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Social Information Processing Skills in Children
with Histories of Heavy Prenatal Alcohol Exposure

A dissertation submitted in partial satisfaction of the
requirements for the degree of Doctor of Philosophy
in
Clinical Psychology

by
Christie L. McGee

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2009
The Dissertation of Christie L. McGee is approved, and it is acceptable in quality and form for publication on microfilm:
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<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ADHD</td>
<td>attention deficit hyperactivity disorder</td>
</tr>
<tr>
<td>ANOVA</td>
<td>analysis of variance</td>
</tr>
<tr>
<td>ALC</td>
<td>group of children with prenatal alcohol exposure</td>
</tr>
<tr>
<td>ARND</td>
<td>alcohol-related neurodevelopmental disorder</td>
</tr>
<tr>
<td>BRIEF</td>
<td>Behavior Rating Inventory of Executive Function</td>
</tr>
<tr>
<td>CBCL</td>
<td>Child Behavior Checklist</td>
</tr>
<tr>
<td>CBT</td>
<td>Center for Behavioral Teratology</td>
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<tr>
<td>CD</td>
<td>conduct disorder</td>
</tr>
<tr>
<td>CNS</td>
<td>central nervous system</td>
</tr>
<tr>
<td>CON</td>
<td>control group</td>
</tr>
<tr>
<td>FAS</td>
<td>fetal alcohol syndrome</td>
</tr>
<tr>
<td>FASD</td>
<td>fetal alcohol spectrum disorders</td>
</tr>
<tr>
<td>fMRI</td>
<td>functional magnetic resonance imaging</td>
</tr>
<tr>
<td>FSIQ</td>
<td>Full scale IQ index from the Wechsler Intelligence Scale for Children-III</td>
</tr>
<tr>
<td>LD</td>
<td>learning disability</td>
</tr>
<tr>
<td>MFC</td>
<td>medial frontal cortices</td>
</tr>
<tr>
<td>MR</td>
<td>mental retardation</td>
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<tr>
<td>MRI</td>
<td>magnetic resonance imaging</td>
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<td>MRS</td>
<td>magnetic resonance spectroscopy</td>
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<tr>
<td>ODD</td>
<td>oppositional defiant disorder</td>
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<tr>
<td>PET</td>
<td>positron emission tomography</td>
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<tr>
<td>RCT</td>
<td>randomized clinical trial</td>
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</table>
SPECT – single-photon emission computerized tomography

SPSI-R – Social Problem Solving Inventory, Revised

SSRS – Social Skills Rating System

TOPS-3 – Test of Problem Solving, Third Edition
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ABSTRACT OF THE DISSERTATION

Social Information Processing Skills in Children with Histories of Heavy Prenatal Alcohol Exposure

by

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Doctor of Philosophy in Clinical Psychology

University of California, San Diego, 2009
San Diego State University, 2009

Professor Edward P. Riley, Chair

Based on caregiver report, children with histories of prenatal alcohol exposure show significant difficulty with social functioning, but little is known about their social cognition. The current study assessed the social information processing skills of school-age children with histories of heavy prenatal alcohol exposure using a paradigm based on Crick and Dodge’s reformulated six-stage model. Fifty-two children (aged 7 to 11) with and without heavy prenatal alcohol exposure were compared using a structured interview measure of social information processing involving 18 videotaped vignettes of children in Group Entry and Provocation situations. Scores were generated for each of the six steps: encoding, attribution, goal clarification, response generation, response evaluation, and enactment. Group
differences in performance at each step were examined through univariate analysis of variance techniques and age and sex were modeled when relevant. The relationships between social information processing variables and related cognitive and behavior constructs were examined through canonical correlation. Children with heavy prenatal alcohol exposure demonstrated significant impairments in social information processing in all six steps across Group Entry and Provocation situations. Areas of impairment differed by the type of social situation, which is consistent with the previously reported situational specificity of social information processing. Specifically, alcohol-exposed children had difficulty on the goal, response generation, and response evaluation steps in Group Entry situations, and difficulty with encoding, attribution, response evaluation, and enactment during Provocation situations. Strong correlations with a measure of critical thinking and problem solving skills support the concurrent validity of the social information processing measure. Stronger social information processing skills were related to higher intelligence, stronger executive functioning, improved social functioning, fewer disruptive behavior problems, and lower levels of depression. Deficits in social information processing in children with prenatal alcohol exposure are likely related to alterations in brain structure and function as well as postnatal environmental factors. Such deficits are likely to result in significant problems with everyday functioning and poor quality of life. Social skills deficits, including social information processing deficits, are amenable to intervention and results from the current study may help in improving interventions for children with prenatal alcohol exposure.
I. INTRODUCTION

Background on Fetal Alcohol Syndrome and Fetal Alcohol Spectrum Disorders

Fetal Alcohol Syndrome

The devastating consequences of prenatal alcohol exposure have been alluded to for centuries (Calhoun & Warren, 2007). However, it was not until the late 1960s and early 1970s that the fetal alcohol syndrome (FAS) was first identified by the medical community (Jones & Smith, 1973; Jones, Smith, Ulleland, & Streissguth, 1973; Lemoine, Harousseau, Borteyru, & Menuet, 1968). Diagnostic criteria for FAS have not changed dramatically in the last 30 years, with refinements generally attempting to better quantify the degree or number of anomalies required (Bertrand et al., 2004; Hoyme et al., 2005). To receive a diagnosis of FAS, the following three criteria must be met: 1) characteristic facial abnormalities (e.g., short palpebral fissures, thin vermillion of the upper lip, indistinct philtrum), 2) pre- and/or postnatal growth deficiency, and 3) central nervous system (CNS) dysfunction. CNS dysfunction is measured by the presence of structural brain abnormalities, small head circumference, neurological problems, or functional deficits in areas such as intelligence, problem solving, attention, arithmetic, motor, or social functioning. Structural anomalies and functional impairments associated with prenatal alcohol exposure are described in more detail below. Studies of the birth incidence of FAS generally report a range of 0.5 to 2 of 1,000 live births depending on the ascertainment method and region sampled (May & Gossage, 2001); however estimates as high as almost 90 per 1,000 live births have been reported in specific populations (May, Gossage, et al., 2007)
Fetal Alcohol Spectrum Disorders

It is clear from the scientific and clinical literature that FAS is not the only consequence of prenatal alcohol exposure. A number of diagnostic terms (e.g., partial FAS, fetal alcohol effects, alcohol-related neurodevelopmental disorder [ARND], alcohol related birth defects [ARBD]) have been proposed to describe those individuals with behavioral or physical anomalies related to prenatal alcohol exposure, but who lack all of the features necessary to qualify for an FAS diagnosis (Hoyme et al., 2005). Most recently, the non-diagnostic umbrella term, fetal alcohol spectrum disorders (FASD), was proposed to encompass the full spectrum of effects ranging from FAS to more subtle physical, cognitive, and behavioral effects resulting from prenatal alcohol exposure (Bertrand et al., 2004; Hoyme et al., 2005). While the incidence of the full spectrum is unknown, epidemiological studies estimate the combined incidence of FAS and ARND at 10 per 1000, or one percent, of all live births (Sampson, Streissguth et al., 1997).

The reasons for this range of outcomes vary. The amount of alcohol that reaches the fetus is a major factor influencing outcomes. Dose and pattern of consumption by the mother determine this amount, as well as genetic factors affecting maternal and fetal metabolism and sensitivity to alcohol, and other variables such as nutritional status, medication and drug usage, stress, and maternal age (Gemma, Vichi, & Testai, 2007; Niccols, 2007). The teratogenic effects of alcohol also depend on the timing of the exposure relative to the developmental stage of the cells and tissues involved and variation in regional brain vulnerability. Multiple mechanisms of damage are well accepted, which are likely activated at different stages of development or dose
thresholds of exposure. Several of these mechanisms include disruption of midline serotonergic neuronal development, interference of L1-mediated cell-cell interactions, disruption of growth factor signaling, oxidative stress, and alteration of metabolic enzymes. These and other mechanisms can affect both anticipatory (i.e., biologically pre-determined) and adaptive developmental processes and may result in reduced neurogenesis, altered cellular migration and neurite outgrowth, mistiming of cellular events, altered synaptogenesis and myelination, and cell damage and death (Goodlett, Horn, & Zhou, 2005). Variability in the post-natal environment also likely contributes to the range of outcomes seen in children with prenatal alcohol exposure (Niccols, 2007).

So why are FASD important to study?

Based on incidence rates alone it is obvious that FASD are a major public health concern. FASD can occur wherever pregnant women consume alcohol and are not restricted by social class, ethnicity, or geographic region. In addition to the burden of care placed on the family, schools, and the community, estimates of the economic consequences of FASD are staggering. A recent report estimated that the adjusted lifetime cost is 2.9 million dollars per individual with FAS (Lupton, Burd, & Harwood, 2004). Thus, FASD have a devastating impact on society as a whole. The following several sections will outline areas of cognitive and behavioral impairment identified in individuals with FASD and describe alterations in brain structure and function associated with prenatal alcohol exposure. This review will serve to provide background knowledge as well as illustrate areas for continued study.
Prior to discussing research findings, it is important to consider differences in recruitment methodology in the field as this knowledge often aids in reconciling discrepancies between studies. Typically in prospective designs, detailed information on alcohol consumption is gathered from women during pregnancy and their children are followed longitudinally from birth. These studies often represent population-based research and the exposures are mostly at moderate or “social drinking” levels. Advantages of this design include more accurate measurement of alcohol consumption, greater control of confounding factors, stronger conclusions regarding changes over time, and the ability to examine dose-response relationships. Disadvantages include the expense and time it takes to conduct such studies, the small number of heavily exposed individuals often sampled, and the large number of subjects that must be recruited to detect effects related to the exposure. In retrospective designs, individuals are identified at some time after the alcohol exposure occurred, often during childhood or adolescence. Such samples frequently contain a large number of “clinically referred subjects” who come to the study because of some clinically significant manifestation of the exposure. The advantages of this methodology include increased sampling of more severe cases, smaller overall sample size required to detect effects, reduced time and cost to conduct the study, and the ability to include distinct control or comparison groups. Reporting and ascertainment biases are disadvantages of retrospective designs.

Cognitive Impairments

**General intellectual functioning:** The effect of prenatal alcohol exposure on intellectual functioning has received considerable attention, and FAS is frequently
cited as the leading known cause of mental retardation in the western world (Pulsifer, 1996). However, only about 25% of individuals with FAS have mental retardation (Streissguth et al., 2004) and IQ scores vary widely, ranging from as low as 20 to a high of at least 120 (Mattson & Riley, 1998). The average IQ of individuals with FAS is estimated to fall between 65 to 75 (Mattson & Riley, 1998) and estimates for individuals without FAS, but with histories of heavy prenatal alcohol exposure, average from the low to mid 80s (Mattson, Riley, Gramling, Delis, & Jones, 1997). Prospective studies of children with low to moderate levels of exposure are more variable, with reductions in IQ relating more to the pattern of exposure and other maternal and environmental characteristics than average alcohol consumption across pregnancy. Specifically, reductions in IQ are seen with children exposed to a binge pattern of drinking (Bailey et al., 2004; Streissguth, Barr, Sampson, Darby, & Martin, 1989), born to older mothers, receiving less optimal cognitive stimulation in the home environment (Jacobson, Jacobson, Sokol, Chiodo, & Corobana, 2004), or of African-American descent (Willford, Leech, & Day, 2006).

Information Processing: Deficits in information processing occur in both infants and children with histories of prenatal alcohol exposure (Burden, Jacobson, & Jacobson, 2005; Jacobson, 1998; Kable & Coles, 2004; Sampson, Kerr et al., 1997; Simmons, Wass, Thomas, & Riley, 2002; Streissguth, 2007). In general, both prospective and retrospective studies find increased or more variable response time (RT) on cognitive tasks, suggesting that individuals prenatally exposed to alcohol suffer from inefficient cognitive processing systems. A generalized deficit in complex information processing may help explain many of the cognitive difficulties seen in
children prenatal alcohol exposure (Kodituwakku, 2007). Consistent with this hypothesis, one study found that alcohol-exposed children demonstrate deficits in peripheral, but not central processing speeds when cognitive demands are low, but show deficits in both central and peripheral processing during more complex tasks (Simmons et al., 2002). While a follow-up study identified a linear relationship between the speed of information processing and the amount of information presented, no group differences in RT were found in an older sample, suggesting that younger children’s performance is adversely affected by a developmental delay that is no longer evident by adolescence (Simmons, Thomas, Levy, & Riley, 2006). Alcohol-exposed animals also have slower or more variable response times on cognitive tasks (Hausknecht et al., 2005).

Attention: Attention is an important domain of study given the characteristic attention deficits exhibited by individuals with prenatal alcohol exposure. In fact, many children with FASD receive diagnoses of attention deficit hyperactivity disorder (ADHD; Burd, Klug, Martsolf, & Kerbeshian, 2003; Fryer, McGee, Matt, Riley, & Mattson, 2007; Steinhausen & Spohr, 1998). Studies comparing attention measures in FASD and ADHD populations support somewhat different patterns of impairment (Coles et al., 1997; Nanson & Hiscock, 1990). For example, in one study, children with FASD had the most difficulty with encoding and shifting attention, whereas children with ADHD demonstrated greater difficulty focusing and sustaining attention (Coles et al., 1997). Children with prenatal alcohol exposure exhibit greater impairments in sustained visual attention, while auditory attention is less affected (Coles, Platzman, Lynch, & Freides, 2002; Mattson, Calarco, & Lang, 2006);
however, a study with adults found the opposite pattern (Connor, Streissguth, Sampson, Bookstein, & Barr, 1999). The Seattle 500 prospective study has consistently documented difficulties with attention across time (Streissguth, 2007). However, other prospective studies fail to find a relationship between prenatal alcohol exposure and sustained attention performance with children age 7 or younger (Boyd, Ernhart, Greene, Sokol, & Martier, 1991; Brown et al., 1991; Burden, Jacobson, Sokol, & Jacobson, 2005; Coles et al., 1997; Fried, Watkinson, & Gray, 1992). Animal studies find no differences in the orienting response (Hayne, Hess, & Campbell, 1992), but identify impairments in signal detection and sustained attention in alcohol exposed rats (Hausknecht et al., 2005; Woolfrey, Hunt, & Burk, 2005).

**Language:** Retrospective studies report consistent deficits in receptive and expressive language in children with prenatal alcohol exposure (Carney & Chermak, 1991; Church, Eldis, Blakley, & Bawle, 1997; Conry, 1990; Janzen, Nanson, & Block, 1995; Mattson, Riley, Gramling, Delis, & Jones, 1998; McGee, Bjorkquist, Riley, & Mattson, submitted), and these deficits tend to be commensurate with estimates of IQ (Becker, Warr-Leeper, & Leeper, 1990; McGee, Bjorkquist et al., submitted). Prospective studies, which tend to focus on children with lower exposures, are less consistent and results are variable in young children (Fried, O'Connell, & Watkinson, 1992; Fried & Watkinson, 1988, 1990; Greene, Ernhart, Martier, Sokol, & Ager, 1990; Gusella & Fried, 1984). However, one large study with adolescents found a moderate dose-response relationship between alcohol exposure and phonological processing, which underlies basic reading skills (Streissguth, Barr et al., 1994). In addition to age
and level of exposure, task complexity may also account for differences among studies (Kodituwakku, 2007).

**Visual spatial:** Impairments in visual spatial skills are consistently found in alcohol-exposed children (Conry, 1990; Janzen et al., 1995; Mattson et al., 1998; Streissguth, 2007), although one study suggested that deficits on some tests may be due to motor rather than perceptual problems (Janzen et al., 1995). With hierarchical stimuli, alcohol-exposed children display difficulties recalling local features, but show little to no impairment in recalling the global features when compared with controls (Mattson, Gramling, Delis, Jones, & Riley, 1996). The perception of geometric forms may depend on the integrity of the orientation selectivity of visual cortical neurons, which is altered in mammals with prenatal alcohol exposure. These findings suggest reduced plasticity, which may relate to impairments in NMDA receptor and CREB activation (Medina & Krahe, 2008).

**Learning and memory:** A number of studies demonstrate significant learning and memory impairments in individuals with prenatal alcohol exposure, with later work attempting to discern specific patterns of strengths and weaknesses in this domain. Explicit memory, or the active storage and retrieval of learned information, is impaired in alcohol-exposed individuals, whereas implicit memory, or more automatic and habitual processing, appears largely intact, although only limited data are available (Mattson & Riley, 1999). Within the domain of explicit memory, individuals prenatally exposed to alcohol display both retrieval (Mattson & Riley, 1999; Roebuck-Spencer & Mattson, 2004) and encoding deficits (Kaemingk, Mulvaney, & Tanner Halverson, 2003; Mattson, Riley, Delis, Stern, & Jones, 1996; Mattson & Roebuck,
Studies have also examined the type of information to be encoded and retrieved. Several studies demonstrate that children with heavy prenatal alcohol exposure have impaired verbal learning but are able to retain learned information (Kaemingk et al., 2003; Mattson, Riley, Delis et al., 1996; Mattson & Roebuck, 2002). However, when an implicit strategy (i.e., semantic clustering) is not included, alcohol-exposed children exhibit retrieval deficits beyond what is expected due to poor encoding (Roebuck-Spencer & Mattson, 2004). Similarly, children with light to moderate levels of prenatal alcohol exposure demonstrate impaired learning of verbal information that accounts for observed memory deficits (Willford, Richardson, Leech, & Day, 2004).

For material presented nonverbally, children with heavy prenatal alcohol exposure show both impaired encoding and retrieval (Kaemingk et al., 2003; Mattson & Roebuck, 2002). Prospective studies are more variable, with some finding a relationship between prenatal alcohol exposure and difficulty with nonverbal memory (Streissguth, 2007), and others not (Willford et al., 2004). These differences may be a result of level and pattern of exposure, task complexity, and type of stimuli used. Individuals with prenatal alcohol exposure exhibit spatial learning and recall deficits, whereas object recall is generally intact (Hamilton, Kodituwakku, Sutherland, & Savage, 2003; Streissguth, Sampson et al., 1994; Uecker & Nadel, 1996, 1998).

However, learning was not controlled for in these studies and therefore it is unknown if spatial recall deficits are due to learning impairments or retrieval deficits. Animal studies consistently find alcohol-related deficits in spatial learning and memory, and
these deficits are congruous with neuroanatomical and electrophysiological alterations to the hippocampus seen in animals exposed to alcohol (Berman & Hannigan, 2000).

**Motor**: The majority of studies of motor abilities identify fine and gross motor deficits in children and adolescents with prenatal alcohol exposure (Adnams et al., 2001; Barr, Streissguth, Darby, & Sampson, 1990; Conry, 1990; Jones et al., 1973; Kalberg et al., 2006; Korkman, Kettunen, & Autti-Rämö, 2003; Mattson et al., 1998; Streissguth, Barr, Sampson, & Bookstein, 1994). In addition, impairments in postural balance are well characterized (Roebuck, Simmons, Mattson, & Riley, 1998; Roebuck, Simmons, Richardson, Mattson, & Riley, 1998). Specifically, children with prenatal alcohol exposure show greater body sway when somatosensory information is unreliable, and balance impairments are related to CNS dysfunction rather than problems with peripheral sensory or motor function. Alcohol-exposed children also are slower and less accurate on bimanual coordination tasks, especially with increased task complexity (Roebuck-Spencer, Mattson, Marion, Brown, & Riley, 2004). Findings with retrospectively identified adults with heavy exposure suggest that motor deficits persist into adulthood. However, a longitudinal prospective study failed to find the same dose-dependent relationship between motor performance and alcohol exposure at age 25 (Connor, Sampson, Streissguth, Bookstein, & Barr, 2006) that was present at age 4 (Barr et al., 1990), suggesting a developmental delay. Animal models demonstrate a wide range of balance and coordination deficiencies associated with prenatal alcohol exposure including problems with balance, gait, muscle tremors, and deficits in fine and gross motor functioning (Goodlett, Thomas, & West, 1991; Hannigan & Riley, 1989; Klintsova et al., 1998; Meyer, Kotch, & Riley, 1990a,
The severity of motor coordination problems in animals exposed to alcohol correlates with the quantity of cerebellar Purkinje cell loss (Thomas et al., 1998).

