson et al., 2001) is a 26-item parent-completed questionnaire assessing ADHD and Oppositional Defiant Disorder (ODD) symptoms. The instrument demonstrates good internal consistency (Cronbach's α = .79–.90), factorial validity, and predictive validity (Bussing et al., 2008). Symptoms are scored on a 4-point scale. Two scales from the instrument—Inattention and Hyperactivity/Impulsivity—were used. Cutoff scores of 9.6 and 7.2 for Inattention and Hyperactivity/Impulsivity, respectively, have been reported to differentiate ADHD positive from negative cases (Bussing et al., 2008).

The Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2001a) is a parent-report checklist targeting several problem domains. Two indices—Internalizing Problems and Externalizing Problems—were used. Scores on the Internalizing Problems index refer to symptoms of anxiety, depression, somatic complaints without known medical cause, and withdrawal from social contacts. Scores on the Externalizing Problems index represent conflict with others and rule-breaking behaviors. *T*-scores were produced for each index. Psychometric data for the Internalizing Problems and Externalizing Problems indices are good for test-retest reliability (r = .91 and .92, respectively) and internal consistency

(Cronbach's α = .90 and .94, respectively), and the measure enjoys strong empirical affirmation of criterion, construct, and content validity (Achenbach & Rescorla, 2001a).

The Teacher Report Form (TRF; Achenbach & Rescorla, 2001b) is the teacher-report version of the CBCL and assesses classroom behaviors. *T*-scores were produced on the same indices as the CBCL. Psychometric data for the Internalizing Problems and Externalizing Problems indices are good for test-retest reliability (r = .86 and .89, respectively) and internal consistency (Cronbach's α = .90 and .95, respectively). This measure also has strong validity support (Achenbach & Rescorla, 2001b).

The Pictorial Depression Scale (PDS; O'Connor & Kasari, 2000) is a 23-item, validated self-rating scale based on the Children's Depression Inventory (Kovacs, 1992) and adapted by O'Connor and Kasari (2000) for use with children as young as 4 years of age. The test consists of pictures of two side-by-side identical children (matched to the participant's gender) with neutral facial expressions. One figure is described in terms of depressive symptomatology (e.g., "This child feels sad") while the second figure is described as not depressed (e.g., "This child does not feel sad"). Participants then point to the child that is most like him/her. The sum of the responses reflecting depressive symptomatology comprises the total score. The instrument demonstrates a strong correlation (r = .85) with the Children's Depression Inventory. A total score of 10 or greater is considered significant.

Social Cognition.—The Hypothetical Attribution Task (HAT; Dodge, 1980) formerly the Home Interview with the Child, consists of eight verbally presented vignettes (accompanied by an illustration) of hypothetical social situations depicting ambiguous peer provocations and problematic group entry situations. For each vignette, the child is first asked why the peer did what they did with responses coded as *benign intent* or *hostile intent*. Good interrater reliability has been obtained with this measure in previous research, and this measure has been found to be predictive of children's behavioral problems as reported by teachers (Dodge, Laird, Lochman, & Zelli, 2002). Two scores were used: the proportion of hostile attribution responses for (a) the Provocation Scenario and (b) the Peer Entry Scenario.

Data Analysis

All analyses were conducted using PASW (Predictive Analytics Software) for Windows, Release Version 18.0 (SPSS Inc., 2009). Prior to analyses, all data were screened for completeness. Two cases were missing from the CCT due to the children not understanding the instructions. One case was missing from the Figurative Language test due to administrator error. Additionally, two cases recently adopted from Russia were excluded from the Figurative Language analyses. Forty-seven cases were missing from the BRIEF-Teacher version: 39 cases due to the measure being a late addition to the test battery and eight cases due to noncompletion. The PBCL-Teacher version was missing eight cases and the TRF 16 cases, both due to noncompletion. Due to the degree and blocked nature of these missing data (eight cases were missing all three teacher measures), imputation methods were not viable, and all instances of nonrandom missing data were managed by pairwise deletion. One-way analysis of variance (ANOVA) and chi-square analysis indicated that participants with missing data did not differ on demographic variables from those of the same group with data present.