**Executive functioning**: Executive functioning is a complex construct that has been broadly defined as “the ability to maintain an appropriate problem solving set for the attainment of a goal” (Welsh & Pennington, 1988). A variety of cognitive domains are subsumed under this general definition including inhibition, set shifting and set maintenance, planning, working memory, and the ability to integrate information across time and space (Pennington & Ozonoff, 1996). Executive functions are essential for adaptive responses to novel situations and are the basis of many cognitive, emotional, and social skills (Lezak, Howieson, Loring, Hannay, & Fischer, 2004). Individuals prenatally exposed to alcohol have deficits on measures of planning, set shifting and flexibility, some aspects of inhibition, fluency, working memory, concept formation, problem solving, and abstract reasoning (Burden, Jacobson, Sokol et al., 2005; Carmichael Olson, Feldman, Streissguth, Sampson, & Bookstein, 1998; Connor, Sampson, Bookstein, Barr, & Streissguth, 2000; Green, Munoz, Nikkel, & Reynolds, 2007; Kodituwakku et al., 2006; Kodituwakku, Handmaker, Cutler, Weathersby, & Handmaker, 1995; Kodituwakku, May, Clericuzio, & Weers, 2001; Kopera-Frye, Dehaene, & Streissguth, 1996; Mattson, Goodman, Caine, Delis, & Riley, 1999; Mattson et al., 1998; McGee, Schonfeld, Roebuck-Spencer, Riley, & Mattson, submitted; Schonfeld, Mattson, Lang, Delis, & Riley, 2001). Research demonstrates that deficits in executive functioning are above and beyond deficits on more basic component processes (Mattson et al., 1999).
**Academic:** Children and adolescents with histories of prenatal alcohol exposure often have difficulties in school, and many require remedial placements or additional educational resources and supports (Spohr, Willms, & Steinhausen, 2007; Streissguth, Barr, & Sampson, 1990; Streissguth et al., 2004). Standardized testing reflects significant impairments in academic achievement for most samples, with arithmetic performance being especially poor (Coles et al., 1991; Goldschmidt, Richardson, Stoffer, Geva, & Day, 1996; Howell, Lynch, Platzman, Smith, & Coles, 2006; Kopera-Frye et al., 1996; Mattson et al., 1998; Streissguth, 2007; Streissguth et al., 1991). For example, one study found mean achievement scores in a retrospective sample of older adolescents and adults in reading, spelling, and arithmetic at the fourth, third, and second grade levels, respectively (Streissguth et al., 1991). Alcohol exposure and arithmetic performance exhibit a linear dose response relationship, whereas reading and spelling performance are only affected past a threshold equivalent of 1 drink per day (Goldschmidt et al., 1996). Math and reading scores are also negatively correlated to teacher-rated inattentive symptoms (Kodituwakku et al., 2006).

**Behavior**

**Adaptive and social functioning:** Adaptive functioning is one of the most important aspects of behavior because it involves being able to perform daily activities and adapt to changes in one’s environment. Without effective adaptive skills, an individual would have difficulty coping with everyday stressors and completing even basic tasks of daily living. Studies with retrospectively identified alcohol-exposed children and adults demonstrate significantly poorer adaptive functioning in
comparison with non-exposed controls, especially in the domain of social functioning (Streissguth et al., 1991; Whaley, O'Connor, & Gunderson, 2001). For example, one study found that although the mean chronological age of the sample was 17, the mean adaptive age was approximately 7 years. In this sample, alcohol-exposed individuals showed the highest scores in the domain of daily living (mean age equivalent of 9 years) and the lowest scores in socialization (mean age equivalent of 6 years), with no individual meeting age expectations in the domains of communication or socialization (Streissguth et al., 1991). In contrast, a longitudinal prospective study found no significant differences in adaptive functioning with respect to level of alcohol exposure at ages 6 or 15, with scores falling in the average range (Coles et al., 1991; Howell et al., 2006). Possible explanations for this discrepancy between studies include differences in ascertainment method (e.g., lower exposures, fewer children with FAS), the demographics of populations sampled (e.g., African American children from low socioeconomic backgrounds), and differences in caregiver expectations.

Additional studies with retrospectively-identified children with prenatal alcohol exposure find that socialization scores decrease with age, suggesting that as expectations increase as children get older, children with prenatal alcohol exposure have more difficulty meeting age-expected standards (Thomas, Kelly, Mattson, & Riley, 1998; Whaley et al., 2001). Comparisons with specific contrast groups demonstrate that deficits in socialization are above and beyond what would be expected based on deficits in intellectual functioning (Thomas et al., 1998) or the presence of problems requiring clinical intervention (Whaley et al., 2001). Within the socialization domain, interpersonal functioning is particularly affected (Thomas et al.,
1998). While children with prenatal alcohol exposure display a normal frequency of social interactions with appropriate facial expressions and nonverbal behaviors, the quality of their social interactions with others is often poor and inappropriate (Bishop, Gahagan, & Lord, 2007). Several studies suggest possible mechanisms for these deficits including: poorer attachment to adult caregivers during young childhood (O'Connor, Kogan, & Findlay, 2002), which may limit exposure to and learning of appropriate social skills; deficits in executive functioning (Schonfeld, Paley, Frankel, & O'Connor, 2006); and increased difficulty providing sufficient information to communicative partners (Coggins, Friet, & Morgan, 1998). Findings of impaired social functioning in humans are consistent with results of animal studies that show poor pup-dam interactions, alterations in play behavior, increased aggression, impaired social recognition, and changes in active social interactions (for a review see Kelly, Day, & Streissguth, 2000).

**Behavioral and emotional functioning:** Retrospectively identified children and young adults with prenatal alcohol exposure are generally rated by their caregivers and teachers as having more significant behavioral problems than their typically developing peers (Mattson & Riley, 2000; Roebuck, Mattson, & Riley, 1999; Spohr et al., 2007; Steinhausen & Spohr, 1998; Steinhausen, Willms, Metzke, & Spohr, 2003). The most significant and consistent difficulties are seen in the areas of attention, disruptive and delinquent behavior, and social problems. Prospective studies also find alcohol-related behavior problems in children and adolescents with prenatal alcohol exposure, but results are somewhat less consistent and may be due to differences in caregiver expectations or demographic characteristics of individual samples (Bailey et
Delinquent and aggressive behavior problems are most commonly found across prospective studies and a binge pattern of drinking is related more strongly to delinquent behavior problems than a steady pattern of drinking (Bailey et al., 2004; Carmichael Olson et al., 1997). High rates of delinquent behavior are associated with a lower level of moral maturity seen in children with prenatal alcohol exposure, especially with respect to their relationships with others (Schonfeld, Mattson, & Riley, 2005). Studies utilizing animal models commonly find overactivity and aggressive behavior in alcohol-exposed animals (Driscoll, Streissguth, & Riley, 1990; Kelly et al., 2000; Thomas, Melcer, Weinert, & Riley, 1998). Poor behavioral regulation may be partially related to alcohol-induced dysregulation of the limbic-hypothalamic-pituitary-adrenocortical (LHPA) axis, which is involved in the stress response (Schneider, Moore, & Kraemer, 2004).

**Psychopathology:** Most studies on the prevalence of psychopathology in individuals with prenatal alcohol exposure report high rates of psychiatric diagnoses across the age range and co-morbidity is common. In a large study (Streissguth, Barr, Kogan, & Bookstein, 1996) of alcohol-exposed individuals (n = 415) between the ages of 6 and 51, 94% of the sample had experienced at least one mental health problem and 23% had been hospitalized in an inpatient psychiatric facility for treatment. Additional studies with children find similar rates of psychopathology ranging from 87 to 97 percent of the alcohol-exposed sample meeting criteria for at least one psychiatric disorder, and 62 to 71 percent of children meeting criteria for 2 or more co-morbid disorders (Burd et al., 2003; Fryer, McGee et al., 2007; O'Connor, Shah et
ADHD is one of the most prevalent disorders among children with prenatal alcohol exposure, and rates of mood disorders and other disruptive behavior disorders are also relatively high in comparison to rates in the general population. One longitudinal retrospective investigation demonstrated the persistence of psychopathological symptoms from preschool through young adulthood and found a positive relationship between number of symptoms and severity of exposure (Spohr et al., 2007; Steinhausen & Spohr, 1998). Studies with adults also identify high rates of psychopathology. The most common diagnoses are alcohol and drug dependence, depressive disorders, and anxiety disorders, and maternal binge drinking is associated with increased odds of several disorders in comparison to a steady drinking pattern (Barr et al., 2006; Famy, Streissguth, & Unis, 1998). Several studies find that prenatal alcohol exposure is a stronger predictor of alcohol problems in adolescence and young adulthood than a positive family history of alcoholism (Alati et al., 2006; Baer, Barr, Bookstein, Sampson, & Streissguth, 1998; Baer, Sampson, Barr, Connor, & Streissguth, 2003). High rates of suicidality in adults and adolescents with histories of prenatal alcohol exposure are also commonly noted (Baldwin, 2007; O'Malley & Huggins, 2005; Streissguth et al., 1996).

Several mechanisms for the development of depressive symptoms have been investigated. Negative affect during infancy and caregiver-child attachment mediate the relationship between prenatal alcohol exposure and depressive symptomatology in childhood (Lowe, Handmaker, & Aragón, 2006; O'Connor, 2001; O'Connor & Kasari, 2000; O'Connor, Kogan et al., 2002; O'Connor & Paley, 2006). Alcohol-related alterations to circadian rhythms may also play an important role in the etiology of
mood disorders, as well as disruptions in sleeping and eating, social deficits, and attention problems (Sakata-Haga et al., 2006; Sher, 2004). The influence of maternal thyroid hormone deficiency, due to the suppressive effects of alcohol on the maternal and fetal hypothalamic-pituitary-thyroid axes, also likely contributes to the development of depressive symptomatology in prenatally exposed offspring (Wilcoxon, Kuo, Disterhoft, & Redei, 2005).

**Quality of life:** Many individuals with prenatal alcohol exposure have a reduced quality of life and are more likely to be in a dependent living environment and have difficulty with employment (Grant, Huggins, Connor, & Streissguth, 2005; Spohr et al., 2007; Streissguth et al., 1996). For example, in one sample of 90 adults with histories of prenatal alcohol exposure, 83 percent were in a dependent living environment (e.g., group home, with relatives) and 79 percent had problems with employment. A large proportion had difficulty managing finances and making decisions on their own, and many had difficulty obtaining medical and social services. Alcohol-exposed individuals had more difficulty holding down a job than obtaining one, and employment problems often included getting easily frustrated, poor task comprehension, poor judgment, social problems, unreliability, poor anger management, and problems with supervisors. In addition, almost half of the adults in the sample were parents, and half of these individuals were separated from their children. Protective factors for improved outcomes included early identification and diagnosis, a stable and nurturant home, no violence against oneself, and developmental disabilities services (Streissguth et al., 1996).
Brain Abnormalities

Early autopsy studies of individuals with prenatal alcohol exposure revealed widespread CNS disorganization, including microcephaly, neuroglial heterotopias, and ventricle, corpus callosum, basal ganglia, and cerebellar anomalies (for a review see Clarren, 1986). However, one limitation to these findings is that the cases that are typically autopsied are the most severe, which may not be typical of the brain changes that occur in the majority of individuals with prenatal alcohol exposure. More recently, structural and functional neuroimaging techniques have allowed for identification of specific alterations in brains of living individuals exposed prenatally to a range of alcohol levels. Findings from neuroimaging studies reveal a pattern of structural and functional abnormalities consistent with the cognitive and behavioral impairments found in individuals with prenatal alcohol exposure. First, structural findings will be discussed by brain region or structure, and identification of brain-behavior relationships will be noted as relevant. Recent functional studies are also discussed.

Cerebral volume and shape abnormalities: Volumetric reductions of the cranial vault are consistently found in individuals with prenatal alcohol exposure (Archibald et al., 2001; Autti-Rämö et al., 2002; Johnson, Swayze, Sato, & Andreasen, 1996; Mattson et al., 1992; Mattson et al., 1994; Mattson, Riley, Sowell et al., 1996; Sowell et al., 2001, 2002; Swayze et al., 1997). Lobular analyses reveal volumetric reductions in the parietal, frontal, and temporal lobes (Sowell et al., 2002); however, when the reduction in overall brain size is considered, only the parietal lobe is disproportionately reduced (Archibald et al., 2001; Sowell et al., 2002). Detailed
regional analyses find reduced local brain growth bilaterally in the inferior parietal and perisylvian areas as well as in the left anterior and orbitofrontal cortex (Sowell et al., 2002). Local reductions in growth result in changes to the overall shape of the brain, such that alcohol-exposed subjects have smaller and narrower brains with some blunting in frontal areas, compared to typically developing children. Ultrasonographic methods also show reductions in frontal lobe size in fetuses exposed to alcohol prenatally (Kfir et al., in press; Wass, Persutte, & Hobbins, 2001). Frontal lobe anomalies are consistent with findings of executive functioning deficits in this population (Rasmussen, 2005). Alterations to the parietal lobe may relate to impairments seen in individuals with prenatal alcohol exposure in spatial working memory, object and face recognition, and language processing (Mattson & Riley, 1998; Sowell et al., 2002).

Studies with animal models are congruous with human findings and find decreased overall brain weight, reductions in neuronal and glial cells, altered dendritic morphology and neuronal distribution, and abnormal connectivity (West, Chen, & Pantazis, 1994). Research demonstrates that brain regions show selective vulnerability to alcohol exposure, which varies depending on the pattern and timing of exposure relative to the developmental stage of the cell populations (Dunty, Chen, Zucker, Dehart, & Sulik, 2001; Maier & West, 2001). For example, mouse embryos exposed to ethanol on gestational day 7 (equivalent to 3rd week of human gestation) exhibit craniofacial and midline abnormalities consistent with FAS (Sulik, Johnston, & Webb, 1981); however, if exposed 1.5 days later (equivalent to 4th week of human gestation) embryos show more diffuse brain hypoplasia and facial features similar to the
DiGeorge sequence (Sulik, Johnston, Daft, Russell, & Dehart, 1986). Later in development during the rodent postnatal period (equivalent to human third trimester), ethanol exposure results in selective loss of cerebellar purkinje and granular cells (Bonthius & West, 1990; Goodlett, Marcussen, & West, 1990).

Differences in tissue composition in the cerebrum: In addition to volumetric and shape analyses, studies have examined the tissue composition of the cerebrum and results are generally consistent. Significant overall gray and white matter reductions are found in individuals with prenatal alcohol exposure (Archibald et al., 2001; Sowell et al., 2001). When reduced brain size is taken into account, white matter is disproportionately reduced and more severe than gray matter hypoplasia (Archibald et al., 2001). White and gray matter volumes have also been examined within each lobe, and both white and gray matter are disproportionately reduced in the parietal lobe (Archibald et al., 2001). More specific analyses reveal increased gray matter and decreased white matter in the left posterior temporo-parietal region in alcohol exposed subjects when compared to controls (Sowell et al., 2001). Consistent with findings of increased gray matter, increases in cortical thickness are noted in bilateral temporal and inferior parietal regions and also in right frontal regions, while more dorsal regions are relatively spared (Sowell, Mattson et al., 2008). Increased cortical thickness in dorsal frontal regions is related to poorer verbal recall in individuals with prenatal alcohol exposure. The increases in gray matter and cortical thickness observed through MRI may actually be unmyelinated peripheral axon fibers and reflect decreased myelination. A study using diffusion tensor imaging is in line with this hypothesis, identifying decreased fiber coherence in white matter innervating the
right lateral temporal lobe (Sowell, Johnson et al., 2008). Gray matter density asymmetry has also been examined directly, and findings show that alcohol-exposed subjects lack the prominent right greater than left asymmetry of gray matter seen in the posterior inferior temporal lobe in controls (Sowell et al., 2002).

**Cerebellum:** Volumetric reductions of the cerebellum are commonly found in studies with individuals prenatally exposed to alcohol (Archibald et al., 2001; Autti-Rämö et al., 2002; Bookstein, Streissguth, Connor, & Sampson, 2006; Mattson et al., 1992; Mattson et al., 1994; Riikonen, Salonen, Partanen, & Verho, 1999). Prenatal ultrasound also shows reductions in cerebellar width in heavily exposed fetuses (Handmaker et al., 2006). In addition to gross cerebellar reductions, disproportionate reductions are found in the anterior portion of the vermis (Lobules I-V), whereas the later-developing posterior regions are relatively spared (O'Hare et al., 2005; Sowell et al., 1996). The superior and anterior edges of the anterior vermis are also displaced more than other regions of the vermis in alcohol-exposed subjects compared to non-exposed controls (O'Hare et al., 2005). Vermal dysmorphology directly correlates with verbal learning and memory in alcohol-exposed individuals (O'Hare et al., 2005). In addition, alterations to the cerebellum are likely related to deficits in postural balance (Roebuck, Simmons, Mattson et al., 1998), temporal processing (Wass, Simmons, Thomas, & Riley, 2002), eye-blink conditioning (Coffin, Baroody, Schneider, & O’Neill, 2005; Jacobson et al., 2008), and attention (Coles et al., 2002; Coles et al., 1997; Streissguth, Bookstein, Sampson, & Barr, 1995) commonly seen in individuals with prenatal alcohol exposure. Concordant with human findings, research from animal models indicate that decreases in cerebellar size are due to alcohol-
induced apoptosis of Purkinje cells, especially in the earlier maturing lobules I to III and lobule IX (Bonthius et al., 1996; Bonthius & West, 1991; Hamre & West, 1993).

**Corpus callosum:** The corpus callosum is a tract of fibers that connects the two cerebral hemispheres and facilitates interhemisphereic communication. Reports of agenesis, or complete absence of the corpus callosum, have been noted in children and adolescents prenatally exposed to alcohol, as well as less severe alterations such as thinning, hypoplasia, or partial agenesis (Autti-Rämö et al., 2002; Bhatara et al., 2002; Clark, Li, Conry, Conry, & Loock, 2000; Johnson et al., 1996; Mattson et al., 1992; Riikonen et al., 1999; Riley et al., 1995; Sowell et al., 2001; Swayze et al., 1997).

Detailed analyses reveal disproportionate reductions in regions of the corpus callosum, most notably in the splenium (Riley et al., 1995; Sowell et al., 2001). In addition, the splenium is displaced in the inferior and anterior direction, and displacement is a significant predictor of verbal learning for alcohol-exposed subjects (Sowell et al., 2001). In a study utilizing pediatric ultrasonography of infants in the first 3 months of life, half of the sample of alcohol-exposed infants showed an abnormality in the angle of curvature of the splenium (Bookstein et al., 2007). Other studies find excess variability of callosal shape (Bookstein, Sampson, Connor, & Streissguth, 2002; Bookstein, Sampson, Streissguth, & Connor, 2001), which relates to differential performance on motor or executive functioning tasks (Bookstein, Streissguth, Sampson, Connor, & Barr, 2002). Finally, regions of the corpus callosum in children and young adults with prenatal alcohol exposure show decreased fiber coherence especially in posterior regions (Ma et al., 2005; Sowell, Johnson et al., 2008; Wozniak et al., 2006). In one study, abnormal microstructure in the lateral aspects of the
splenium correlated with visuomotor performance in children with prenatal alcohol exposure (Sowell, Johnson et al., 2008). In addition to the directly measured brain-behavior correlates discussed above, alterations to the corpus callosum may relate to alcohol-related impairments found in bimanual coordination (Roebuck-Spencer et al., 2004), interhemispheric transfer (Roebuck, Mattson, & Riley, 2002), attention (Coles et al., 2002; Coles et al., 1997; Streissguth et al., 1995), and executive functioning (Rasmussen, 2005). Research with animal models is consistent with imaging findings of the corpus callosum in children and adults, showing delayed or altered myelination, abnormal distribution of projection neurons, altered dendritic development, agenesis, and reductions in callosal area (Lancaster, 1994; Miller, 1997; Qiang, Wang, & Elberger, 2002; Wainwright & Gagnon, 1985).

Basal ganglia: The basal ganglia are a group of subcortical nuclei including the caudate, nucleus accumbens, and lenticular nucleus. The basal ganglia of alcohol-exposed subjects are reduced in volume, compared to controls (Mattson et al., 1992; Mattson et al., 1994; Mattson, Riley, Sowell et al., 1996). However, when overall brain size is taken into account, disproportionate reductions are only evident in the caudate while the volumes of the lenticular nucleus and nucleus accumbens remain relatively spared (Archibald et al., 2001; Mattson et al., 1992; Mattson, Riley, Sowell et al., 1996). The basal ganglia maintain many connections with other regions of the brain and may be involved in a number of critical functions such as motor coordination, executive functioning, spatial memory, perseveration, and set shifting, all of which are impaired in individuals with prenatal alcohol exposure (Mattson & Riley, 1998; Rasmussen, 2005).
Cingulate: The cingulate cortices are highly interconnected with other brain regions and are involved in functions including executive skills, social and affective processing, and attention. Children with prenatal alcohol exposure show volumetric reductions of both cingulate grey and white matter; however, only white matter volume is disproportionately reduced above and beyond global white matter hypoplasia (Bjorkquist, Fryer, Reiss, Mattson, & Riley, in preparation).

Hippocampus: Imaging studies observe hippocampal damage in alcohol-exposed subjects, though not consistently. Hippocampal abnormalities including hypoplasia, regional thinning, and asymmetry are noted in some studies (Autti-Rämö et al., 2002; Riikonen et al., 1999), whereas another study failed to find disproportionate reductions in hippocampal volume (Archibald et al., 2001). Animal findings are more congruous, showing reductions in cell numbers, abnormal branching of mossy fibers, reductions in dendritic spines, and impaired plasticity. Behavioral and electrophysiological studies in animals are consistent with observed neuroanatomical abnormalities (for a review see Berman & Hannigan, 2000).

Metabolic alterations: Several studies using functional imaging techniques such as single-photon emission computerized tomography (SPECT), positron emission tomography (PET), and magnetic resonance spectroscopy (MRS) reveal alterations in brain metabolism associated with prenatal alcohol exposure. SPECT results indicate decreased cerebral blood flow in the left parieto-occipital region, abnormal functional symmetry with similar blood flow in bilateral frontal lobes, reduced serotonin in the medial frontal cortex, and an increase in striatal dopamine transporter binding (Riikonen et al., 1999, 2005). The PET study found subtle reductions in glucose
metabolism in medial subcortical areas, including caudate and thalamic nuclei (Clark et al., 2000). In an MRS study, individuals with prenatal alcohol exposure have showed lower NAA/Cho and/or NAA/Cr ratios in parietal and lateral frontal cortices, frontal white matter, corpus callosum, anterior cingulate, thalamus, and cerebellar dentate nucleus, likely reflecting alterations to the glial rather than neuronal cell pool (Fagerlund et al., 2006). A second preliminary MRS study focusing on the caudate revealed increased NAA/Cr ratio in alcohol-exposed subjects (Cortese et al., 2006).

**Brain functioning:** Several recent studies have utilized functional magnetic resonance imaging (fMRI) to examine the hemodynamic brain response in adults and children with prenatal alcohol exposure. During a verbal paired associate task, alcohol-exposed children showed less activation in left medial and posterior temporal regions and more activation in the right dorsal frontal cortex, suggesting a compensatory mechanism for dysfunctional medial temporal memory systems (Sowell et al., 2007). On a response inhibition task, alcohol-exposed subjects exhibited increased frontal and decreased caudate activation, indicating that frontal-subcortical circuits are sensitive to prenatal alcohol exposure (Fryer, Tapert et al., 2007). Finally, a third study examining working memory found increased activation in the inferior and middle frontal cortices in alcohol-exposed participants but not in controls, although no between-group comparisons were conducted (Malisza et al., 2005). The results from this third study are difficult to interpret due to differences in task performance across groups (Bookheimer & Sowell, 2005). Although further functional studies are needed, these early studies are consistent with structural findings and
provide more direct evidence for altered brain-behavior relationships in individuals with prenatal alcohol exposure.

Pharmacological and Behavioral Interventions

Fetal alcohol spectrum disorders are entirely preventable. The most logical intervention is to convince women who are pregnant or trying to get pregnant to abstain from consuming alcohol. While a number of recent studies detail effective interventions aimed at prevention (e.g., Floyd et al., 2007; May, Miller et al., 2007), it is unlikely that prevention efforts will reach or be effective for all women at risk. For this reason, a number of studies are underway to design and evaluate molecular and behavioral treatments aimed at ameliorating the effects of prenatal alcohol exposure on the offspring. Research in basic science and animal models have identified a number of substances (e.g., choline, NAP, SAL, antioxidant supplements) that are effective in preventing the physical and behavioral effects of exposure if administered simultaneously or shortly after alcohol exposure (Goodlett et al., 2005). In addition, behavioral interventions in adult rats, such as motor training and environmental enrichment, show improvements in behavioral functioning in offspring with histories of prenatal exposure. The mechanism behind these improvements may be a result of enhanced plasticity, although not all studies have found accompanying brain changes (Berman & Hannigan, 2000; Hannigan & Berman, 2000; Klintsova et al., 1998; Klintsova, Goodlett, & Greenough, 2000; Medina & Krahe, 2008).

The effectiveness of pharmacological treatments for children with histories of prenatal alcohol exposure also has received limited attention recently. While two studies demonstrated positive responses to stimulant medication (O'Malley, Koplin, &
Dohner, 2000; Oesterheld et al., 1998), one study found a differential positive response of dextroamphetamine (Adderall) over methylphenidate (Ritalin; O'Malley et al., 2000). However, these studies had very small samples, and conclusions should be made with caution.

Several recent behavioral interventions show promise in improving the academic and behavioral functioning of school-aged children with prenatal alcohol exposure. Two randomly controlled trials (RCT) found improvements in mathematics or language and early literacy skills in children with prenatal alcohol exposure (Adnams et al., 2007; Kable, Coles, & Taddeo, 2007). Another RCT demonstrated the effectiveness of a manualized 12-week parent-assisted friendship training group on the social skills of alcohol-exposed children, who showed further improvement at the 3-month follow-up (O'Connor et al., 2006). Medication status was related to outcome in the friendship training intervention. Children prescribed with neuroleptic medication showed greater improvement on all outcome measures when compared to children not prescribed with neuroleptics, whereas children prescribed with stimulants either failed to show improvement or showed poorer outcomes when compared to children not prescribed with stimulants (Frankel, Paley, Marquardt, & O'Connor, 2006). A virtual fire and safety training intervention also was effective with children with prenatal alcohol exposure and generalized to behavioral testing at a 1-week follow-up (Coles, Strickland, Padgett, & Bellmoff, 2007). Only one pilot study has evaluated an intervention with adults with prenatal alcohol exposure. This study utilized an intervention that was modified from an existing framework developed to assist women with young children access appropriate services and ensure adequate housing.
Improved outcomes included decreased alcohol and drug use, increased use of contraceptives, improved utilization of medical and mental health care, and stable housing (Grant et al., 2004).

What is missing in our knowledge of FASD?

Upon review, it is evident that considerable work has been done characterizing the strengths and weaknesses of individuals with FASD. However, there are several areas where additional focus is warranted, most notably in domains that significantly impact adaptive functioning and may be amenable to intervention. One area not widely studied is social, or everyday, problem solving. Our knowledge of alcohol-exposed children’s social functioning is almost entirely based on caregiver report measures of general social skills and problem behaviors. Very limited information is available on how individuals with prenatal alcohol exposure process social information and solve problems with others, even though many parents report strong concerns in these areas. One preliminary study of adolescents with prenatal exposure to alcohol identified considerable impairments in social problem solving skills (McGee, Fryer, Bjorkquist, Mattson, & Riley, in press). In this sample, alcohol-exposed adolescents reported approaching problems with a pessimistic orientation and indicated a low frustration tolerance when confronted with a difficult task. In addition, they rated themselves as less effective at identifying problems, generating alternate solutions, making decisions, and implementing and verifying the chosen solution. Finally, alcohol-exposed adolescents were more likely than controls to endorse an avoidant, careless, or impulsive approach to solving their everyday problems. Such impairments are likely to have a devastating impact on an individual’s ability to
function adaptively in the social environment. However, studies of social cognitive abilities have not been conducted with younger children with prenatal alcohol exposure. By identifying children with social problem solving impairments at a young age, interventions can be introduced that may lead to improved adaptive functioning before the child reaches adolescence. Social problem solving is a domain amenable to intervention and a number of therapeutic approaches have been developed and empirically studied (e.g., Kam, Greenberg, & Kushé, 2004; Knoff & Batsche, 1995; Spivak & Shure, 1989). In addition, research shows that early identification and intervention leads to improved outcomes (Streissguth et al., 1996). Therefore, the current study aims to evaluate the social information processing and problem solving skills of younger children with heavy prenatal alcohol exposure to determine whether these are areas of impairment for this population and if intervention is warranted.

Social Information Processing and Problem Solving

Social Information Processing Model

During childhood, common types of social problems include initiating friendships, acquiring objects, seeking and offering help, seeking attention or information, and stopping others from acting in an undesirable way (Rubin & Krasnor, 1986). The current most common method utilized to measure social problem solving skills in children involves presenting hypothetical vignettes to children either in vivo or in story format and asking the child how he or she would respond to or solve the given problem. One such approach was developed by Dodge (1980) using a social information processing model. This nonlinear, reciprocal model (see Figure 1; Crick & Dodge, 1994) involves six steps: 1) encoding of external and internal cues, 2)
interpretation and mental representation of those cues, 3) clarification or selection of a goal, 4) response access or construction, 5) response decision, and 6) behavioral enactment.


During Steps 1 and 2, children selectively attend to particular situational and internal cues, encode those cues, and interpret them utilizing one or more independent processes as shown in Figure 1 (Crick & Dodge, 1994). Such processes may include accessing a personalized mental representation of situational cues stored in long term memory, performing a causal analysis of situational events, making inferences about
the intent of others, evaluating previous goal attainment or past performance with the peer, or inferring the meaning of the present exchange in relation to previous exchanges for oneself and the peer. In Step 3, after interpreting the situation, children select a goal or desired outcome for the situation. Next, in Step 4, children either access possible responses from memory or, if a situation is novel, construct new behaviors in response to immediate social cues. Children then evaluate these responses in Step 5 and select the most positively evaluated response for enactment. A number of factors are involved in children’s evaluations including outcome expectations, the degree of confidence they have in their ability to enact each response, and their evaluation of the appropriateness of each response. Once selected, the behavioral response is enacted in Step 6. While this model may lead to the view of children as conscious, reflective processors, the majority of processing is likely highly automated.

Children approach a social situation with a set of biologically limited capabilities and memories of previous experiences (illustrated by the “database” in the center of the model; Crick & Dodge, 1994). The relationship between these capabilities and information represented by the database and the social information processing steps is reciprocal: the processing steps can alter the database and the database can influence processing. As the child engages in additional social interactions, information gathered during each step of the process is integrated in the child’s mental representations and has the potential to influence future actions. These representations constitute the child’s social knowledge. These knowledge structures are important in representing social cues and guiding behavioral selection. Once perceived, important social cues are categorized into an existing memory store and
matched with a similar knowledge structure. Especially when social cues are unfamiliar, ambiguous, or complex, knowledge structures facilitate the representation of the current event by filling in missing information from existing memory stores.

Once the initial working representation is complete, knowledge structures can further aid in elaboration of that representation by supplying information regarding past consequences for similar situations and play an important role in guiding the selection of behavior. The chronic activation of similar knowledge structures over time may explain individual differences in social information processing (Burks, Laird, Dodge, Pettit, & Bates, 1999). As is illustrated by the cyclical structure and feedback loops in the model, social information processing proceeds in simultaneous parallel paths. That is, children are concurrently encoding, interpreting, and accessing responses.

However, although processing occurs simultaneously for these steps, the path for a specific stimulus to a behavioral response follows a time-related linear sequence of steps. Thus, deficits in one stage of processing can affect adequate functioning in other stages. For example, poor encoding may result in biased interpretations of the peer’s intent if the child did not encode the appropriate social cues. To adequately examine deficits in problem solving (i.e., response access and decision) comprehensive assessment of the six social information processing steps is essential (Crick & Dodge, 1994).

While Crick and Dodge (1994) recognize the importance of emotion in social information processing, the role of emotion was not explicitly integrated into the model until recently. Lemerise and Arsenio (2000) postulate the influence of emotion processes in all six steps. During the encoding and interpretation steps, children must
attend to and interpret their own internal emotion cues as well as the affective cues of others. Reciprocally, mood, emotions, and arousal levels can affect what the child notices about the social situation and how information is interpreted. During the goal clarification step, the intensity with which children experience emotions and their ability to regulate their emotional response will influence the types of goals selected. Children’s goals for social situations are linked to the type of response strategies selected (Chung & Asher, 1996; Erdley & Asher, 1999), and mediate the relationship between how children feel about and view themselves and their peers and their subsequent behavior in social situations (Salmivalli, Ojanen, Haanpaa, & Peets, 2005).

Emotional processing plays a significant role in reducing the infinite number of potential responses by prioritizing among different plans of action (Lemerise & Arsenio, 2000). Some emotional responses (e.g., feeling overwhelmed, impulsivity) may limit processing at the response generation and evaluation steps and may result in acting on the first response that comes to mind. Emotional intensity and the child’s regulatory capabilities are also likely to influence the child’s ability to enact the behavioral response chosen. Finally, differences in temperament, ability to regulate one’s emotions, and previous experiences with affective states (belonging to the “database” in the model) are likely to influence social information processing.

Although the effect of development on social information processing has not been well addressed empirically, Crick and Dodge (1994) provide a brief discussion on developmental implications for social information processing. Based on social learning theory, children acquire social problem solving skills through social modeling from adults and peers as well as experience in social situations. Children with
maladaptive social problem solving skills may have poor social models or have experienced fewer social exchanges in comparison with peers. Biological and attachment theories have also been investigated, and findings suggest the importance of biological dispositions and genetic factors as well as early mother-infant attachment in the development of adaptive social information processing skills (Dodge, 1993; Haskett & Willoughby, 2006; Ziv, Oppenheim, & Sagi-Schwartz, 2004). Additionally, maladjusted children may have an impairment, either congenital or acquired, that may hinder their ability to acquire age appropriate skills (Guralnick, 1999).

The developmental maturation of social information processing skills results from changes in two areas (Crick & Dodge, 1994). The first source of developmental change in children’s processing is the acquisition of cognitive skills, such as an increase in knowledge, improved attention, and greater mental organizational skills, that are generally commensurate with advances in brain maturation. As children get older, their experiences with social situations increase. Therefore, they are likely to undergo change in their social knowledge and exhibit qualitative differences in their strategy repertoires. Improvement in the ability to pay attention is likely to facilitate improved detection of subtle features of stimuli, and more efficient ways of representing and organizing social information are likely to enhance processing. The second source of developmental change is the speed of processing. Increased speed of processing allows for improved efficiency and complexity of processing social information. Consistent with these hypotheses, studies find that children become more efficient and accurate in their encoding of social information, are less likely to make biased attributions, and generate a greater number of competent responses in response
to peer conflict as they age (Gifford-Smith & Rabiner, 2004).

In addition to developmental considerations, differences between the sexes are important to consider when evaluating social information processing. Research shows that girls tend to be more interpersonally oriented (e.g., more pro-social, cooperative, concerned about social disapproval), whereas boys tend to be more instrumentally oriented (e.g., concerned about controlling external events, physical aggression, domination; Crick & Dodge, 1994). With respect to social information processing, girls make fewer encoding errors, endorse relationship maintenance goals over instrumental ones, and endorse more accommodation and compromise strategies in response to peer conflict. In contrast, boys are more likely to positively endorse aggressive strategies, negatively evaluate passive or pro-social strategies, and select goals concerning dominance and control (Gifford-Smith & Rabiner, 2004). Crick and Dodge propose two different hypotheses for how sex may moderate the relationship between social information processing and social adjustment. First, socially maladjusted children may act appropriately for their sex but in such an extreme manner that they are considered deviant. They may also exhibit non-normative behavior for their sex. Although probably less common, gender-aberrant behavior is likely to result in more negative consequences than extreme gender-consistent behavior (Crick & Dodge, 1994).

Empirical evidence has linked effective social information processing with social competence and peer acceptance (Dodge & Price, 1994; Nelson & Crick, 1999). Children who are accepted by their peers, as measured by sociometric status or competence ratings by teachers and peers, are more accurate in encoding, are less
likely to attribute hostile intent, and are more likely to perceive benign intent in response to provocation. In addition, accepted children are more likely to endorse relational goals over instrumental ones, and are more likely to generate and positively evaluate pro-social, competent problem solving strategies (Dodge & Price, 1994; Gifford-Smith & Rabiner, 2004; Mayeux & Cillessen, 2003; Nelson & Crick, 1999).

In contrast, rejected children tend to demonstrate some impairment in social information processing and are less competent and display more problematic behaviors (Crick & Dodge, 1994). The relationship between sociometric status and social behavior is likely reciprocal (Cillessen & Mayeux, 2004). For example, the experience of early peer rejection, either through confirming biased processing patterns or limiting social experience, can lead to stronger cognitive biases and increases in maladaptive behavior, which may lead to further rejection (Dodge et al., 2003; Gifford-Smith & Rabiner, 2004). Peer acceptance is important for adult functioning, and rejection can lead to significant problems later in life (Kupersmidt & DeRosier, 2004). Thus, social information processing is an important area for assessment. Children who have poorer social information processing skills are at risk for maladjustment and may benefit from intervention.

Neuroanatomy of Social Cognition

Research on the neurological bases of social cognition and behavior has expanded over recent years, especially with the increased utilization of fMRI technology. In combination with knowledge accumulated from research utilizing models from developmental psychology, such as the social information processing model discussed above, studies examining the functional anatomy of social cognition
have the potential to improve our understanding of brain-behavior relationships with respect to social functioning. This knowledge could lead to better assessment tools and a greater number of empirically derived treatment options. Like with many complex behaviors, a range of brain structures is involved in social cognition (Adolphs, 2003). Interactions between structures are complex and several of the proposed structures participate in multiple processes, often during distinct windows of time. Processing occurs in parallel circuits and routes differ in terms of their automaticity, detail of representations involved, and processing speed. A high level of feedback is also present between levels. A visual representation of structures involved in social cognition is depicted in Figure 2.