Mean differences between groups on demographic variables were tested via chi-square and one-way ANOVA analyses (see Table 1). Bivariate correlations were calculated between demographic and dependent variables. Caregiver years of education and child IQ demonstrated significant associations with dependent variables, though were strongly correlated in the FAS ($r = .66$; $p < .05$) and nonexposed groups ($r = .63$; $p < .001$). As a primary aim for the current study was to assess for the impact of PAE above and beyond the relation with intelligence, for purposes of parsimony, IQ was designated the sole control variable.

Prior to substantive analyses, outlying scores in control and dependent variables (> 1.5 interquartile range (IQR) from the nearest Tukey's hinge) were Winsorized, in which the cutoff value was substituted for the outlying score, thus providing a more robust mean estimation while retaining the median. This method is preferable to outlier identification through *z*-score calculation in that it is less susceptible to outlier concealment and allows for retaining all participants, unlike deletion strategies. The percentage of cases Winsorized per scale ranged from 0.0%–6.4%. Four cases with an excessive (i.e., > 3) number of outlying scores were excluded from substantive analyses, resulting in a final sample size of 125. Multivariate outliers were examined through the Mahalanobis distance calculation and comparison with chi-square critical values ($p < .001$); none were detected.

The relations between FASD group classification (i.e., FAS, pFAS, ARND) and dependent variables were first explored using a series of one-way ANOVAs and planned Scheffe post hoc analyses. Next, to account for the possible interrelation of subscales, a series of multivariate variance analyses (MANOVAs) was conducted by measure, consisting of the respective comprising subscales (see Table 2). Total scores, and those measures composed of only one scale, were subjected to an ANOVA. All multivariate analyses were followed with a univariate analysis of variance with the Benjamini-Hochberg procedure (Thissen, Steinberg, & Kuang, 2002) implemented as an additional control for multiple comparisons. Analyses were then repeated controlling for IQ.

RESULTS

Comparison of Children across FASD Diagnostic Classifications

Results of the physical examination for an FASD indicated that, of the 97 participants with PAE, 10 met criteria for FAS, 43 for pFAS, and 44 for ARND. The remaining 28 were in the nonexposed group and did not meet criteria for an FASD. Univariate analyses of variance comparing the relations among children according to FASD group classification (i.e., FAS, pFAS, ARND) and dependent variables indicated that the three groups did not significantly differ from one another. As such, they were combined into an overall PAE group, which was compared with the nonexposed group for substantive analyses.

Neurocognitive Differences between Children with and without PAE

Results are presented by construct. All univariate and multivariate analysis of variance assumptions were met unless otherwise noted. See Table 2 for means, standard deviations, omnibus and individual F statistics, and adjusted marginal means and standard errors after controlling for IQ.

Executive Functioning.—The BRIEF-Parent MANOVA comparing PAE and nonexposed groups produced significant overall, $F(2, 122) = 44.78$, $p < .001$, and individual F statistics, with the PAE group demonstrating higher scores. The significance of these results was maintained in the follow-up MANCOVA, controlling for IQ, for multivariate, $F(2, 121) = 39.47$, $p < .001$, and individual effects. The teacher version of the BRIEF produced the same pattern of results on the two-group MANOVA, which indicated significant overall, $F(2, 75) = 10.39$, $p < .001$, and component differences, with the PAE group demonstrating higher scores. The overall F maintained significance after controlling for IQ, $F(2, 74) = 8.54$, $p < .001$, as did the individual effects. Executive functioning as measured by the CCT was significantly different between groups as measured by the two-group MANOVA, $F(2, 124) = 4.38$, $p < .05$, with the PAE group demonstrating poorer scores. Controlling for IQ, however, reduced the overall effect to nonsignificance.