As reviewed in Adolphs (2003), social information processing typically begins with perceptual representation of stimuli through activation of higher-order sensory cortices. The amygdala, striatum, and orbitofrontal cortex mediate perceptual representations with emotional response, motivation, and cognitive processing. Higher cortical regions, such as left prefrontal, right parietal, and anterior and posterior cingulate cortices, are then involved in the construction of an internal model of the social environment including a representation of others, their relationships with oneself, and the significance of one’s actions in the social group. Further delineation of medial frontal cortices (MFC), including the anterior cingulate cortex, suggests that representations become more complex and abstract going from posterior to anterior regions. Specifically, the posterior rostral MFC represents and monitors the value of possible future actions, which is especially important for tasks involving response conflicts or response inhibition. Orbitofrontal regions of the MFC represent and update the value of future outcomes by processing information concerning rewards and punishment. Finally, anterior rostral regions of the MFC are involved in self-knowledge, perception and judgment of others, and representing another person’s psychological perspective (Amodio & Frith, 2006). As shown in Figure 2, several of the components of social cognition contribute to social knowledge (i.e., representation of emotional response and perceived action, modulation of cognition, and social reasoning), which is likely to expand with increased experience and refined connectivity between structures.

The majority of studies contributing to the model above has been conducted with adults, and specific neural structures involved in social cognition may subserve
somewhat different functions during different stages of development (Adolphs, 2001). However, studies during infancy, primarily using ERP and EEG technology, demonstrate some similarities between how adult and infant brains process social information. Specifically, most regions involved in adult social cognition can be activated in infants on basic social tasks such as face and eye gaze processing, perception of emotions, and decoding biological motion, although activation may extend into other regions and regions involved may have broader functions in infancy. With experience structures may become more differentiated and specialized in their response properties as seen in adulthood (Grossmann & Johnson, 2007). Limited research with children and adolescents has supported this hypothesis, and generally finds increasingly similar and more differentiated activation patterns, with younger individuals showing greater activation in specific regions than adults, which diminish as children get older. It has been suggested that age-related improvements in social cognition are at least partially related to increases in myelination in the prefrontal cortex and the wave of synaptogenesis and pruning during puberty (Blakemore & Choudhury, 2006). Future studies examining individuals across the lifespan could greatly improve our knowledge of brain-behavior relationships underlying social cognition.

Social Information Processing in Related Populations

Children with behavioral or cognitive profiles similar to children with FASD show deficits in social information processing and problem solving skills, suggesting that alcohol-exposed children may have related impairments. Much of the research in this area has been conducted with aggressive children. In fact, the social information
processing model detailed above was originally formulated and revised to study children with increased levels of aggression, and later was found to generalize to other groups (Gifford-Smith & Rabiner, 2004). Research suggests impairments in all six steps of the social information processing model with aggressive children (Dodge, 1993; Matthys, Cuperus, & Van Engeland, 1999; Yoon, Hughes, Gaur, & Thompson, 1999). In general, aggressive children encode fewer relevant cues, are biased towards hostile cues in their interpretations, are more likely to generate aggressive and less competent responses, and evaluate aggressive responses more positively than their non-aggressive peers. Moreover, research demonstrates the utility of examining differences between proactive and reactive aggressive children. Reactive aggression involves the display of angry aggression in response to perceived threat and typically has an earlier age of onset. Proactive aggression is non-angry aggression aimed at attaining instrumental or relational goals and typically emerges later in childhood. Reactive aggression is often associated with histories of trauma, abuse, and family instability, whereas proactive aggression is more related to social learning of aggressive models during childhood (Dodge, Lochman, Harnish, Bates, & Pettit, 1997; Gifford-Smith & Rabiner, 2004). Because reactive aggression is motivated by perceived threat, processing biases are more likely in the early stages of information processing (e.g., selective attention to hostile cues, hostile attribution biases). In contrast, proactively aggressive children exhibit biases in later stages of processing (e.g., goal setting, response evaluation) because of the desire to obtain specific outcomes. Findings from several studies to date have generally been consistent with these hypotheses (Crick & Dodge, 1996; Dodge et al., 1997).
In addition to the proactive and reactive subtypes, studies have subtyped aggressive children into those that are instrumentally aggressive versus those who are relationally aggressive. This classification has been especially illustrative of the gender-related differences of aggression, as girls tend to be more relationally aggressive than boys. Specifically, results indicate that the presence of hostile attribution bias for relationally and instrumentally aggressive children is specific and respective to the type of provocation. In other words, instrumentally aggressive children exhibit hostile attribution biases for instrumental provocation situations, whereas relationally aggressive children exhibit hostile attribution bias in response to relational provocation situations (Crick & Grotpeter, 1995; Crick, Grotpeter, & Bigbee, 2002). Furthermore, children who display high levels of aggressive behavior often receive clinical diagnoses of conduct disorder or oppositional defiant disorder. As identified above, children with prenatal alcohol exposure display higher levels of aggressive behavior and are more likely to receive diagnoses of disruptive behavior disorders than their non-exposed peers.

A few studies have examined the social information processing abilities of hyperactive children, which may be especially relevant due to the high levels of hyperactivity and inattention seen in children with FASD (Burd et al., 2003; Fryer, McGee et al., 2007). Imaging studies commonly find alterations to the prefrontal cortex in children with ADHD (Nigg & Casey, 2005), which may be consistent with deficits in social cognition. Several studies with children with ADHD find impaired encoding and higher levels of aggressive responses to provocation than controls (Matthys et al., 1999; McCann, 2001). However, when separated into accepted and
rejected hyperactive children, research shows that hyperactive children who are rejected by their peers have specific difficulty encoding and recalling socially relevant information, whereas non-rejected hyperactive children do not demonstrate difficulties in social information processing (Moore, Hughes, & Robinson, 1992). Thus, social information processing deficits may be more related to peer rejection than hyperactivity per se.

In addition to studies of children with more externalizing behaviors, research is emerging on the social information processing abilities of children with internalizing behaviors such as social withdrawal or depression. Withdrawn children generate fewer assertive and aggressive problem solving solutions and significantly more indirect, passive, and avoidant responses (Stewart & Rubin, 1995). In addition, one study found differential patterns of social information processing skills consistent with hypothesized subtypes of withdrawn children (Harrist, Zaia, Bates, Dodge, & Pettit, 1997). The first subtype was termed active-isolates and consists of socially unskilled children who are withdrawn because their peers do not allow them to play. These children are generally interested in playing with other children but due to immature or aggressive behaviors they are rejected by peers. Similar to active-isolates, passive-anxious children are interested in other children; however, they avoid play with peers due to fear of social interaction. The third hypothesized subtype is unsociable children who prefer to play alone but do not necessarily lack the social skills to interact competently with peers. With regard to social information processing, the active-isolate children display the most deviations, demonstrating encoding errors, high rates of hostile attributions, and low rates of competent problem solving responses. In
contrast, the passive-anxious and unsociable children deviate only in their tendency to underattribute hostility from peers. A fourth group of withdrawn children is classified as depressed or sad (Harrist et al., 1997). These children, while experiencing high levels of rejection and neglect by peers, display comparable patterns of social information processing to non-withdrawn children.

Other studies of depressed children find deficits in social information processing in all stages, although not always consistently. Common findings show that depressed children selectively attend to negative cues, display a hostile attribution bias, report less self-efficacy for assertive and competent responses, and make internal attributions for social rejection (Dodge, 1993; Quiggle, Garber, Panak, & Dodge, 1992). While depressed children display a hostile attribution bias similar to aggressive children, they are less likely to suggest assertive responses and view assertive behavior as resulting in fewer positive and more negative outcomes. Depressed children also evaluate withdrawal more favorably than non-depressed peers. While children with FASD tend to manifest a high level of disruptive and externalizing behaviors, high rates of depression have also been found (Burd et al., 2003; Fryer, McGee et al., 2007; O'Connor, Shah et al., 2002). In addition, children prenatally exposed to alcohol often have difficulty forming and maintaining friendships (O'Connor et al., 2006), and therefore children with FASD may show similar social information processing skills to withdrawn and depressed children.

As detailed above, children with FASD tend to have lower overall intellectual abilities than non-exposed peers, with 25 percent of children with FASD falling in the mentally retarded (MR) range (Streissguth et al., 2004). Compared to separate groups
matched on chronological age or mental age, children with MR are less accurate in interpreting accidental cues and are more hostile in responding to ambiguous cues (Gomez & Hazeldine, 1996). For children with FASD with higher IQ scores, it is not uncommon to find significant learning difficulties (Burd et al., 2003; Streissguth et al., 1990). Studies indicate that children with learning disabilities perform less well on each of the steps of the social information processing model than average-achieving classmates, and show specific deficits in encoding and response decision when compared with low-achieving children without learning disabilities (Tur-Kaspa, 2002).

Finally, many children with FASD experience maltreatment in their early environments. Studies with children with histories of maltreatment demonstrate significant social information processing impairments. Specifically, maltreated children show hostile encoding patterns, hostile attribution bias, and aggressive problem-solving styles, similar to aggressive children (Price & Glad, 2003; Weiss, Dodge, Bates, & Pettit, 1992). Research specifically examining reactive aggression in children often finds histories of physical abuse and harsh parenting, which is consistent with the pattern seen in maltreated children (Dodge et al., 1997). Further research shows that physically abused children generate more hostile attributions, more aggressive responses, and fewer competent responses than neglected and comparison children, whereas neglected children tend to generate more inept responses and fewer competent responses than comparison children (Keil & Price, in press).
Social information processing and FASD

The patterns of social information processing in these clinical populations suggest that children with FASD may have difficulty in the area of social information processing. Several possibilities exist: children with FASD will display social information processing patterns 1) consistent with one of the populations discussed above, 2) as a combination of patterns of several groups, or 3) different from the related populations. For example, one study found that children who were both aggressive and depressed displayed the social information processing difficulties of both aggressive and depressed children (Quiggle et al., 1992). However, researchers have utilized a variety of methods to classify and group children and the groups discussed above are not mutually exclusive. While it is difficult to hypothesize a specific pattern of social information processing performance, children with FASD demonstrate difficulty forming and maintaining friendships (O'Connor et al., 2006) and display a number of behavior patterns likely to interfere with appropriate social problem solving. In addition, many of the brain structures involved in social cognition discussed above are affected by prenatal alcohol exposure. Thus, based on our current knowledge of the cognitive and behavioral impairments as well as alterations in brain structure and function in individuals with prenatal alcohol exposure and findings with related or overlapping populations, it is hypothesized that children with prenatal alcohol exposure will show impairments in social information processing and problem solving.

Research suggests that social information processing and problem solving are domain-specific (Dodge, Laird, Lochman, Zelli, & Conduct Problems Prevention
Research Group, 2002). The current study focused on two areas of interpersonal problem solving common in children: peer group entry and response to provocation by a peer. Failure to achieve these goals effectively and consistently may result in difficulty with normal adjustment and social development. By comprehensively assessing social information processing, deficits may be identified that will assist in tailoring appropriate interventions and improving the quality of life for children with FASD.

Aims of the current study

(1) The first and primary aim of the current study was to investigate the social problem solving skills of children with heavy prenatal exposure to alcohol, with and without FAS, utilizing a social information processing approach. It was hypothesized that children with prenatal exposure to alcohol would display significant impairments in social information processing when compared to non-exposed controls. In addition, it was hypothesized that performance would correlate with an additional measure of problem solving.

(2) A second aim of the current study was to evaluate the relationship between social information processing and related cognitive and behavioral constructs with children prenatally exposed to alcohol. Constructs include intelligence, executive functions, social functioning, depression, and disruptive behavior. In addition, a measure of caregiver social problem solving skills was administered to evaluate the relationship between caregiver and child social problem solving. It was hypothesized that lower intelligence, poorer executive skills, poorer social functioning, higher levels of depression, and increased disruptive behavior would be related to impaired social
problem solving. Finally, more adaptive caregiver social problem solving was hypothesized to correlate positively with more competent child social information processing.
II. METHODS

Recruitment

Two groups of children were included in this study: children with heavy prenatal alcohol exposure (ALC) and a typically developing control group of children without prenatal alcohol exposure (CON). Children were recruited as part of a larger ongoing study of the behavioral teratogenicity of alcohol. Alcohol-exposed children are recruited into this larger study via several mechanisms, including professional referral or self-referral. Non-exposed participants are recruited from the community via advertising at various agencies and child-related venues. Mothers of children in the ALC group consumed at least 4 drinks per occasion at least once per week or 14 drinks per week during 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 was generally unavailable, as many children with heavy prenatal alcohol exposure no longer reside with their biological families. The majority of children in the control group reside with their biological mothers. Therefore, screening for exposure to alcohol or other teratogens in the CON group was determined through direct maternal report. Mothers of these children 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 in the alcohol-exposed group were also 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. Diagnostic information for three children was obtained through record review. Alcohol-exposed children with or without a diagnosis of FAS were included in the ALC group. Exclusionary criteria for both groups were language other than English, head injury with loss of consciousness greater than 30 minutes, and other disabling psychiatric or physical disorders that would prohibit participation (e.g., psychoses, paralysis).

**Participants**

Fifty-two children (aged 7 to 11 years) participated in this study, with (n = 26) and without (n = 26) prenatal alcohol exposure. Groups were matched on age, sex, and race/ethnicity. Within the ALC group, 6 had a diagnosis of FAS, 18 had histories of heavy prenatal alcohol exposure but did not meet criteria for FAS, and 2 had heavy exposure but had not been evaluated by a dysmorphologist upon study completion.

**General Procedure**

At the time of recruitment all procedures were explained to the parent/caregiver and child, and informed consent was obtained from the parent or guardian and assent from the child. Testing was completed at the Center for Behavioral Teratology (CBT) or at or near the child’s home if travel to the CBT posed a significant burden to the family. The testing session was conducted in a room with as few distractions as possible and typically lasted about 2 to 2.5 hours. Children were provided with breaks throughout the testing session as needed or requested. Parents or
caregivers were asked to complete several questionnaires at the time of testing. Upon completion of testing, children were provided with an incentive (money or a toy of similar value) for their participation. In addition to the specific measures described below, scores from the Wechsler Intelligence Scale for Children, Third Edition were available for most children as part of their participation in our ongoing studies. All procedures were approved by the Internal Review Board at San Diego State University and the Human Research Protections Program at University of California, San Diego.

**Measures**

During the testing session, children completed the Social Information Processing interview and the Test of Problem Solving, Third Edition Elementary Version (TOPS-3). Parents were asked to complete the Child Behavior Checklist (CBCL) if not completed within the last year at the CBT, the Behavior Rating Inventory of Executive Function (BRIEF), the Social Skills Rating System (SSRS), and the Social Problem Solving Inventory, Revised (SPSI-R). All of these measures are described in more detail below.

**Social Information Processing Interview**

The social information processing interview (Keil & Price, in press) was adapted from a measure created by Dodge and colleagues (Dodge, 1980) to better reflect the ethnic composition in San Diego. In this measure, the child was presented with 18 videotaped vignettes of problematic social situations. Child actors from four major ethnic groups (Caucasian, Latino, African-American, and Asian) were included, with ethnicity being randomized across stories. Two domains of problematic social
situations were presented: peer group entry and response to provocation. Each domain was composed of nine stories. In the hypothetical stories depicting Provocation situations, a child experiences some type of negative outcome in a social situation where the intention of the other peer was accidental, ambiguous, or hostile (3 stories of each intent type are used). For example, one Provocation situation involves the child being hit with a ball by a peer. For the stories depicting Group Entry situations, a child approaches two peers involved in some type of social activity. For example, one Group Entry scenario involves the child attempting to join two peers that are playing a board game. Across the nine stories, the peers respond to the child’s group entry attempt in a friendly, unresponsive, or rejecting manner (3 stories of each intent type are used). Following each video clip, the child completed a standardized interview that involved both forced choice and free response options that correspond to the six-step model of social information processing presented above.

**Step 1: Encoding** – In order to assess encoding patterns, children were asked to describe the events viewed in the vignette. For example, they were asked, “What happened in the story, from the beginning to the end?” Responses were coded according to the number of details provided by the child for a possible total of 6 points. Children received 2 points if they described the actions of the other child toward one’s self, and 1 point for each of the following: action of self, identification of activity, mention the presence of other child or children, and any detail about the setting. Scores from the stories were summed and averaged to arrive at a single encoding score for each of the two domains.
Step 2: Interpretation – The attribution step was assessed somewhat differently in the Provocation and Group Entry domains. In the Provocation domain, children were asked why the other child acted the way that s/he did in order to investigate their attribution of peer intent. In the forced choice follow-up to this question, children were asked to choose from the following intent options: (1) being mean, (2) not being mean, (3) hard to tell, (4) don’t know. Hostile attribution was calculated by taking the proportion of times that a child responded, “being mean” in either benign or ambiguous stories. Non-hostile attribution was calculated by taking the proportion of times that a child responded, “not being mean” in either hostile or ambiguous stories. In the Group Entry domain, children were asked how much the other kids want to play with them and were asked to choose from the following intent options: (1) not at all, (2) just a little, (3) very much. Hostile attribution was calculated by taking the proportion of times that a child responded, “not at all” in either benign or ambiguous stories. Nonhostile attribution was calculated by taking the proportion of times that a child responded, “just a little” or “very much” in either hostile or ambiguous stories.

Step 3: Clarification or selection of a goal – This step was not included when the videotape and standardized interview were developed. To be consistent with current theory a free-response question was added to assess the child’s goal for the given situation. After assessing the child’s attribution, the child was asked, “What do you want to happen next?” For both domains, responses were coded as pro-social, non-social, negative/aggressive, inept, or irrelevant. The proportion of each type of goal was calculated across stories for each domain.
Step 4: Response generation – The standardized questions for the two domains varied slightly. In the Provocation domain, the interviewer made one of three possible comments based on the intent of the characters in the vignettes: “Let say that it was hard to tell if this kid was being mean or not being mean,” “Let’s say that the other kid was being mean,” or “Let’s say that the other kid was not being mean.” The children’s problem-solving patterns were then assessed by asking, “What would you say or do if this happened to you?” After each response, children were asked, “What else could you say or do if this happened to you?” The child was questioned until either 6 responses were obtained or the child had no additional responses. In the Group Entry domain, the interviewer made one of three possible comments, again based on the designed intent of the characters in the vignettes: “Let say that it was hard to tell whether these kids wanted to you to play with them,” “Let’s say that the other kids did not want you to play with them,” or “Let’s say that the other kids did want you to play with them.” Again, the child was questioned until either 6 responses were obtained or the child had no additional responses. For both domains, responses were then coded as aggressive (e.g., hit the peer), competent (e.g., ask the peer why they did that), or inept (e.g., pout or whine). The aggressive problem-solving variable was then created by taking the proportion of aggressive responses over the total number of responses made. The competent and inept problem-solving variables were created in the same manner. Similar proportions counting only non-repeated responses were also formed. Finally the quality of the first response given was assessed by counting the number of aggressive, competent, and inept first responses and dividing each total by the total number of stories in that domain (i.e., 9 for each domain).
Step 5: Response evaluation – Children were then asked to evaluate the interpersonal and instrumental outcomes of three different response strategies (i.e., aggressive, competent, and inept). They were told that they were going to watch some other things that they could have said or done. After each response option, they were asked about the effectiveness of the strategy. For example, to assess affiliative outcomes, the child was asked, “Would the other kids like you if you did/said that?” To assess instrumental outcomes, they were asked, “Would the other kids let you play if you did that?” Specifically, the participants were first asked to judge the effectiveness of the presented response by answering either “yes” or “no.” Next, they were asked how certain they are about their choice, deciding between either “really sure” or “a little sure.” The order of presentation of endorsement options (i.e., “yes,” or “no,” and “really sure,” or “a little sure”) was counterbalanced across items to discourage participants from using a set response. There were four possible response options: (1) Yes, really sure; (2) Yes, a little sure; (3) No, a little sure; and (4) No, really sure. The evaluation variables were created by taking the sum of each participant’s endorsement of a certain type of strategy (either aggressive, competent, or inept) divided by the total endorsement score (i.e., the tendency to endorse affiliation or instrumental outcomes regardless of the strategy type). This resulted in six evaluation variables for each domain: three for affiliation scenarios and three for instrumental scenarios.

Step 6: Enactment – For each vignette, the subject was then asked to role-play a competent response to the event. The interviewer commented, “Let’s pretend that we are the people in the story. Now I want you to show me how you would say (the stated competent response).” For example, the interviewer asked a child to show her how
s/he would say, “That hurt. That wasn’t very nice.” The child’s responses were coded on the following scale: (0) very incompetent: failure to role play; (1) incomplete, inappropriate, or irrelevant response and/or lack of appropriate eye contact and tonal quality; (2) accurate recitation of response using either eye contact or conversational level voice tone; (3) accurate recitation of response using appropriate eye contact and conversational level voice tone; (4) very competent “Academy Award” performance of competent responses. Scores from the stories within each domain were summed and averaged to arrive at a single enactment score for each of the two domains.

**Reliability** – All files were independently scored by two raters and any discrepancies were resolved before calculating final scores. Inter-rater agreement was examined for steps requiring subjective ratings or response coding, which included the encoding, goal, response generation, and enactment steps. Ten files were selected at random and percent agreement (based on initial ratings) was determined for each story. Mean percentage agreement was also calculated across all stories and for each domain separately. For encoding, agreement for individual stories ranged from 70 to 100 percent, and overall agreement was 86.1 percent (Group Entry 88.9%, Provocation 83.3%). For the goal clarification step, independent raters only disagreed once across all stories (range 90-100%); overall mean percentage agreement was 99.4 percent (Group Entry 100.0%, Provocation 98.9%). Percentage agreement ranged from 73 to 98 percent (Mean = 86.3%, Group Entry 85.1%, Provocation 87.5%) for response generation when agreement on individual codes was examined. When agreement for overall response generation categories (i.e., competent, inept, aggressive) was calculated, percentage agreement was higher and ranged from 82 to 100 percent.
Agreement for Group Entry on response generation was likely somewhat lower than Provocation because the coding system was more complex. For enactment, percentage agreement ranged from 70 to 100 percent with an overall mean agreement of 88.3 percent (Group Entry 91.1%, Provocation 85.6%). Percentage agreement estimates are similar to or higher than previous studies (e.g., Dodge et al., 2003; Price & Landsverk, 1998; Quiggle et al., 1992).

Although there has not been an extensive amount of research on the psychometric properties of this type of measure, a recent study evaluating the effect of maltreatment on social information processing presented internal consistency estimates for each of the 13 scores for each domain (Keil & Price, in press). For the Provocation domain, alpha coefficients ranged from .53 for encoding to .94 for competent problem solving. The mean and median alpha values were .71 and .74, respectively, supporting the generally strong reliability of the processing variables. For the Group Entry domain, alpha coefficients ranged from .56 for hostile bias to .84 for aggressive evaluations in instrumental scenarios. The mean and median alpha values were .77 and .79, respectively. These alpha levels are equal or higher than estimates found for other measures involving social information processing variables (e.g., Dodge et al., 2002; Dodge & Price, 1994; Price & Glad, 2003; Price & Landsverk, 1998). Correlations between processing variables within each domain were conducted. Results showed that in general there were stronger relationships within processing steps, as compared to between steps, illustrating that while the processing steps are related to each other, they are not redundant. Correlation analyses were also conducted.
across domains, and results indicate that processing variables within steps are moderately related across the two social domains of Provocation and Group Entry. It should be noted that the encoding system utilized in the current study was altered prior to data collection to improve the distribution of scores and the goal selection step was not assessed in the Keil et al. study. In addition, a large study measuring 4 of the 6 stages of social information processing with slightly different tasks than those used in this study, demonstrated adequate reliability and evidence of convergent, discriminant, and construct validity through confirmatory factor analytic methods (Dodge et al., 2002).

Test of Problem Solving, Third Edition Elementary Version (TOPS-3)

The TOPS-3 (Bowers, Huisingh, & LoGiudice, 2005) measures a child’s language-based problem solving and critical thinking skills and contains six scales including Making Inferences, Predicting, Determining Causes, Sequencing, Negative Questions, and Problem Solving. A Total summary score is also provided reflecting the child’s average performance across the test. During the test, the child is presented with 18 photographs of various situations (e.g., child sick laying in bed, basketball practice, firefighter and small child) and is asked specific questions corresponding to the six scales. Children’s responses received 2, 1, or 0 points, depending on the appropriateness of the content, semantics, and linguistics. Internal consistency using Kuder-Richardson coefficients and averages across age groups range from .56 for Predicting to .69 for Negative Questions and Sequencing. In general, reliability coefficients are higher for younger children. Test-retest coefficients range on average from .62 for Predicting to .84 for the Total Test summary score. Inter-rater reliability
was also adequate with percent agreement ranging from 88% to 89% across 26 protocols. Evidence for validity was supported through the test’s ability to distinguish typically developing children from children with language disabilities (Bowers et al., 2005).

Child Behavior Checklist (CBCL)

The CBCL (Achenbach & Rescorla, 2001) is a widely used measure in child psychology that is designed to assess the social competence and behavior problems in children. Four of the Problem scales were selected for this study: Anxious/Depressed, Withdrawn/Depressed, Social Problems, and Rule-Breaking Behavior. Parents rated their child for how true each item was within the past 6 months on a three point scale ranging from not true to often true. Internal consistency (alpha) estimates for the whole measure range from .63 to .97 and test-retest correlations range from .82 to .94. Considerable evidence exists supporting the content, criterion, and construct validity of the CBCL (Achenbach & Rescorla, 2001).

Behavior Rating Inventory of Executive Function (BRIEF)

The BRIEF (Gioia, Isquith, Guy, & Kenworthy, 2000) measures the behavioral manifestations of executive functioning in children. Parents were asked to indicate the frequency of 86 behaviors as never, sometimes, or often. The two index scores from the BRIEF were selected for this study. The Behavioral Regulation Index (BRI) is comprised of the Inhibit, Shift, and Emotional Control scales and represents the child’s ability to shift cognitive set and regulate behavior and emotions by appropriate inhibitory control. The Metacognition Index (MI) measures the child’s ability to self-manage problem solving tasks and monitor his or her performance. The MI is
comprised of the Initiate, Working Memory, Plan/Organize, Organization of Materials, and Monitor scales. Internal consistency estimates range from .90 to .97 and test-retest correlations range from .76 to .88 over a two-week period. Evidence for construct validity was demonstrated by correlational analyses with other commonly used behavior rating scales and a series of factor analyses (Gioia et al., 2000).

Social Skills Rating System (SSRS)

The SSRS (Gresham & Elliot, 1990) provides a measure of a child’s social skills and problem behaviors that may impair an individual’s social functioning. The Elementary level parent form consists of 55 items rated on a three-point frequency scale. The two summary scores were selected for this study. The Social Skills score consists of items measuring cooperation, assertion, responsibility, and self-control. The Problem Behaviors scale includes externalizing, internalizing, and hyperactive behaviors. Internal consistency estimates range from .65 to .87 and test-retest coefficients range from .48 to .87. Support for construct validity was established through examining developmental changes, correlations with other measures, factor analyses, and group discrimination (Gresham & Elliot, 1990).

Social Problem Solving Inventory, Revised (SPSI-R)

The SPSI-R (D'Zurilla, Nezu, & Maydeu-Olivares, 2002) measures the ability to resolve problems in everyday living. This self-report measure is composed of 52 Likert-type items that are rated on a 5-point scale from 0-4, with 0 indicating “not at all like me” and 4 “extremely true of me.” The SPSI-R contains two adaptive problem-solving dimensions (positive problem orientation and rational problem solving) and three dysfunctional dimensions (negative problem orientation,
impulsivity/carelessness style, and avoidance style), and provides a total summary score. Internal consistency estimates ranged from .79 to .96 and test-retest correlations range from .72 to .88. The SPSI-R correlated with related measures as predicted theoretically, providing support for criterion and construct validity (D'Zurilla et al., 2002).

Statistical Analyses

Data Processing and Examination of Assumptions

Prior to primary analyses, a trained research assistant rechecked all scoring and data entry. Variables were examined for missing data. IQ data was missing for 5 children (3 CON, 2 ALC). In addition, caregivers failed to complete questionnaires (i.e., SSRS, CBCL, BRIEF, SPSI-R) for 5 children (3 CON, 2 ALC); these cases did not overlap with those cases missing IQ data. Children with missing data were only excluded from analyses when those variables were included. The presence of univariate outliers was identified through visual inspection of histograms and boxplots. Outliers were most common for goal and response generation variables from the social information processing measure as these variables tended to be skewed. However, no systematic outliers were identified on the social information processing measure and therefore all data points were retained. Deviations from normality and homogeneity of variance were also assessed for all variables. Normality was examined through visual examination of histograms and normal Q-Q plots. Multiple social information processing variables exhibited marked deviations for normality, especially for goal and response generation steps. For these variables the majority of children identified pro-social goals and competent responses in both groups, resulting in highly
skewed distributions. For the most part, the shape of the distributions did not differ across groups. Multiple transformations were applied to variables (e.g., arcsine, square root), but they did not substantially improve normality or affect results of significance testing. Nonparametric tests (e.g., Mann-Whitney) were also conducted and compared to standard analysis of variance (ANOVA) results and did not markedly differ. Since the majority of statistical tests for homogeneity of variance are affected by deviations from normality, homogeneity of variance was assessed by comparing variance ratios between groups. Only Group Entry Pro-social and Negative/Aggressive Goals and Provocation Irrelevant Goals had variance ratios greater than 4, with the ALC group being more variable than the CON group. Especially when sample sizes are equal, ANOVA tends to be more robust to violations of normality than homogeneity (Maxwell & Delaney, 2004). To ensure that groups were appropriately matched and to characterize the sample, group differences for demographic variables were examined through Chi-Square (sex, race, ethnicity, living environment) and univariate ANOVA (age, SES, FSIQ) techniques.

Aim 1: Group Differences on Social Information Processing

Due to the large number of social information processing variables, data reduction techniques were attempted through principal components analyses. However, due to variables loading on multiple components and low interpretability of individual components, this approach was discontinued. Examination of zero-order correlations revealed that correlations varied considerably in magnitude within steps and therefore a theoretical approach utilizing multivariate ANOVA to simultaneously examine variables within steps would not be incrementally beneficial. For this reason,
a univariate approach to ANOVA was selected. Due to the increased probability of making a type 1 error with multiple univariate comparisons, group differences were only considered if they represented medium to large effects (> 0.5). An effect (Cohen’s d) is considered small if it is greater than 0.2, medium if greater than 0.5, and large if greater than 0.8 (Cohen, 1988). As discussed above, some components of social information processing are influenced by age and sex. To explore these effects, zero-order correlations were examined between age and sex and all social information processing variables. When significantly correlated, age or sex was included in univariate ANOVA models as either a covariate or explanatory variable, respectively. In those cases where age was included as a covariate, analyses were run to ensure that age did not interact with other explanatory variables and was appropriate for use as a covariate. Effect sizes and results from significance testing are presented in tables to enhance readability.

Aim 2: Relationship of Social Information Processing and Related Constructs

A second measure of problem solving was included in this study to provide evidence of the concurrent validity of the social information processing measure and additional information on the social problem solving abilities of children with prenatal alcohol exposure. Group differences on TOPS-3 scales were examined using the same methods as discussed for the social information processing variables. In addition, the relationship between problem solving variables on the TOPS-3 and social information processing measure were examined through canonical correlation.

Relationships between social information processing and related cognitive and behavioral constructs were also examined through canonical correlation (as described
in more detail below). Related constructs included intelligence, executive functioning, social functioning, depression, and disruptive behavior. Individual variables representing the constructs are as follows. Verbal IQ and Performance IQ were entered to represent the construct of intelligence. Executive functioning was measured with the Behavior Regulation and Metacognition indices from the BRIEF. Measures of social functioning utilized in analyses include Social Problems scale from the CBCL and the Social Skills total score from the SSRS. Disruptive behavior was represented by the Rule Breaking Behavior scale from the CBCL and the Total Problems score from the SSRS. The Anxious/Depressed and Withdrawn/Depressed scales from the CBCL formed the depression construct. Group differences on variables forming the cognitive and behavioral constructs are also presented. Finally, the relationship between caregiver social problem solving skills and child social information processing abilities was examined.

Separate canonical correlational analyses were run for Group Entry and Provocation domains for all analyses. Social information processing variables were selected for inclusion in specific models if their zero-order correlations were between .3 and .7 for variables representing the given construct and correlations within groups were not markedly different. Canonical correlation is a multivariate technique that examines the relationship between two sets of variables. Variables in each set are linearly combined to form a canonical variate that maximizes the relationship with the other set of variables. The correlation is then calculated for the two canonical variates that form the canonical pair. Canonical correlation produces as many canonical pairs as the number of variables in the smallest set. Wilks λ statistic, which follows a chi-
square distribution, provides information on the overall model fit across all canonical pairs. If the overall test is significant, at least the first canonical pair accounts for a significant amount of variance. Next the statistic is run following removal of the first canonical pair to determine if remaining canonical pairs account for a significant amount of variance. Canonical correlation values ($r_c$) and fit statistics are provided in tables and only canonical pairs accounting for a significant amount of variance are discussed in the text. A measure of effect size ($\eta^2$) is provided. Once identified, interpretation of significant canonical variate pairs was determined through examination of standardized canonical correlation coefficients and canonical loadings for each set. Standardized canonical correlation coefficients provide information on the unique contribution of each variable to its canonical variate. Canonical loadings indicate the zero-order correlation between each variable and its canonical variate, not controlling for other variables. A cutoff value of greater than |.30| was utilized for practical significance. A canonical adequacy coefficient is reported for each set, which indicates the proportion of variance in the canonical variate that is explained by the variables within its set. The redundancy coefficient provides the proportion of variance in a canonical variate that is explained by the opposite set of variables.
III. RESULTS

Group Differences on Demographic Variables

Demographic information for both groups is provided in Table 1. Groups did not significantly differ with respect to sex, race, ethnicity, age, or SES (p’s > .05).

Groups differed dramatically on living environment ($\chi^2 (1) = 40.75, p < .001$), as only 2 children in the ALC group lived with a biological parent. Groups also significantly differed on FSIQ ($F(1, 46) = 12.89, p = .001$), with children in the ALC group having lower FSIQ scores on average than children in the CON group. These findings are consistent with previous studies.

<table>
<thead>
<tr>
<th>Table 1. Demographic information for non-exposed control (CON) and alcohol-exposed (ALC) groups.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>N</td>
</tr>
<tr>
<td># FAS</td>
</tr>
<tr>
<td>Sex [N (% Female)]</td>
</tr>
<tr>
<td>Race [N (% White)]</td>
</tr>
<tr>
<td>Ethnicity [N (% Hispanic)]</td>
</tr>
<tr>
<td>Home [N (% Biological)]</td>
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<tr>
<td>[N (% Adoptive)]</td>
</tr>
<tr>
<td>[N (% Relative)]</td>
</tr>
<tr>
<td>[N (% Foster)]</td>
</tr>
<tr>
<td>Age in Years [Mean (SD)]</td>
</tr>
<tr>
<td>SES [Mean (SD)]</td>
</tr>
<tr>
<td>FSIQ [Mean (SD)]b</td>
</tr>
</tbody>
</table>

*Two children in the ALC group had not been seen by a dysmorphologist at study completion; *Five children were missing FSIQ data (3 CON, 2 ALC).

Group Differences on Social Information Processing

Group Entry: Means, effect sizes, and significance testing results for Group Entry variables can be found in Table 2. Examination of results from significance testing and effect size calculations reveal group differences in the goal, response generation, and response evaluation steps of social information processing. Specifically, the ALC
group gave fewer pro-social goals and more inept goals than the CON group. It should be noted that the difference on the proportion of inept goals was due to responses from 5 children in the ALC group; no child in the CON group provided any inept goals. During the response generation step, groups did not differ with respect to the total number of responses given or the overall quality of these responses. However, alcohol-exposed children generated a higher proportion of aggressive responses and a lower proportion of competent responses for their first response to the Group Entry situations. In comparison to non-exposed controls, children in the ALC group evaluated competent responses as less effective in convincing the other children to let them play and viewed inept responses as more effective in achieving this goal. Alcohol-exposed children also evaluated inept responses more favorably than control children in getting the other children to like them. A medium to large effect was also found on encoding with the ALC group encoding and recalling less relevant information than the CON group; however, this difference was not significant when age was included in the model.
Table 2. Means, effect sizes, and significance testing results for non-exposed controls (CON) and children with prenatal alcohol exposure (ALC) on social information processing variables in Group Entry situations. Age and sex effects are listed when relevant.