Working and Visuospatial Memory.—The two-group MANOVA of the Digit Span and Spatial Span subtests produced a significant overall effect, $F(2, 122) = 9.59$, $p < .001$, and both subtests demonstrated significant group differences, with the PAE group demonstrating poorer scores. The overall significance maintained after controlling for IQ, $F(2, 121) = 5.24$, $p < .01$, but the individual effect of the Digit Span subtest was reduced to nonsignificance.

Language.—For the Figurative Language subtest of the Test of Language Competence, the two-group ANOVA indicated that the PAE group produced significantly poorer scores, $F(1, 120) = 8.43$, $p < .01$, than the nonexposed group. The significance was lost after controlling for IQ, $F(1, 119) = 1.50$, *ns*.

Adaptive/Emotional/Behavioral Functioning.—The MANOVA for the VABS produced a significant overall effect, $F(3, 121) = 16.53$, $p < .001$, which was maintained after controlling for IQ, $F(3, 120) = 12.78$, $p < .001$. All comprising scales individually demonstrated significant differences between groups, with the PAE group returning poorer scores than the nonexposed group.

A one-way ANOVA for the PBCL-Parent total score indicated a significant mean difference between the PAE and nonexposed groups that was maintained in a follow-up analysis of covariance (ANCOVA) controlling for IQ. The two-group MANOVA that included all seven scales indicated a significant overall effect, $F(7, 117) = 14.26$, $p < .001$, with the PAE group demonstrating elevated symptom scores when compared to the nonexposed group. Between-subjects effects were significant for all scales. Follow-up MANCOVA, controlling for IQ, indicated that the overall effect maintained significance, $F(7, 116) = 12.52$, $p < .001$, as did each of the individual effects for the comprising scales except Motor Skills and Activities.

The PBCL-Teacher version demonstrated a similar pattern. A one-way ANOVA for the total score indicated a significant mean difference between the PAE and nonexposed groups that was maintained in a follow-up ANCOVA controlling for IQ. The two-group MANOVA involving all seven scales indicated a significant overall effect, $F(7, 109) = 3.65$, $p < .001$. All comprising scales, except for Motor Skills and Activities, demonstrated significant group differences. This pattern maintained after controlling for IQ, $F(7, 112) = 2.67$, $p < .05$, with the exception of Academic/Work Performance, which was rendered nonsignificant.

Parent ratings of Inattention and Hyperactivity, as measured by the SNAP-IV, were significantly different across groups in the two-group MANOVA, with the PAE group demonstrating elevated scores when compared to the nonexposed group. The significance of the overall effect, $F(2, 122) = 36.07$, $p < .001$, was maintained after controlling for IQ, $F(2, 121) = 32.32$, $p < .001$. Individual scale effects were maintained as well.

The two-group MANOVA for the CBCL indicated a significant overall effect, $F(2, 122) = 50.96$, $p < .001$, with the PAE group receiving higher scores than the nonexposed group. Follow-up MANCOVA, controlling for IQ, indicated a maintained overall group difference, $F(2, 121) = 45.69$, $p < .001$, and the comprising indices continued to demonstrate significant group differences.

Regarding the TRF subscales, the two-group MANOVA produced a significant overall effect, $F(2, 106) = 8.70$, $p < .001$, with both indices demonstrating significant individual effects. The multivariate effect was maintained in the follow-up MANCOVA, $F(2, 105) = 5.60$, $p < .01$, though only the Externalizing Symptoms index demonstrated a significant difference.

The PDS score ANOVA indicated a significant group difference, $F(1, 123) = 8.06$, $p < .01$, with the PAE group receiving higher scores on depressive symptomatology. The significance was maintained after controlling for IQ, $F(1, 122) = 5.83$, $p < .01$.

Social Cognition

For the HAT, the two-group MANOVA indicated a significant overall effect, $F(2, 122) = 4.87$, $p < .01$, with only the Peer Entry scale demonstrating significant group differences, a pattern that was maintained after controlling for IQ, $F(2, 121) = 4.01$, $p < .05$. The PAE group scored higher on percentage of negative attributions than the nonexposed group.

DISCUSSION

This study examined whether the emerging “generalized deficit” conceptualization of children with prenatal alcohol exposure extends to children with higher intellectual functioning, or whether it may be an artifact associated with the lower intellectual performance of more severely affected/exposed children. The neurocognitive and behavioral functioning of higher functioning children with PAE who met criteria for FASD and who had social skills deficits were compared with that of a nonexposed group of children with social skills deficits. Consistent with the generalized deficit conceptualization, children in the PAE group returned significantly poorer scores than the nonexposed group on every construct assessed, including executive functioning, attention, working/visuospatial memory, adaptive behavior, emotional/behavioral functioning, language abstraction ability, and social cognition. Findings were similar regardless of the source of the information, including performance tasks, self-report, parent, or teacher ratings. Moreover, differences were largely maintained after controlling for child IQ with the exception of some scales discussed below.

Executive functioning abilities were rated as significantly poorer for the PAE group by parents and teachers in both metacognitive and behavioral regulation domains. This is consistent with previous research using the BRIEF that included lower functioning PAE participants (Rasmussen, McAuley, & Andrew, 2007). Executive functioning as measured by the CCT was also significantly poorer for the PAE group, although, similar to previous work (Chasnoff et al., 2010), controlling for IQ reduced this finding to nonsignificance.

Working memory as measured by the WISC-III-PI subscales was also significantly poorer for the PAE group, though only the Spatial Span group differences remained significant after controlling for IQ. The Spatial Span difference remaining significant after controlling for IQ is consistent with findings from heavily exposed PAE samples (Mattson et al., 2010). Given that neuropsychological measures such as Digit Span are correlated with intelligence scales, it is not surprising that group differences were reduced to nonsignificance for this scale when controlling for IQ.

Language abstraction ability was significantly poorer for the PAE group, though it was rendered nonsignificant after controlling for IQ. Given the positive association between abstraction reasoning ability and intelligence, this result is not surprising and highlights the need to design interventions for children with PAE that are presented in a simple and concrete fashion.

Measures assessing adaptive, emotional, and behavioral functioning consistently indicated poorer performance for the PAE group. Adaptive behavior, as measured by the VABS, was particularly poor, even after controlling for IQ, when compared to the nonexposed control group who also had social skills deficits. In fact, the scores of the PAE children were similar to those reported for higher functioning children with an autism spectrum disorder (Perry, Flanagan, Dunn Geier, & Freeman, 2009), which underscores the importance of routinely incorporating prenatal substance exposure questions in evaluations of children with developmental disabilities to reduce the risk of misdiagnosis.

PBCL ratings indicated consistently greater behavior problems in the PAE group above and beyond the influence of IQ, save for the Motor Skills and Activities scale (parents and teachers). One reason may be that individuals with significant motor difficulties were excluded from the original sample recruitment process, potentially contributing to this finding. After controlling for IQ, the Academic/Work performance scale was no longer significant according to teachers' reports. This may be due to the confounding of academic performance and IQ in that children with lower IQs may be viewed by their teachers as having more significant academic problems.

Regarding emotional regulation, teachers consistently noted problems in externalizing symptoms on the TRF that were also highly endorsed by parents on the CBCL. Parent reports of inattention and hyperactivity/impulsivity were also significantly greater for the PAE group than the nonexposed group on the SNAP-IV. It is noteworthy that teachers noted fewer internalizing behaviors on the TRF than parents did on the CBCL. This finding is particularly interesting, as children with PAE endorsed significantly greater depressive symptoms than the nonexposed group on the PDS and parent reports of elevated Internalizing Symptoms on the CBCL are consistent with the reports of their children. These findings suggest that teachers are less likely to be sensitive to children whom are not acting out in the classroom but whom, nonetheless, are experiencing emotional problems.