<table>
<thead>
<tr>
<th>Variable</th>
<th>CON</th>
<th>ALC</th>
<th>ES</th>
<th>F</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1: Encoding</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Average Encoding</td>
<td>4.25 (0.79)</td>
<td>3.68 (1.07)</td>
<td>0.61</td>
<td>2.67</td>
<td>0.109</td>
</tr>
<tr>
<td>Age</td>
<td>11.31</td>
<td>0.002</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 2: Attribution</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hostile Attribution</td>
<td>0.43 (0.28)</td>
<td>0.55 (0.30)</td>
<td>0.41</td>
<td>2.06</td>
<td>0.157</td>
</tr>
<tr>
<td>Non-hostile Attribution</td>
<td>0.25 (0.24)</td>
<td>0.27 (0.28)</td>
<td>0.08</td>
<td>0.07</td>
<td>0.793</td>
</tr>
<tr>
<td><strong>Step 3: Goals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proportion Pro-social</td>
<td>0.92 (0.12)</td>
<td>0.79 (0.31)</td>
<td>0.55</td>
<td>3.85</td>
<td>0.055</td>
</tr>
<tr>
<td>Proportion Negative/Aggressive</td>
<td>0.03 (0.07)</td>
<td>0.06 (0.15)</td>
<td>0.26</td>
<td>1.16</td>
<td>0.287</td>
</tr>
<tr>
<td>Proportion Nonsocial</td>
<td>0.04 (0.10)</td>
<td>0.07 (0.12)</td>
<td>0.27</td>
<td>0.94</td>
<td>0.337</td>
</tr>
<tr>
<td>Proportion Inept</td>
<td>0.00 (0.00)</td>
<td>0.05 (0.11)</td>
<td>0.64</td>
<td>5.66</td>
<td>0.021</td>
</tr>
<tr>
<td>Proportion Irrelevant</td>
<td>0.01 (0.03)</td>
<td>0.02 (0.05)</td>
<td>0.24</td>
<td>1.10</td>
<td>0.300</td>
</tr>
<tr>
<td><strong>Step 4: Response Generation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Total Responses</td>
<td>31.12 (16.04)</td>
<td>26.65 (14.16)</td>
<td>0.30</td>
<td>0.45</td>
<td>0.504</td>
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<tr>
<td>Age</td>
<td>3.30</td>
<td>0.075</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proportion Competent</td>
<td>0.71 (0.17)</td>
<td>0.64 (0.25)</td>
<td>0.33</td>
<td>1.13</td>
<td>0.293</td>
</tr>
<tr>
<td>Proportion Aggressive</td>
<td>0.04 (0.06)</td>
<td>0.05 (0.09)</td>
<td>0.13</td>
<td>0.58</td>
<td>0.451</td>
</tr>
<tr>
<td>Proportion Inept</td>
<td>0.24 (0.14)</td>
<td>0.26 (0.20)</td>
<td>0.12</td>
<td>0.13</td>
<td>0.718</td>
</tr>
<tr>
<td>Number Non-repeated Responses</td>
<td>23.69 (11.48)</td>
<td>21.19 (10.64)</td>
<td>0.23</td>
<td>0.06</td>
<td>0.807</td>
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<td>7.98</td>
<td>0.007</td>
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<tr>
<td>Proportion Non-repeated Competent</td>
<td>0.68 (0.15)</td>
<td>0.62 (0.24)</td>
<td>0.30</td>
<td>1.13</td>
<td>0.292</td>
</tr>
<tr>
<td>Proportion Non-repeated Aggressive</td>
<td>0.04 (0.06)</td>
<td>0.06 (0.08)</td>
<td>0.28</td>
<td>0.64</td>
<td>0.428</td>
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<tr>
<td>Proportion Non-repeated Inept</td>
<td>0.26 (0.14)</td>
<td>0.28 (0.20)</td>
<td>0.12</td>
<td>0.11</td>
<td>0.739</td>
</tr>
<tr>
<td>Proportion First Competent</td>
<td>0.82 (0.18)</td>
<td>0.67 (0.25)</td>
<td>0.69</td>
<td>3.96</td>
<td>0.052</td>
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<tr>
<td>Age</td>
<td>7.62</td>
<td>0.008</td>
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<td></td>
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</tr>
<tr>
<td>Proportion First Aggressive</td>
<td>0.01 (0.05)</td>
<td>0.05 (0.07)</td>
<td>0.66</td>
<td>4.10</td>
<td>0.048</td>
</tr>
<tr>
<td>Proportion First Inept</td>
<td>0.12 (0.14)</td>
<td>0.21 (0.22)</td>
<td>0.49</td>
<td>1.30</td>
<td>0.260</td>
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<tr>
<td>Age</td>
<td>4.43</td>
<td>0.041</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Step 5: Response Evaluation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Affiliation Competent</td>
<td>0.18 (0.05)</td>
<td>0.21 (0.07)</td>
<td>0.49</td>
<td>3.66</td>
<td>0.062</td>
</tr>
<tr>
<td>Sex</td>
<td>4.69</td>
<td>0.035</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Affiliation Aggressive</td>
<td>0.44 (0.03)</td>
<td>0.43 (0.05)</td>
<td>0.24</td>
<td>1.01</td>
<td>0.319</td>
</tr>
<tr>
<td>Affiliation Inept</td>
<td>0.38 (0.03)</td>
<td>0.36 (0.04)</td>
<td>0.57</td>
<td>3.81</td>
<td>0.057</td>
</tr>
<tr>
<td>Instrumental Competent</td>
<td>0.18 (0.05)</td>
<td>0.23 (0.06)</td>
<td>0.91</td>
<td>6.70</td>
<td>0.013</td>
</tr>
<tr>
<td>Age</td>
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<td>0.119</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Instrumental Aggressive</td>
<td>0.44 (0.03)</td>
<td>0.42 (0.05)</td>
<td>0.49</td>
<td>3.14</td>
<td>0.083</td>
</tr>
<tr>
<td>Instrumental Inept</td>
<td>0.38 (0.03)</td>
<td>0.36 (0.04)</td>
<td>0.57</td>
<td>6.93</td>
<td>0.011</td>
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<td><strong>Step 6: Enactment</strong></td>
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<tr>
<td>Average Enactment</td>
<td>2.72 (0.57)</td>
<td>2.59 (0.37)</td>
<td>0.27</td>
<td>0.85</td>
<td>0.360</td>
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</tbody>
</table>
**Provocation:** Means, effect sizes, and significance testing results for Provocation variables can be found in Table 3. Examination of results from significance testing and effect size calculations revealed group differences in the encoding, attribution, response evaluation, and enactment steps of social information processing. Specifically, children in the ALC group encoded and recalled less relevant information from the vignettes than controls. On the attribution step, alcohol-exposed children were less likely than their typically developing peers to attribute benign intent when the intent of the other child was hostile or ambiguous. Children with prenatal alcohol exposure evaluated competent responses as less effective in getting the other child to like them on the response evaluation step. Finally, control children were rated more effective in their ability to repeat a competent response with appropriate eye contact and tone of voice during the enactment step.
<table>
<thead>
<tr>
<th>Variable</th>
<th>CON</th>
<th>ALC</th>
<th>ES</th>
<th>F</th>
<th>p-value</th>
</tr>
</thead>
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<tr>
<td><strong>Step 1: Encoding</strong></td>
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<tr>
<td>Average Encoding</td>
<td>4.82 (0.38)</td>
<td>4.33 (0.66)</td>
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<tr>
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<td></td>
<td>5.49</td>
<td>0.023</td>
</tr>
<tr>
<td><strong>Step 2: Attribution</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Hostile Attribution</td>
<td>0.41 (0.27)</td>
<td>0.43 (0.25)</td>
<td>0.08</td>
<td>0.07</td>
<td>0.791</td>
</tr>
<tr>
<td>Non-hostile Attribution</td>
<td>0.12 (0.15)</td>
<td>0.06 (0.08)</td>
<td>0.50</td>
<td>3.75</td>
<td>0.058</td>
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<td><strong>Step 3: Goals</strong></td>
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<tr>
<td>Proportion Pro-social</td>
<td>0.89 (0.22)</td>
<td>0.80 (0.29)</td>
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<td>0.67</td>
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<td>3.31</td>
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</tr>
<tr>
<td>Proportion Negative/Aggressive</td>
<td>0.04 (0.08)</td>
<td>0.04 (0.07)</td>
<td>0.00</td>
<td>0.04</td>
<td>0.842</td>
</tr>
<tr>
<td>Proportion Nonsocial</td>
<td>0.03 (0.10)</td>
<td>0.05 (0.12)</td>
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<td>0.405</td>
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<td>Proportion Inept</td>
<td>0.04 (0.16)</td>
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<td>0.23</td>
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<td>0.465</td>
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<tr>
<td>Proportion Irrelevant</td>
<td>0.00 (0.02)</td>
<td>0.03 (0.08)</td>
<td>0.51</td>
<td>1.77</td>
<td>0.189</td>
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<tr>
<td><strong>Step 4: Response Generation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Total Responses</td>
<td>32.27 (15.82)</td>
<td>26.15 (13.92)</td>
<td>0.41</td>
<td>1.01</td>
<td>0.319</td>
</tr>
<tr>
<td>age</td>
<td></td>
<td></td>
<td></td>
<td>5.53</td>
<td>0.023</td>
</tr>
<tr>
<td>Proportion Competent</td>
<td>0.81 (0.18)</td>
<td>0.77 (0.22)</td>
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<td>0.67</td>
<td>0.418</td>
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<td>Proportion Aggressive</td>
<td>0.08 (0.12)</td>
<td>0.07 (0.15)</td>
<td>0.07</td>
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<tr>
<td>Proportion Inept</td>
<td>0.11 (0.13)</td>
<td>0.16 (0.20)</td>
<td>0.30</td>
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<td>0.236</td>
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<tr>
<td>Number Non-repeated Responses</td>
<td>26.65 (12.15)</td>
<td>22.50 (11.24)</td>
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<td>0.50</td>
<td>0.483</td>
</tr>
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<td>8.89</td>
<td>0.004</td>
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<td>Proportion Non-repeated Competent</td>
<td>0.81 (0.18)</td>
<td>0.75 (0.23)</td>
<td>0.29</td>
<td>0.87</td>
<td>0.355</td>
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<tr>
<td>Proportion Non-repeated Aggressive</td>
<td>0.08 (0.12)</td>
<td>0.07 (0.16)</td>
<td>0.07</td>
<td>0.06</td>
<td>0.810</td>
</tr>
<tr>
<td>Proportion Non-repeated Inept</td>
<td>0.11 (0.13)</td>
<td>0.17 (0.20)</td>
<td>0.36</td>
<td>1.81</td>
<td>0.185</td>
</tr>
<tr>
<td>Proportion First Competent</td>
<td>0.85 (0.21)</td>
<td>0.77 (0.24)</td>
<td>0.35</td>
<td>0.58</td>
<td>0.449</td>
</tr>
<tr>
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<td></td>
<td>7.01</td>
<td>0.011</td>
</tr>
<tr>
<td>Proportion First Aggressive</td>
<td>0.04 (0.10)</td>
<td>0.05 (0.16)</td>
<td>0.07</td>
<td>0.12</td>
<td>0.727</td>
</tr>
<tr>
<td>Proportion First Inept</td>
<td>0.09 (0.17)</td>
<td>0.15 (0.20)</td>
<td>0.32</td>
<td>0.54</td>
<td>0.467</td>
</tr>
<tr>
<td>age</td>
<td></td>
<td></td>
<td></td>
<td>4.19</td>
<td>0.046</td>
</tr>
<tr>
<td><strong>Step 5: Response Evaluation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Affiliation Competent</td>
<td>0.25 (0.04)</td>
<td>0.28 (0.04)</td>
<td>0.75</td>
<td>6.17</td>
<td>0.016</td>
</tr>
<tr>
<td>Affiliation Aggressive</td>
<td>0.39 (0.03)</td>
<td>0.38 (0.03)</td>
<td>0.33</td>
<td>2.40</td>
<td>0.128</td>
</tr>
<tr>
<td>Affiliation Inept</td>
<td>0.35 (0.03)</td>
<td>0.34 (0.03)</td>
<td>0.33</td>
<td>2.80</td>
<td>0.100</td>
</tr>
<tr>
<td>Instrumental Competent</td>
<td>0.26 (0.04)</td>
<td>0.27 (0.04)</td>
<td>0.25</td>
<td>1.84</td>
<td>0.181</td>
</tr>
<tr>
<td>Instrumental Aggressive</td>
<td>0.40 (0.04)</td>
<td>0.39 (0.04)</td>
<td>0.25</td>
<td>0.87</td>
<td>0.356</td>
</tr>
<tr>
<td>Instrumental Inept</td>
<td>0.35 (0.04)</td>
<td>0.34 (0.04)</td>
<td>0.25</td>
<td>0.16</td>
<td>0.696</td>
</tr>
<tr>
<td><strong>Step 6: Enactment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Enactment</td>
<td>2.72 (0.53)</td>
<td>2.29 (0.38)</td>
<td>0.93</td>
<td>11.27</td>
<td>0.002</td>
</tr>
</tbody>
</table>
Concurrent Validity: Test of Problem Solving-Third Edition

Group Differences: Means, effect sizes, and significance testing results for the TOPS-3 can be found in Table 4. Group differences were statistically significant for all scales of the TOPS-3 and represent medium and large effects. For all scales, the ALC group had lower scores than the CON group, reflecting weaker critical thinking and problem solving skills. The largest effect was seen on the Negative Questions subscale and the smallest effect was seen on the Making Inferences subscale.

Table 4. Means, effect sizes, and significance testing results for non-exposed controls (CON) and children with prenatal alcohol exposure (ALC) on the Test of Problem Solving, 3rd edition.

<table>
<thead>
<tr>
<th>Variable</th>
<th>CON</th>
<th>ALC</th>
<th>ES</th>
<th>F</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Making Inferences</td>
<td>100.42 (10.09)</td>
<td>92.08 (16.20)</td>
<td>0.62</td>
<td>4.97</td>
<td>0.030</td>
</tr>
<tr>
<td>Sequencing</td>
<td>101.00 (9.49)</td>
<td>87.46 (17.28)</td>
<td>0.97</td>
<td>12.26</td>
<td>0.001</td>
</tr>
<tr>
<td>Negative Questions</td>
<td>99.62 (12.29)</td>
<td>84.19 (17.83)</td>
<td>1.01</td>
<td>13.19</td>
<td>0.001</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>100.54 (11.37)</td>
<td>90.15 (15.88)</td>
<td>0.75</td>
<td>7.35</td>
<td>0.009</td>
</tr>
<tr>
<td>Predicting</td>
<td>97.85 (11.74)</td>
<td>87.62 (15.62)</td>
<td>0.74</td>
<td>7.13</td>
<td>0.010</td>
</tr>
<tr>
<td>Determining Causes</td>
<td>100.88 (13.06)</td>
<td>88.69 (14.38)</td>
<td>0.89</td>
<td>10.24</td>
<td>0.002</td>
</tr>
<tr>
<td>Total Test</td>
<td>100.12 (9.34)</td>
<td>86.58 (16.99)</td>
<td>0.99</td>
<td>12.68</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Correlational analyses: Canonical correlation analyses were conducted within each social information processing domain separately. See Table 5 for model fit statistics for both domains and Table 6 for standardized canonical coefficients and canonical loadings.

Table 5. Canonical correlation and fit indices for the relationship between social information processing and the Test of Problem Solving, 3rd edition.

<table>
<thead>
<tr>
<th>Domain</th>
<th>r_2</th>
<th>Wilks λ</th>
<th>χ²</th>
<th>p value</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group Entry</td>
<td>0.708</td>
<td>0.386</td>
<td>43.31</td>
<td>0.009</td>
<td>0.614</td>
</tr>
<tr>
<td></td>
<td>0.407</td>
<td>0.774</td>
<td>11.64</td>
<td>0.076</td>
<td>0.226</td>
</tr>
<tr>
<td></td>
<td>0.252</td>
<td>0.928</td>
<td>3.38</td>
<td>0.908</td>
<td>0.072</td>
</tr>
<tr>
<td></td>
<td>0.093</td>
<td>0.991</td>
<td>0.40</td>
<td>0.941</td>
<td>0.009</td>
</tr>
<tr>
<td>Provocation</td>
<td>0.628</td>
<td>0.430</td>
<td>38.80</td>
<td>0.003</td>
<td>0.570</td>
</tr>
<tr>
<td></td>
<td>0.445</td>
<td>0.710</td>
<td>15.76</td>
<td>0.107</td>
<td>0.290</td>
</tr>
<tr>
<td></td>
<td>0.339</td>
<td>0.885</td>
<td>5.63</td>
<td>0.229</td>
<td>0.115</td>
</tr>
<tr>
<td>Variables</td>
<td>coeff</td>
<td>load</td>
<td>adeq</td>
<td>redun</td>
<td>Related Constructs</td>
</tr>
<tr>
<td>---------------</td>
<td>-------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>--------------------</td>
</tr>
<tr>
<td>Group Entry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Encoding</td>
<td>-0.12</td>
<td>-0.51</td>
<td></td>
<td></td>
<td>Making Inferences</td>
</tr>
<tr>
<td>Nonhostile Attribution</td>
<td>0.61</td>
<td>0.88</td>
<td></td>
<td></td>
<td>Sequencing</td>
</tr>
<tr>
<td>First Competent</td>
<td>-0.45</td>
<td>-0.80</td>
<td></td>
<td></td>
<td>Negative Questions</td>
</tr>
<tr>
<td>Total Responses</td>
<td>-0.08</td>
<td>-0.52</td>
<td></td>
<td></td>
<td>Problem Solving</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Predicting</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Determining Causes</td>
</tr>
<tr>
<td>Provocation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Encoding</td>
<td>-0.68</td>
<td>-0.93</td>
<td></td>
<td></td>
<td>Making Inferences</td>
</tr>
<tr>
<td>First Competent</td>
<td>-0.24</td>
<td>-0.75</td>
<td></td>
<td></td>
<td>Sequencing</td>
</tr>
<tr>
<td>Total Responses</td>
<td>-0.30</td>
<td>-0.64</td>
<td></td>
<td></td>
<td>Negative Questions</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Problem Solving</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Predicting</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Determining Causes</td>
</tr>
</tbody>
</table>
Canonical correlation analyses for both domains produced one significant canonical variate pair. Encoding, total number of responses, and the proportion of first competent responses loaded highly on the social information processing variate for both domains. The social information processing variate correlated highly with the problem solving variate formed from Tops-3 variables suggesting that the encoding and response generation steps are most strongly related to Tops-3 performance.

Results indicate that weaker social information processing skills are associated with poorer critical thinking and problem solving skills. Taken together, strong correlations with the Tops-3 for both domains provide evidence for the concurrent validity of the social information processing measure.

Correlations with Related Constructs

Cognition: Means, effect sizes, and significance testing results for cognitive variables can be found in Table 7. All effects were large to very large in magnitude.

<table>
<thead>
<tr>
<th>Variable</th>
<th>CON Mean (SD)</th>
<th>ALC Mean (SD)</th>
<th>ES</th>
<th>F</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal IQ</td>
<td>110.48 (16.32)</td>
<td>92.96 (19.55)</td>
<td>0.97</td>
<td>11.07</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Performance IQ</td>
<td>103.52 (9.97)</td>
<td>91.33 (17.46)</td>
<td>0.86</td>
<td>8.54</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>BRIEF Behavioral Regulation Index</td>
<td>47.74 (9.57)</td>
<td>66.67 (14.32)</td>
<td>1.55</td>
<td>28.14</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>BRIEF Metacognition Index</td>
<td>48.23 (7.98)</td>
<td>65.58 (11.33)</td>
<td>1.77</td>
<td>35.47</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Canonical correlations and model fit statistics can be found on table 8 for the constructs of intelligence and executive functioning. Table 9 contains standardized canonical coefficients and canonical loadings.
Table 8. Canonical correlation and fit indices for the relationship between social information processing and related cognitive constructs.

<table>
<thead>
<tr>
<th>Domain</th>
<th>r&lt;sub&gt;c&lt;/sub&gt;</th>
<th>Wilks λ</th>
<th>χ&lt;sup&gt;2&lt;/sup&gt;</th>
<th>p value</th>
<th>η&lt;sup&gt;2&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTELLIGENCE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provocation</td>
<td>0.538</td>
<td>0.706</td>
<td>14.97</td>
<td>0.020</td>
<td>0.294</td>
</tr>
<tr>
<td></td>
<td>0.081</td>
<td>0.993</td>
<td>0.28</td>
<td>0.868</td>
<td>0.007</td>
</tr>
<tr>
<td>EXECUTIVE FUNCTIONS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group Entry</td>
<td>0.511</td>
<td>0.694</td>
<td>15.34</td>
<td>0.018</td>
<td>0.306</td>
</tr>
<tr>
<td></td>
<td>0.247</td>
<td>0.939</td>
<td>2.65</td>
<td>0.266</td>
<td>0.061</td>
</tr>
<tr>
<td>Provocation</td>
<td>0.640</td>
<td>0.578</td>
<td>23.62</td>
<td>&lt;.001</td>
<td>0.422</td>
</tr>
<tr>
<td></td>
<td>0.143</td>
<td>0.980</td>
<td>0.88</td>
<td>0.350</td>
<td>0.020</td>
</tr>
</tbody>
</table>

Table 9. Standardized canonical coefficients (coeff), canonical loadings (load), and adequacy (adeq) and redundancy (redun) coefficients for canonical correlation analyses between social information processing and related cognitive constructs.

<table>
<thead>
<tr>
<th>Variables</th>
<th>coeff</th>
<th>load</th>
<th>adeq</th>
<th>redun</th>
<th>Related Constructs</th>
<th>coeff</th>
<th>load</th>
<th>adeq</th>
<th>redun</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTELLIGENCE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provocation</td>
<td>0.483</td>
<td>0.140</td>
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<td></td>
<td></td>
<td>0.728</td>
<td>0.211</td>
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</tr>
<tr>
<td>Encoding</td>
<td>-0.63</td>
<td>-0.83</td>
<td></td>
<td></td>
<td></td>
<td>-0.04</td>
<td>-0.68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hostile Attribution</td>
<td>0.32</td>
<td>0.58</td>
<td></td>
<td></td>
<td></td>
<td>-0.98</td>
<td>-1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Affiliation Competent</td>
<td>0.45</td>
<td>0.65</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXECUTIVE FUNCTIONS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group Entry</td>
<td>0.420</td>
<td>0.110</td>
<td></td>
<td></td>
<td></td>
<td>0.914</td>
<td>0.238</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonhostile Attribution</td>
<td>-0.47</td>
<td>-0.67</td>
<td></td>
<td></td>
<td>Behavior Regulation</td>
<td>-0.26</td>
<td>-0.92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Aggressive</td>
<td>-0.70</td>
<td>-0.73</td>
<td></td>
<td></td>
<td>Metacognition</td>
<td>-0.76</td>
<td>-0.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Responses</td>
<td>0.33</td>
<td>0.53</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provocation</td>
<td>0.551</td>
<td>0.225</td>
<td></td>
<td></td>
<td></td>
<td>0.911</td>
<td>0.373</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Encoding</td>
<td>-0.85</td>
<td>-0.90</td>
<td></td>
<td></td>
<td>Behavior Regulation</td>
<td>0.78</td>
<td>0.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonhostile Attribution</td>
<td>-0.44</td>
<td>-0.54</td>
<td></td>
<td></td>
<td>Metacognition</td>
<td>0.24</td>
<td>0.92</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The first related construct examined was intelligence. The relationship between IQ and social information processing in the Group Entry domain was unable to be tested through canonical correlation due to group differences in zero-order correlations for individual variables. Results from the Provocation domain suggest that encoding, hostile attribution, and affiliative evaluation of competent responses are strongly related to the social information processing variate. The correlation between social information processing and IQ variate pairs was .538, which represents a large effect. Results indicate that lower IQ is associated with weaker social information processing skills.