Regarding social cognition, performance on the HAT indicated that the PAE and nonexposed children exhibited similar degrees of hostile attribution to scenarios involving provocation by peers (pushing, bumping, etc.). However, in the peer-entry scenarios that did not involve physical provocation (e.g., a child asks two others if he can play with them and is told "no"), the PAE group was significantly more likely to attribute hostile intent to other children than the nonexposed social skills deficit control group. This effect also remained significant after controlling for IQ. These results are consistent with and extend previous research comparing PAE and normal controls (Greenbaum, Stevens, Nash, Koren, & Rovet, 2009) and suggest that children with PAE may have experienced considerable peer rejection and therefore expect peers to be hostile toward them even when compared to a social skills deficit nonexposed group of children.

Interestingly, while all children in the study demonstrated social skills deficits, the PAE group was rated as having significantly more social problems by both parents and teachers on the PBCL and by parents on the VABS Socialization scale. These effects maintained their significance even after controlling for IQ. These results collectively illustrate that higher functioning children with PAE demonstrate significantly poorer functioning, beyond the influence of IQ, in multiple domains, and that relying on IQ alone to guide parental, peer, and school expectations may be misleading.

A primary goal of the current study was to investigate whether a generalized deficit model of impairment (Kodituwakku et al., 2011) extends to children with PAE who do not have a global intellectual disability. Consistent with the results of PAE samples with heavy alcohol exposure and those with intellectual disabilities, as well as a number of structural and functional imaging studies, the results from this study support the generalized deficit model. This study is notable for several reasons. First, it utilized children without global intellectual deficits. Second, children with PAE were compared to a nonexposed group of children who were themselves impaired socially rather than to a typically developing control group, thus contributing to efforts to distinguish between individuals with PAE and those with other developmental issues. Third, group differences largely remained significant even after controlling for IQ, illustrating that the negative effects of PAE are above and beyond the influence of intelligence. Fourth, this study supports a growing body of literature on the generalized deficit conceptualization of the functioning of children with PAE (Kodituwakku et al., 2011). Future research may benefit from a focus on strategies employed by children with PAE that may be less efficient than those used by typically developing children. Interventions could be designed to assist in the actual processing and retention of appropriate strategies for learning.

While a strength of this study, restricting the sample to those children with an IQ of 70 or higher limits the generalization of results to children whose functioning falls within the range of intellectual disability. In addition, the study was restricted to children with PAE who had deficits in socialization and did not address children with PAE who may not have social skills deficits. However, convergent evidence suggests that socialization in children with PAE may be the most affected domain within adaptive functioning (Mattson et al., 2011), so it is unlikely that the current sample is uncharacteristic of children with PAE. Additionally, the findings in this study are limited by sampling constraints. This study relied on a community-based convenience sample and stratified sampling techniques were not applied. Finally, although the measures comprising the assessment battery were selected to reflect a wide range of commonly researched neurocognitive and behavioral variables associated with PAE, they are not exhaustive in their reach. Episodic memory (Kully-Martens, Pei, Job, & Rasmussen, 2012) and numerical cognition (Kopera-Frye, Dehaene, & Streissguth, 1996), for example, are constructs with demonstrated sensitivity to PAE that were not captured by this battery. Certainly, there may be other abilities, behaviors, or skills that may also be impacted by PAE that would benefit from future study. As important is the identification of abilities that exhibit resilience to PAE. These intact abilities may be relative strengths through which tailored interventions may more effectively operate for individuals with PAE who do not benefit from existing treatment protocols.