Next, the relationship between social information processing and executive functioning was examined. Variables relating to the social information processing variate varied somewhat between domains. Nonhostile attribution uniquely contributed to the canonical variate in both domains, although interpretation of this variable differed. Specifically, nonhostile attribution was related to poorer executive skills in Group Entry situations and stronger executive skills on Provocation. This discrepancy may be related to the efficacy of this type of attribution in different social situations. The proportion of first aggressive responses and total number of responses were more important in the Group Entry domain, whereas encoding played a role in the Provocation domain. While variables composing the social information processing variate differ, results are consistent from both domains in suggesting that poorer executive functioning skills are related to weaker social information processing.

**Behavior:** Means, effect sizes, and significance testing results for behavioral variables can be found in Table 10. Effects ranged from medium to very large. The largest
group differences were seen on rule breaking and problem behavior variables and measures of social functioning, with children in the ALC group demonstrating higher levels of disruptive and rule breaking behavior and poorer social functioning on average.

Table 10. Means, effect sizes, and significance testing results for non-exposed controls (CON) and children with prenatal alcohol exposure (ALC) on related behavioral variables.

<table>
<thead>
<tr>
<th>Variable</th>
<th>CON</th>
<th>ALC</th>
<th>ES</th>
<th>F</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSRS Social Skills</td>
<td>110.65 (17.44)</td>
<td>85.25 (17.99)</td>
<td>1.43</td>
<td>24.13</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>CBCL Social Problems</td>
<td>54.91 (7.25)</td>
<td>64.08 (9.93)</td>
<td>1.05</td>
<td>13.30</td>
<td>0.001</td>
</tr>
<tr>
<td>CBCL Anxious/Depressed</td>
<td>54.83 (7.78)</td>
<td>60.04 (9.30)</td>
<td>0.61</td>
<td>4.46</td>
<td>0.040</td>
</tr>
<tr>
<td>CBCL Withdrawn/Depressed</td>
<td>54.17 (7.38)</td>
<td>58.88 (8.12)</td>
<td>0.61</td>
<td>4.47</td>
<td>0.040</td>
</tr>
<tr>
<td>CBCL Rule Breaking Behavior</td>
<td>53.57 (6.19)</td>
<td>60.96 (8.08)</td>
<td>1.03</td>
<td>12.67</td>
<td>0.001</td>
</tr>
<tr>
<td>SSRS Problem Behavior</td>
<td>93.05 (12.83)</td>
<td>117.79 (16.71)</td>
<td>1.66</td>
<td>31.32</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Canonical correlations and model fit statistics can be found in Table 11 for the constructs of social functioning, depression, and disruptive behavior. Table 12 contains standardized canonical coefficients and canonical loadings for these constructs.

Table 11. Canonical correlation and fit indices for the relationship between social information processing and related behavioral constructs.

<table>
<thead>
<tr>
<th>Domain</th>
<th>( r_c )</th>
<th>Wilks ( \lambda )</th>
<th>( \chi^2 )</th>
<th>p value</th>
<th>( \eta^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOCIAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group Entry</td>
<td>0.655</td>
<td>0.480</td>
<td>30.81</td>
<td>0.001</td>
<td>0.520</td>
</tr>
<tr>
<td>Provocation</td>
<td>0.398</td>
<td>0.841</td>
<td>7.26</td>
<td>0.123</td>
<td>0.159</td>
</tr>
<tr>
<td>Depression</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provocation</td>
<td>0.617</td>
<td>0.589</td>
<td>22.73</td>
<td>0.001</td>
<td>0.411</td>
</tr>
<tr>
<td>DISRUPTIVE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group Entry</td>
<td>0.221</td>
<td>0.951</td>
<td>2.15</td>
<td>0.314</td>
<td>0.049</td>
</tr>
<tr>
<td></td>
<td>0.510</td>
<td>0.740</td>
<td>12.82</td>
<td>0.012</td>
<td>0.260</td>
</tr>
<tr>
<td></td>
<td>0.114</td>
<td>0.987</td>
<td>0.55</td>
<td>0.457</td>
<td>0.013</td>
</tr>
</tbody>
</table>
Table 12. Standardized canonical coefficients (coeff), canonical loadings (load), and adequacy (adeq) and redundancy (redun) coefficients for canonical correlation analyses between social information processing and related behavioral constructs.

<table>
<thead>
<tr>
<th>Variables</th>
<th>coeff</th>
<th>load</th>
<th>adeq</th>
<th>redun</th>
<th>Related Constructs</th>
<th>coeff</th>
<th>load</th>
<th>adeq</th>
<th>redun</th>
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<tr>
<td><strong>SOCIAL</strong></td>
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<td></td>
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<td></td>
<td>0.755</td>
<td>0.324</td>
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<td></td>
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<td></td>
<td>CBCL Social Problems</td>
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<td>-0.72</td>
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<tr>
<td>Non-repeated Responses</td>
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<td>0.64</td>
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<tr>
<td>First Aggressive</td>
<td>-0.59</td>
<td>-0.61</td>
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<tr>
<td>First Competent</td>
<td>0.23</td>
<td>0.66</td>
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<tr>
<td>Provocation</td>
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<td></td>
<td>0.810</td>
<td>0.302</td>
<td></td>
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</tr>
<tr>
<td>Encoding</td>
<td>-0.89</td>
<td>-0.97</td>
<td></td>
<td></td>
<td>SSRS Social Skills</td>
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<td>-0.94</td>
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<td></td>
</tr>
<tr>
<td>Non-repeated Responses</td>
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<td>-0.60</td>
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<td></td>
<td>CBCL Social Problems</td>
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<tr>
<td><strong>DEPRESSION</strong></td>
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<tr>
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<td></td>
<td></td>
<td>0.809</td>
<td>0.273</td>
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</tr>
<tr>
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<td>0.90</td>
<td></td>
<td></td>
<td>Anxious/Depressed</td>
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<td>-0.86</td>
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<td>0.70</td>
<td></td>
<td></td>
<td>Withdrawn/Depressed</td>
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<tr>
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<tr>
<td>Group Entry</td>
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<td></td>
<td></td>
<td></td>
<td>0.811</td>
<td>0.203</td>
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<tr>
<td>Nonhostile Attribution</td>
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<td></td>
<td></td>
<td>CBCL Rule Breaking</td>
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<td></td>
<td></td>
<td>SSRS Total Problems</td>
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<td>-0.79</td>
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</table>
The relationship between social functioning and social information processing skills was examined first. Encoding, the number of non-repeated responses, and the proportion of competent first responses were strongly related to the social information processing variate for both domains. In addition, nonhostile attribution and the proportion of aggressive first responses also uniquely contributed to the canonical variate in the Group Entry domain. The social information processing variate and social functioning variate had correlations of 0.6 for both domains, representing a large effect. Examination of canonical loadings for both domains suggest that children with weaker social information processing skills tend to have more problems with social functioning.

Next depression was examined. The relationship between depression and social information processing in the Group Entry domain was unable to be tested through canonical correlation due to group differences in the majority of zero-order correlations for individual variables. For the Provocation domain, encoding and the proportion of pro-social goals uniquely contributed to the social information processing variate. In addition the proportion of first inept responses significantly loaded on this variate. Canonical loadings suggest that lower depression scores are associated with stronger social information processing skills.

Finally the relationship between disruptive behavior and social information processing was examined. This relationship was unable to be tested through canonical correlation in the Provocation domain due to group differences in the majority of zero-order correlations for individual variables. In the Group Entry domain, nonhostile attribution and the proportion of first aggressive responses uniquely contributed to the
social information processing variate. This variate significantly correlated with the disruptive behavior variate and canonical loadings indicate that fewer disruptive behavior problems are associated with stronger social information processing skills.

**Caregiver Problem Solving:** Groups had similar mean total problem solving scores (CON 102.92 (12.05); ALC 105.79 (12.08)), which were not statistically different ($F(1,43) = 0.61, p = .439$). Examination of zero-order correlations revealed no significant correlations between caregiver total problem solving and child social information processing variables for the overall sample or within groups. A few zero-order correlations were significant for individual subscales of the SPSI-R, but either differed between groups or were not stable in canonical correlation analyses.
IV. DISCUSSION

The aim of the current study was to assess the social information processing skills of school-age children with histories of heavy prenatal alcohol exposure. Research on social functioning with alcohol-exposed children has largely focused on caregiver report on structured interviews and behavioral questionnaires. Studies indicate that retrospectively identified children with prenatal alcohol exposure have significant social deficits, which are above and beyond what would be expected based on lower intellectual functioning (Thomas et al., 1998). Findings from the current study corroborate and augment caregiver reported social deficits in this population by providing more direct measurement of children’s social cognition, and provide insight into possible mechanisms for impaired social functioning. Children with histories of prenatal alcohol exposure demonstrated impairments in social information processing on all six steps of Crick and Dodge’s reformulated model (Crick & Dodge, 1994) across both hypothetical Group Entry and Provocation situations. However, areas of impairment differ by the type of social situation (i.e., Group Entry vs. Provocation), which is consistent with the previously reported situational specificity of social information processing (Dodge et al., 2002). Specifically, in hypothetical Group Entry situations, children with heavy prenatal alcohol exposure exhibited weaker social information processing skills in comparison with controls in the goal, response generation, and response evaluation steps. Alcohol-exposed children were more likely to give fewer pro-social goals and more inept goals than typically developing peers. In addition, they generated more aggressive and less competent responses as their first solution on the response generation step, even after being told the other children’s
intents. On the response evaluation step, in comparison with their typically developing peers, children with prenatal exposure to alcohol evaluated inept responses as more effective strategies for convincing the other children to let them play, and viewed competent responses as less effective strategies. Alcohol-exposed children also evaluated inept responses more favorably as a strategy for getting the other children to like them than did control children. An example of an inept response when trying to enter a peer group would be to make a self-referent statement unrelated to the activity (e.g., “I went roller skating yesterday.”), whereas a competent response could be a statement about the activity or a direct bid to enter the group (e.g., “That looks like fun. Can I play?”). In Provocation situations, children with prenatal alcohol exposure exhibited impairments in the encoding, attribution, response evaluation, and enactment steps of social information processing. Alcohol-exposed children encoded and recalled less relevant information from the hypothetical vignettes than controls. On the attribution step, children with prenatal alcohol exposure were less likely than non-exposed comparison children to interpret benign intent in response to ambiguous and hostile actions of the other child. In contrast to the Group Entry domain, no differences were seen on the response generation step. While groups did not differ on the number or quality of responses generated, alcohol-exposed children evaluated competent responses as less effective in getting the other child to like them during the response evaluation step. Finally, during the enactment step, alcohol-exposed children were rated as less effective than controls in their ability to use appropriate eye contact and tone of voice while repeating a competent response. Overall, while the nature of deficits appears to differ across the type of social situation, impairment in any one or
multiple steps of social information processing is likely to contribute to poor social outcomes for children with prenatal alcohol exposure.

The influences of age and sex on social information processing skills were also examined and included in between-group analyses when relevant. Significant age effects were found for the encoding and response generation steps across domains, which is consistent with previous studies (Gifford-Smith & Rabiner, 2004). As age increased, children in both groups recalled more relevant cues and generated a larger number of total responses and a higher proportion of competent first responses. The effect of age was particularly important for the encoding stage. While there was a significant difference between groups in children’s abilities to encode and recall relevant cues in Provocation situations, for Group Entry situations, the difference in encoding ability was no longer significant when age was included in the model. This suggests that age is a more significant factor than group membership in explaining encoding performance in Group Entry situations, whereas group accounts for additional significant variance in Provocation situations. Age may play a larger role in Group Entry situations since cues are more subtle and less emotionally salient in comparison with Provocation. Therefore, younger children may have a harder time picking up on these cues than older children. In contrast to some previous studies (Gifford-Smith & Rabiner, 2004), age was not related to attribution scores in this study. This discrepancy may be due to differences in how attribution was measured across studies. Few sex differences in social information processing were identified in either domain. Sex was only significantly related to the evaluation of competent responses in obtaining an affiliative goal (i.e., getting the other kids to like you) for
Group Entry situations. On this variable, girls in both groups evaluated competent responses as more effective than did boys. Previous research has also identified sex differences in the encoding, goal selection, and response generation steps (Gifford-Smith & Rabiner, 2004). However, sex effects tend to be small and may not have been detected in the current study due to smaller sample size or differences in measurement.

The second aim of the current study was to examine the relationship between social information processing and related constructs to improve the characterization of social deficits in children with prenatal alcohol exposure. On a measure of critical thinking and problem solving skills (TOPS-3), children with prenatal alcohol exposure demonstrated impaired performance in comparison to non-exposed controls across all subscales. The largest effect was found when children with prenatal alcohol exposure were asked to describe why something would not occur or why one should not perform a particular action in a specific situation (TOPS-3 Negative Questions). One possible interpretation is that children with prenatal alcohol exposure may have more difficulty with these types of questions due to their increased grammatical complexity. Language impairments are commonly found in children with prenatal alcohol exposure and difficulties with syntax and grammar are prevalent (Becker et al., 1990; Carney & Chermak, 1991; McGee, Bjorkquist et al., submitted). Children with prenatal alcohol exposure also had considerable difficulty providing a logical explanation for situations depicted in the TOPS-3, drawing conclusions about why something happened, and providing appropriate solutions to presented problems. In addition, alcohol-exposed children struggled with determining and describing sequences of behavior and predicting consequences of behaviors compared to their
typically developing peers. Many of these skills require a child to identify and apply relevant previous knowledge to problem-solve while simultaneously considering consequences of possible actions. These findings are consistent with reports of impaired executive functioning in children with prenatal alcohol exposure (for a review see Rasmussen, 2005).

The relationship between social information processing and performance on the TOPS-3 was examined through canonical correlation. Correlations between measures were large and positive, with weaker social information processing skills correlating with poorer critical thinking and problem solving skills. The encoding and response generation steps were most strongly related to TOPS-3 performance across Group Entry and Provocation situations. These findings provide support for the concurrent validity of the social information processing measure. While the measures exhibited strong correlations of .71 and .63 for the Group Entry and Provocation domains, respectively, they are not redundant and each provides unique information. The TOPS-3 places larger emphasis on language skills than does the social information processing measure, which may account for the larger effect sizes seen on the TOPS-3. Consistent with this explanation, the canonical correlation between intellectual functioning and the TOPS-3 was stronger ($r_c = .847$) than the correlation between intelligence and social information processing ($r_c = .538$), especially with respect to VIQ. Differences between the TOPS-3 and the social information processing measure may also be related to the types of scores generated. The TOPS-3 provides standard scores that take the child’s age into account, whereas social information processing variables are presented as proportions or averages of raw data.
While age was modeled for between-group comparisons of social information processing variables when relevant, the standard scores used by the TOPS-3 may better account for age related variance in performance. Standard scores generally have improved psychometric properties, which enhance the reliability of analyses. Age was not included in correlational analyses, which may have reduced the relationship between measures, especially with respect to variables highly influenced by age.

The relationships between intelligence and executive functioning constructs and social information processing variables were also examined. As expected, groups showed significant differences on IQ indices and measures of executive function. Correlations between social information processing variables and intelligence demonstrated that as IQ increases, social information processing skills improve. Performance on the encoding, attribution, and response evaluation steps were most strongly related to IQ performance, especially with respect to PIQ. The relationship between executive functioning and social information processing was of interest since many of the social information processing steps require an individual to integrate multiple sources of information, plan and organize behavior, and problem solve. Like intelligence, executive functioning was positively correlated with social information processing, such that as executive functioning improved, social information processing improved as well, particularly in the encoding, attribution, and response generation steps. Results are consistent with a previous study of children with prenatal alcohol exposure that found a significant relationship between executive functioning and social skills (Schonfeld et al., 2006). Correlations for intelligence and executive functioning in relation to social information processing variables were of similar
magnitude ranging from .51 to .64. Effect sizes were large, but not as substantial as in
the relationship between the TOPS-3 and social information processing variables, as
expected.

The behavioral constructs of social functioning, depression, and disruptive
behavior problems were also examined as these constructs have been found to strongly
predict social information processing. Congruous with previous reports of behavioral
functioning (e.g., Mattson & Riley, 2000), caregivers rated alcohol-exposed children
as having poorer social functioning, higher rates of disruptive behavior, and higher
levels of depression than controls. Effect sizes were very large for the measures of
social functioning and disruptive behavior problems, whereas group differences on
measures of depression were medium in magnitude. Effective social information
processing has been found to correlate with social competence and peer acceptance
(Dodge & Price, 1994; Nelson & Crick, 1999). Results from the current study are
consistent with these findings: stronger social information processing skills were
correlated with better caregiver-rated social functioning. Encoding and response
generation variables were related to social functioning for both group entry and
provocation situations. The contribution of these steps of social information
processing are similar to findings that show that accepted children are more accurate
in encoding and are more likely to generate and positively evaluate pro-social,
competent problem solving strategies (Dodge & Price, 1994; Gifford-Smith &
Rabiner, 2004; Mayeux & Cillessen, 2003; Nelson & Crick, 1999). These results are
also consistent with previous studies of alcohol-exposed children’s social functioning
(Bishop et al., 2007; Mattson & Riley, 2000; Streissguth et al., 1991; Thomas et al.,
that find poorly developed social skills, decreased quality of observed social interactions, and increased problem behaviors interfering with social functioning. Moreover, current results provide additional information on the specific areas of children’s social cognition that may be contributing to observed difficulties.

Previous studies of depressed children have found deficits in social information processing in all stages, although not always consistently. Common findings show that depressed children display a hostile attribution bias, report less self-efficacy for assertive and competent responses, and make internal attributions for social rejection (Dodge, 1993; Quiggle et al., 1992). Due to elevated rates of depressive disorders in children with histories of prenatal alcohol exposure (Burd et al., 2003; Fryer, McGee et al., 2007; O'Connor, Shah et al., 2002), the relationship between depressive symptoms and social information processing was of interest. Findings from the current study identified a significant correlation between social information processing variables and depressive symptoms across the entire sample. Children with higher levels of caregiver-reported depressive symptoms also evidenced weaker social information processing, especially in the encoding, goal, and response generation steps.