It is important to note that there is controversy regarding the use of analysis of covariance to equate groups on an attribute (IQ) that is intrinsic to the condition being studied (Dennis et al., 2009; Pedhazur & Schmelkin, 1991; Wu & Slakter, 1989). Ideally, the independent variable and the covariate should be unrelated, and the inclusion of the covariate in the statistical analysis should increase power for finding a true relation between the independent and the dependent variables. However, for groups with neurodevelopmental disorders, mean IQ scores will be generally below the population normative mean. In this case, controlling for the covariate often reduces the magnitude of group differences. Specifically, as the correlation between the covariate and the independent variable becomes increasingly nonzero, the conclusions drawn about the independence of these variables and the legitimacy of controlling for the independent variable becomes suspect. In our study, the restriction of the range of IQs to 70 and above, resulted in a correlation of .24 between the independent variable, group (PAE versus no PAE) and the covariate IQ, accounting for only 6% of shared variance. Moreover, with the exception of a few outcome measures, the relations between IQ and the dependent variables were statistically significant ranging from .18, $p < .05$, to .67, $p < .0001$. Given that we were interested in examining these relations in individuals with PAE without intellectual disabilities (IQ ≥ 70), the result is that covarying IQ yielded little change in the outcome of the data analyses without such control. While we understand differing points of view and the statistical assumptions related to the appropriateness of controlling for IQ when it represents a characteristic intrinsic to individuals with developmental disabilities, we believe it an important issue to consider when addressing characteristics of children with PAE as previous studies have examined groups with highly differing mean IQ scores (Astley et al., 2009) that could result in spurious conclusions as to the nature and the uniqueness of the deficits shown by individuals with PAE.

In conclusion, study results indicate that children with PAE who do not have a global intellectual disability are at high risk for developing significant problems in a broad array of cognitive, emotional, behavioral, and social domains. As the problems of individuals with PAE and their individual, financial, and social impacts are better understood, it becomes increasingly evident that there is a pressing need for early identification and intervention in order to take advantage of the developing brain's plasticity and to maximize the likelihood of effecting meaningful functional improvement. This is particularly true for higher functioning individuals with PAE, who are less likely to be identified and treated than more severely affected children, and thus at arguably greater risk for maladaptive outcomes. Identification and treatment, however, may depend on examining the ways in which these individuals view their world and how they master various tasks of daily living throughout development rather than trying to identify a specific neurocognitive profile.

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Table 1

Sample Characteristics.

Variable	**Total (*N* = 125)**	**FAS (*n* = 10)**	**pFAS (*n* = 43)**	**ARND (*n* = 44)**	**Nonexposed (*n* = 28)**	**F/χ^2**
Ethnicity – White/Hisp (%)	69.6	70.0	69.8	70.5	67.9	0.06
Child Gender – Males (%)	52.8	80.0	55.8	43.2	53.6	4.77
Child Age (*M*, *SD*)	8.53 (1.51)	8.18 (2.10)	8.68 (1.49)	8.60 (1.47)	8.30 (1.43)	0.56
Child IQ (*M*, *SD*)	99.52 (14.87)	90.40 (15.64)	95.70 (14.49)	100.70 (13.65)	106.79 (14.11)	4.96**
Caregiver Ed (*M*, *SD*)	16.50 (2.84)	17.10 (2.78)	16.07 (2.67)	16.39 (2.59)	17.14 (3.43)	0.98

Note. *N* = 125; FAS = Fetal Alcohol Syndrome; pFAS = Partial Fetal Alcohol Syndrome; ARND = Alcohol-Related Neurodevelopmental Disorder.

** $p < .01$.

Table 2

Means, Standard Deviations, MANOVA, and MANCOVA Results for Alcohol-Exposed and Nonexposed Groups.

Variable	Alcohol-Exposed Mean (*SD*)	Nonexposed Mean (*SD*)	MANOVA *F*	Cohen's *d*	Alcohol Exposed Adj Mean (*SE*)	Nonexposed Adj Mean (*SE*)	MANCOVA *F*
Executive Functioning							
BRIEF – Parent			**44.78** ***				**39.47** ***
Metacognition Index	71.10 (9.59)	50.46 (13.04)	84.79 ***	1.82	70.96 (1.07)	50.96 (2.03)	74.16 ***
Behavioral Regulation Index	69.89 (12.07)	47.79 (13.19)	69.92 ***	1.75	69.81 (1.27)	48.06 (2.40)	62.59 ***
BRIEF - Teacher (*n* = 55, 23)			**10.39** ***				**8.54** ***
Metacognition Index	65.36 (14.67)	55.15 (14.75)	7.83 **	0.69	64.63 (1.92)	56.92 (3.02)	4.52 *
Behavioral Regulation Index	68.20 (18.72)	49.91 (6.87)	20.65 ***	1.43	67.71 (2.19)	51.08 (3.43)	16.28 ***
Children's Color Trails (*n* = 95, 28)			**4.73** *				**2.39**
Form 1	85.36 (18.98)	94.36 (14.40)	5.37 *	0.54	85.97 (1.83)	92.28 (3.43)	2.58
Form 2	80.92 (20.48)	92.98 (10.36)	9.00 **	0.78	81.73 (1.86)	90.25 (3.49)	4.54 *
Working/Visuospatial Memory							
WISC-III-PI			**9.59** ***				**5.24** **
Digit Span	8.68 (3.07)	10.14 (2.72)	5.17 *	0.50	8.89 (0.27)	9.42 (0.51)	0.80
Spatial Span	8.35 (3.57)	11.61 (3.14)	19.06 ***	0.97	8.57 (0.32)	10.84 (0.61)	10.57 ***
Language							
Figurative Language (*n* = 94, 28)	8.13 (2.89)	9.93 (2.85)	**8.43** **	0.63	8.41 (0.23)	9.00 (0.42)	**1.50**
Adaptive/Emotional/Behavioral Functioning							
Vineland Adaptive Behavior Scales			**16.53** ***				**12.78** ***
Communication	74.80 (15.21)	95.50 (14.82)	40.68 ***	1.38	75.79 (1.39)	92.07 (2.64)	29.09 ***
Daily Living Skills	62.47 (16.51)	84.54 (16.43)	38.89 ***	1.34	62.67 (1.69)	83.87 (3.21)	33.38 ***
Socialization	62.78 (8.12)	70.36 (9.00)	18.00 ***	0.88	62.90 (0.85)	69.97 (1.62)	14.63 ***
PBCL – Parent total	21.33 (7.59)	7.50 (6.32)	**77.30** ***	1.99	21.19 (0.75)	7.97 (1.42)	**66.28** ***
PBCL– Parent			**14.26** ***				**12.52** ***
Communication & Speech	4.40 (2.45)	1.61 (1.85)	31.25 ***	1.30	4.36 (0.24)	1.77 (0.45)	25.15 ***

Variable	Alcohol-Exposed Mean (*SD*)	Nonexposed Mean (*SD*)	MANOVA *F*	Cohen's *d*	Alcohol Exposed Adj Mean (*SE*)	Nonexposed Adj Mean (*SE*)	MANCOVA *F*
Personal Manner	2.92 (1.55)	1.14 (1.27)	30.63 ***	1.26	2.94 (0.15)	1.07 (0.29)	31.48 ***
Emotions	1.52 (0.75)	0.57 (0.74)	34.90 ***	1.28	1.54 (0.08)	0.50 (0.14)	39.91 ***
Motor Skills & Activities	0.88 (0.78)	0.50 (0.75)	5.15 *	0.50	0.87 (0.08)	0.53 (0.15)	3.83
Academic/Work Performance	2.28 (0.84)	0.93 (1.09)	49.26 ***	1.40	2.25 (0.09)	1.02 (0.17)	39.66 ***
Social Skills & Interactions	6.79 (2.94)	2.11 (2.42)	59.50 ***	1.75	6.71 (0.28)	2.41 (0.54)	48.29 **
Bodily or Physiologic Functions	2.57 (1.18)	0.77 (0.79)	57.27 ***	1.83	2.56 (0.11)	0.79 (0.22)	51.08 ***
PBCL – Teacher total (*n* = 94, 23)	11.12 (7.20)	4.98 (5.85)	**14.36** ***	0.94	10.94 (0.71)	5.69 (1.47)	**10.17** **
PBCL – Teacher (*n* = 94, 23)			**3.65** ***				**3.33** **
Communication & Speech	2.48 (2.06)	1.04 (1.43)	9.99 **	0.83	2.46 (0.20)	1.13 (0.42)	7.96 **
Personal Manner	1.74 (1.52)	0.93 (1.24)	5.58 *	0.59	1.73 (0.15)	0.99 (0.32)	4.32 *
Emotions	0.97 (0.92)	0.18 (0.41)	15.77 ***	1.19	0.96 (0.09)	0.24 (0.18)	12.55 ***
Motor Skills & Activities	0.50 (0.67)	0.43 (0.66)	0.18	0.11	0.48 (0.07)	0.51 (0.14)	0.02
Academic/Work Performance	1.49 (1.12)	0.83 (1.15)	6.37 *	0.58	1.45 (0.11)	0.98 (0.24)	3.23
Social Skills & Interactions	3.65 (2.60)	1.32 (1.90)	16.33 ***	1.04	3.59 (0.25)	1.56 (0.52)	11.83 ***
Bodily or Physiologic Functions	0.96 (0.83)	0.26 (0.54)	14.73 ***	1.02	0.97 (0.08)	0.24 (0.17)	14.57 ***
SNAP-IV			**36.07** ***				**32.32** ***
Inattention	18.15 (5.62)	8.57 (6.98)	56.45 ***	1.52	18.11 (0.61)	8.72 (1.16)	50.16 ***
Hyperactivity/Impulsivity	15.90 (7.00)	4.63 (5.72)	60.79 ***	1.77	15.87 (0.69)	4.73 (1.32)	54.84 ***
Child Behavior Checklist			**50.96** ***				**45.69** ***
Internalizing Symptoms	63.58 (10.11)	50.61 (14.48)	29.03 ***	1.06	63.74 (1.15)	50.04 (2.18)	30.21 ***
Externalizing Symptoms	68.66 (8.86)	47.71 (12.10)	102.10 ***	2.00	68.60 (0.99)	47.93 (1.89)	91.97 ***
Teacher Report Form (*n* = 94, 15)			**8.70** ***				**5.60** **
Internalizing Symptoms	56.65 (9.78)	50.40 (11.73)	5.00 *	0.58	56.49 (1.04)	51.37 (2.69)	3.09
Externalizing Symptoms	61.47 (9.92)	50.20 (8.31)	17.38 ***	1.24	61.18 (0.98)	51.99 (2.54)	11.17 ***
Pictorial Depression Scale	8.21 (6.66)	4.43 (4.19)	**8.06** **	0.70	8.11 (0.63)	4.78 (1.20)	**5.83** *
Social Cognition							

Variable	Alcohol-Exposed Mean (*SD*)	Nonexposed Mean (*SD*)	MANOVA *F*	Cohen's *d*	Alcohol Exposed Adj Mean (*SE*)	Nonexposed Adj Mean (*SE*)	MANCOVA *F*
Hostile Attribution Test			**4.87****				**4.01***
Provocation HAP	0.54 (0.31)	0.46 (0.26)	1.23	0.28	0.53 (0.03)	0.49 (0.06)	0.42
Peer-Entry HAP	0.56 (0.32)	0.35 (0.28)	9.82 **	0.70	0.56 (0.03)	0.36 (0.06)	7.98 **

Note. Overall *F*-statistics are in bold type. Measures composed of one scale were subjected to an ANOVA. Group sizes are, from left to right, 97 and 28, respectively, unless otherwise noted. BRIEF = Behavior Rating Inventory of Executive Function; SNAP-IV = Swanson, Nolan, and Pelham Parent Rating Scale, Version IV; WISC-III PI = Wechsler Intelligence Scale for Children as Process Instrument; PBCL = Problem Behavior Checklist; HAP = Hostile Attribution Proportion.

* $p < .05$.

** $p < .01$.

*** $p < .001$.