Finally the relationship between disruptive behavior and social information processing was examined. Disruptive behavior problems are common in children with prenatal alcohol exposure (e.g., Carmichael Olson et al., 1997; Fryer, McGee et al., 2007; Mattson & Riley, 2000; Schonfeld et al., 2005) and are likely to contribute to poor social and adaptive outcomes. Previous studies of children with disruptive
behavior problems have found deficits on all steps of social information processing. Although reactive and proactive aggression correlate highly (approximately .60 in nonreferred samples and .71 in psychiatric samples; Orobio de Castro, Veerman, Koops, Bosch, & Monshouwer, 2002) and a significant portion of children display both, larger effect sizes on the earlier stages (i.e., encoding, attribution) are found in children with predominantly reactive, or angry aggression, whereas larger effects are identified in later stages (i.e., goals, response evaluation) with children with predominately proactive, or instrumental, aggression (Crick & Dodge, 1996; Dodge et al., 1997; Orobio de Castro et al., 2002). In psychiatric samples, children with ADHD display social information processing deficits more in line with reactive aggression, whereas children with oppositional defiant or conduct disorder (ODD/CD) show impairments similar to children exhibiting high levels of proactive aggression or show a more pervasive pattern. Children with comorbid ADHD and ODD/CD are more severely affected and demonstrate pervasive social information processing deficits (Dodge et al., 1997; Matthys et al., 1999). As discussed above, children with prenatal alcohol exposure have high rates of ADHD and ODD/CD and co-morbidities are common (Burd et al., 2003; Fryer, McGee et al., 2007). Social information processing deficits found in alcohol-exposed children are more similar with the pervasive patterns seen across domains in children with co-morbid ODD/CD and ADHD. Increased disruptive behavior problems were also associated with weaker social information processing skills in the current study, and attribution and response generation steps most strongly contributed to this relationship.
Findings of impaired encoding and recall of relevant social cues in the current study are congruous with the learning and memory profile of children with prenatal alcohol exposure. Alcohol-exposed children consistently display encoding deficits for both verbal and nonverbal information and retrieval deficits for nonverbal and unstructured verbal information (Kaemingk et al., 2003; Mattson, Riley, Delis et al., 1996; Mattson & Roebuck, 2002; Roebuck-Spencer & Mattson, 2004; Willford et al., 2004). Because the encoding step was only measured through verbal recall in this study, it is difficult to know if deficits on the social information processing measure are due to impairments in encoding, retrieval, or a combination of both. Deficits in encoding may also be related to lower intellectual functioning, which is consistent with significant correlations between IQ indices and social information processing variables in this study. Executive skills may also play a role in effective encoding of social cues. A child must be able to identify relevant cues and be able to integrate these cues with previous knowledge to form a mental representation for further processing (Burks et al., 1999; Guralnick, 1999). In support of this hypothesis, children in the current study with stronger executive skills encoded more relevant cues than those with weaker executive skills. More effective encoding performance also related to better social functioning and lower levels of depression. Deficits in encoding are common in children with a range of cognitive and behavioral problems including learning disabilities, ADHD, depression, and aggression (Dodge, 1993; Matthys et al., 1999; Tur-Kaspa, 2002).

On the attribution step, children with heavy prenatal alcohol exposure were less likely to attribute benign intent (i.e., non-hostile attribution) to ambiguous or
hostile situations than their typically developing peers during peer provocation. In contrast, no differences in hostile attribution were found across domains, which was somewhat surprising. Evidence of a hostile attribution bias has been found in children having high levels of aggression, depression, and a history of maltreatment (Dodge, 1993; Orobio de Castro et al., 2002; Price & Glad, 2003), which are common problems in children with prenatal alcohol exposure. The current study may have failed to find this effect due to differences in measurement, variability in story content, and sample size. For example, a recent meta-analysis identified differences in hostile attribution bias in aggressive children relating to the format of presentation. Larger effects were found for open-ended questions and audio or in vivo presentation (vs. video or picture formats) of social situations (Orobio de Castro et al., 2002), which is in contrast to the video presentation and forced-choice format for attribution questions in the current study. However, one study which used the same instrument utilized in the current study, found a significant effect for hostile attribution bias upon provocation in children who had experienced physical abuse (Keil & Price, in press). Alcohol-exposed children had similar or slightly higher mean hostile attribution scores than children with maltreatment in both Provocation and Group Entry domains. However, controls in the current study displayed higher levels of hostile attribution in the Provocation domain as compared to controls in the Keil and Price study, resulting in no significant differences between groups. Children in the Keil and Price study were younger (mean age = 6.5 years) than in the current sample, which may account for some of this difference, although previous research suggests that children make less biased attributions as they get older (Gifford-Smith & Rabiner, 2004).
While groups did not differ with respect to hostile attribution bias in the current study, lower intellectual functioning was related to higher levels of hostile attribution across the sample. One surprising finding was that the relationship between nonhostile attribution of intent and related cognitive and behavioral constructs varied by domain. For example, higher levels of non-hostile attribution were significantly related to stronger executive functioning skills in the Provocation domain. However, in the Group Entry domain, higher levels of non-hostile attribution were correlated with poorer problem solving, weaker executive skills, poorer social functioning, and higher rates of disruptive behavior. One explanation for the contrasting associations with non-hostile attribution between domains may be related to the differential efficacy of non-hostile attribution in social situations. For example, in Group Entry situations children who believe that the other children want to play with them when the other children’s intent is hostile or ambiguous may persist in trying to join the group, resulting in a higher probability of experiencing rejection. As discussed above, peer rejection can lead to the development of maladaptive behavior and poor social functioning (Kupersmidt & DeRosier, 2004), which is consistent with the correlations found in this study. In contrast, attributing benign intent to hostile or ambiguous actions of a peer during provocation could result in fewer altercations with peers and more adaptive functioning.

In the current study, children with prenatal alcohol exposure were likely to give fewer pro-social goals and more inept goals than typically developing peers when trying to join a group of children engaged in an activity. The intensity with which children experience emotions and their ability to regulate their emotional response...
influence the types of goals selected (Lemerise & Arsenio, 2000). Children with prenatal alcohol exposure have considerable difficulty regulating their behavior and are often described as emotionally labile, impulsive, and hyperactive (Mattson, 2003), which may account for the less competent goal selection seen in this study. Previous experiences in similar situations will also likely influence children’s goal selection. Previous experiences with rejection and limited social knowledge of competent responses can result in the selection of less competent or pro-social goals. Children’s goals for social situations are linked to the type of response strategies selected (Chung & Asher, 1996; Erdley & Asher, 1999). Similarly, the goal and response generation variables were related in the current study; correlations between pro-social goals were positively related to competent response generation and negatively related to aggressive or inept responses.

On the response generation step, groups did not differ in the number or the quality of total or non-repeated responses generated for either type of social situation. However, in Group Entry, children with prenatal alcohol exposure were impaired in the quality of their first response. In comparison with controls, alcohol-exposed children generated more aggressive and less competent first responses. Children who are impulsive and have limited executive control are likely to bypass rational response evaluation and decision making processes and enact the first response generated (Dodge, 1993; Fontaine & Dodge, 2006). Consistent with this hypothesis, one study examined the fit of various social information processing models in explaining aggressive behavior in children with mild intellectual disabilities and found that the response-decision step was not necessary to explain behavior in this population. The
authors suggest that aggressive children with intellectual disabilities skip this step due to difficulties with means-end thinking or the demands of comparing multiple response alternatives (van Nieuwenhuijzen et al., 2006). Research consistently demonstrates that alcohol-exposed children have high levels of impulsivity and poor executive skills (e.g., Rasmussen, 2005). Even though children with prenatal alcohol exposure are able to generate a level of competent responses comparable to typically developing children, they may be more likely to enact their first response, which tends to be more aggressive. This hypothesis is consistent with increased levels of disruptive behavior problems found in children with histories of prenatal alcohol exposure. Van Nieuwenhuijzen and colleagues (2006) also examined the influence of mental representations on social functioning and found that the relationship between aggressive mental representations and aggressive behavior was mediated by response generation. Children with prenatal alcohol exposure may similarly show a tendency to think of others in aggressive terms, resulting in aggressive response generation and consequent aggressive behavior. In contrast to Group Entry situations, groups did not differ with respect to the quality of the first response on Provocation. The quality of alcohol-exposed children’s first responses was similar in magnitude across both domains; however, controls tended to generate more aggressive responses upon Provocation than Group Entry, which reduced this effect. Response generation variables significantly correlated with measures of executive skills, social functioning, disruptive behavior, and depression. Higher executive functioning was related to an increased number of total responses and fewer aggressive first responses. A higher number of non-repeated responses, more competent first responses, and fewer
aggressive first responses were associated with improved social functioning. Children displaying higher rates of disruptive behavior provided higher levels of aggressive first responses. Finally, the proportion of first inept responses was related to higher levels of depression, which is consistent with findings in depressed children (Dodge, 1993).

While it is likely that children with histories of prenatal alcohol exposure bypass the response evaluation step during real-life processing, when asked to consciously process evaluative information in hypothetical situations they demonstrated deficits across both Group Entry and Provocation domains. In Group Entry situations, alcohol-exposed children showed impairments for both affiliative and instrumental evaluations of outcomes. Specifically, they evaluated inept responses as more effective than controls in convincing the other children to let them play and getting the other children to like them. In Provocation situations, alcohol-exposed children only showed deficits for affiliative outcomes and evaluated competent responses as less effective in getting the other child to like them. Groups did not differ for either domain in their evaluations of aggressive responses. Previous research on social information processing in depressed or aggressive children has shown that children in both groups show impairments in response evaluation (for a review, see Dodge, 1993). Aggressive children view aggressive responses as more effective, which is in contrast to results from the current study. Alcohol-exposed children are more similar to depressed children on this step who view competent assertive responses as less effective and inept responses as more effective. In addition, children with learning disabilities have considerable difficulties with response evaluation, which may be due to problems understanding or recognizing complex emotions, lower
ability to determine consequences of different responses, or previous experience with rejection (Bauminger, Edelszteim, & Morash, 2005; Tur-Kaspa, 2002). Response evaluation variables generally did not correlate with cognitive and behavioral constructs examined in this study, and those that did significantly correlate were not consistent when examined within groups. The only response evaluation variable included in canonical correlational analyses was affiliative evaluation of competent responses, which was related to intellectual functioning: Specifically, children who rated competent responses as more effective in getting children to like them in provocation situations had higher IQ scores.

Children with histories of prenatal alcohol exposure often have lower IQ scores than typically developing children, as was the case in the current study. To further examine the influence of IQ on social information processing skills, 10 children from each group were individually matched on age, sex, and FSIQ [Means: ALC 102.90, CON 102.60]. Comparison of group means revealed that while some of the differences observed with the larger sample are likely due to IQ, some deficits remained. Specifically, group differences seen on the encoding, goal, and response evaluation steps were attenuated when controlling for IQ. In contrast, medium to large effects remained on the aggressive first response generation variable on Group Entry, and the attribution and enactment steps on Provocation.

While sample sizes precluded formal statistical analyses, the performance of alcohol-exposed children with and without FAS was compared to determine if diagnosis accounted for some of the variability in social information processing scores. Performance was compared through examination of subgroup means and
visual inspection of scatterplots. Subgroup differences were similar across Group Entry and Provocation domains. Children with FAS tended to have lower mean scores on encoding, prosocial goals, and total number of generated responses. On the response generation step, children with FAS tended to give more inept responses, whereas alcohol-exposed children without FAS tended to give more aggressive responses. Both alcohol exposed groups had similar enactment scores. Subgroup differences may be related to lower IQ scores in the FAS subgroup (mean = 81.83 vs. 94.44 in alcohol-exposed children without FAS). The tendency for alcohol-exposed children without FAS to give more aggressive responses than those with FAS is consistent with previous research showing that an FAS diagnosis and lower IQ are protective for a number of secondary disabilities including mental health problems and trouble with the law (Streissguth et al., 1996). Children with FAS are more likely to be diagnosed earlier and receive services than those without FAS, which may result in more structured environments, caregiver attributions focusing on the prenatal alcohol exposure rather than behavior being intentional, and fewer disruptive and aggressive behavior problems.

Possible mechanisms for impaired social information processing in children with prenatal alcohol exposure include alterations in brain structure and function, poorer parenting practices, insecure attachment, and inadequate social learning. As discussed above, alcohol-related alterations in brain structure and functioning have been found in both humans and animal models. Difficulties in encoding may be associated with alcohol-related damage to sensory processing regions in temperoparietal regions and alterations in the hippocampus. Alterations to the
striatum, cingulate, and orbitofrontal cortex in alcohol-exposed individuals may affect the mediation of perceptual representations with emotional response, motivation, and cognitive processing, which is critical for attribution and goal clarification steps. Prefrontal cortices play a large role in social cognition and likely contribute to impairments in response generation and evaluation; children with prenatal alcohol exposure show abnormalities of structure and function in these regions (Fagerlund et al., 2006; Fryer, Tapert, et al., 2007; Riikonen et al., 1999, 2005; Sowell et al., 2002, 2007, 2008). As depicted in the database in Crick and Dodge’s six stage model, social knowledge can influence social information processing in all steps. Prefrontal cortices, the cingulate, temporal cortices, and the hippocampus have all been implicated in social knowledge (Adolphs, 2003) and are affected by prenatal alcohol exposure. While models such as Adolph’s model of social cognition are useful in understanding brain-behavior relationships, caution should be exercised in drawing causal inferences to specific structures as functional connectivity is complex and brain structures are likely involved in multiple processes related to social cognition, which may vary depending on the level of automaticity, detail of representations involved, and processing speed (Adolphs, 2003).

Postnatal family environment and learning context also have the potential to significantly impact social functioning. Previous studies have explored the importance of parenting in social development. Attachment studies show that children with more secure attachments with caregivers exhibit more competent social information processing skills (Ziv et al., 2004). An insecure attachment history and associated mental representations of unsatisfactory peer relations may contribute to knowledge
structures of negative peer relations, which could then influence online processing of social information (Haskett & Willoughby, 2006). Young children with prenatal alcohol exposure demonstrate less secure attachment with caregivers (O'Connor, Kogan et al., 2002), which is consistent with less competent social information processing skills identified in this study. Parents who interpret their children’s misbehavior to be intentionally annoying or disobedient are more likely to be abusive or display authoritarian or harsh parenting styles (Haskett & Willoughby, 2006). Harsh, power assertive, or coercive parenting (e.g., physical punishment, threats) is associated with poorer social information processing, more aggressive behavior, and resultant peer difficulties (Guralnick, 1999; Hart, Ladd, & Burleson, 1990; Pettit, Dodge, & Brown, 1988; Weiss et al., 1992). Consistent exposure to modeled hostile behavior provides children with direct instruction in a means of interacting with others and reinforces such strategies. In contrast, parents who encourage children to think about the consequences of their actions are more likely to have children who engage in friendly assertive strategies and are generally more preferred by peers. Many children with prenatal alcohol exposure experience early abuse or neglect and are often placed in foster or adoptive care. In the current study no alcohol-exposed children lived with their biological mother and only two children lived with their biological fathers. Poor attachment and chaotic early living environments are likely to result in poor social functioning in children with prenatal alcohol exposure. High levels of caregiver stress are also prevalent in both biological and adoptive parents of children with prenatal alcohol exposure (Paley, O'Connor, Frankel, & Marquardt, 2006; Paley, O'Connor, Kogan, & Findlay, 2005), which are likely to impact child-parent interactions.
Children acquire many early skills through social learning and modeling. Poor models or a paucity of interactions due to inconsistent or harsh parenting, increased stress, neglect, or poor attachment are likely to decrease the opportunities for quality learning interactions and may result in acquiring inept or aggressive social information processing skills.

In the current study, the influence of social modeling was examined indirectly by comparing the social problem solving skills of caregivers. Caregivers in both groups had similar social problem solving skills and differences were not significant. While an imperfect proxy for caregiver modeling, this analysis suggests that social information processing deficits seen in children with prenatal alcohol exposure are not entirely explained by inadequate modeling. Although differences were not seen between groups for current caregivers, it is still possible that harsh parenting or maltreatment occurring within some alcohol-exposed children’s biological families (before being transferred to adoptive or foster care) significantly contributed to observed problems in social information processing and social functioning. In addition, since home placement is confounded by group, it is possible that the observed deficits are more related to the experience of being removed from the biological family than the alcohol exposure per se. While sample sizes were small, scatter plots did not reveal any meaningful trends in the alcohol-exposed group with respect to home environment. In addition, the length of time in children’s current placement was not significantly related to social information processing variables. However, it is also possible that alcohol-related brain damage contributes, at least in part, to observed deficits. Future studies including a comparison group of children
without alcohol exposure matched on home placement may help resolve this issue.

Other sociocultural variables including family size, socioeconomic status, and racial background were examined in relation to social information processing performance. Children in both groups had a comparable number of siblings and families of similar size. Family size and number of siblings did not generally account for significant variability in social information processing scores in this sample, with the exception of encoding in Group Entry situations. Specifically, having more siblings and a larger family was correlated with higher encoding scores both across and within groups. Children living in larger families with multiple children may tend to encode and recall more information in social situations due to increased opportunities for practice in interactions with family members.

Children from lower socioeconomic backgrounds may have fewer opportunities for quality social interactions and modeling due to increased parental stress, less adequate childcare, poor peer models, or fewer safe play areas. However, in the current sample, socioeconomic status did not correlate with social information processing outcome variables. While families from a wide range of socioeconomic backgrounds participated in this study, the majority of families in this sample were from middle to upper-middle class backgrounds. Larger samples with increased sampling in the lowest socioeconomic bracket may reveal relevant differences. The influence of race on social information processing variables was also examined through visual inspection of scatterplots. Racial subgroups were similarly represented in both groups and no apparent trends were visualized with respect to race.

Deficits in social information processing are likely to result in impaired
everyday functioning. Humans are social creatures and social interactions pervade everyday tasks. Difficulties with interpersonal functioning can result in problems in multiple environments and may lead to significant emotional and behavioral problems. Children with social information processing deficits are more likely to be rejected by peers, which may result in fewer opportunities to acquire and practice social skills and could lead to further maladjustment and rejection (Dodge et al., 2003; Gifford-Smith & Rabiner, 2004; Kupersmidt & DeRosier, 2004). Social difficulties are a life long problem for individuals with prenatal alcohol exposure. Adolescents with histories of prenatal alcohol exposure show significant deficits in social problem solving that are correlated with impairments in executive functions (McGee et al., in press). Such problems are likely related to the high rates of social withdrawal, loneliness, teasing or bullying, antisocial behavior, dependency, and difficulty with employment seen in adolescents and adults with prenatal alcohol exposure (Streissguth et al., 1996). Interventions targeting social information processing and social skills are strongly needed in this population. As evidenced by the current study, social information processing deficits and problems with social functioning are present beginning as early as the elementary school years. If interventions are begun early, these deficits may be ameliorated or lessened before the child experiences considerable peer rejection and maladjustment in later stages of life. Previous research suggests that early identification of FASD, disability services eligibility, a stable and nurturing home environment, and early intervention may be protective against some of the negative consequences of prenatal alcohol exposure (Streissguth et al., 1996).

Intervention studies of children with prenatal alcohol exposure are few, but
early studies show that academic, social, and behavioral functioning are amenable to intervention in this population (Adnams et al., 2007; Coles et al., 2007; Kable et al., 2007; O'Connor et al., 2006). Relevant to the current study, one well-designed RCT recently evaluated the efficacy of a manualized 12-week parent-assisted friendship intervention in school-age children with prenatal alcohol exposure (O'Connor et al., 2006). In this intervention, separate treatment groups were conducted simultaneously for parents and children. The children’s group focused on specific social skills such as social network formation, informational exchange with peers, group entry, and conflict avoidance and negotiation. Skills were taught through simple rules, modeling, rehearsal, and performance feedback. In the parents’ group, parents were instructed in how to assist their children to generalize and maintain the skills they learned in group to the home environment. Children and parents completed homework assignments and home rehearsal was emphasized. Children who completed the intervention improved in their knowledge of appropriate social skills, and based on caregiver report, demonstrated observable improvement in social skills and reductions in problem behaviors. Caregiver-reported social skills showed further improvement at the 3-month follow-up.

The friendship training program described above utilized several key components and adaptations that likely enhance the efficacy of the intervention with children with prenatal alcohol exposure. A review of recent meta-analyses indicated that social skills training programs do not produce large, meaningful long-term changes in social competence with individuals with developmental disabilities (Gresham, Sugai, & Horner, 2001). To address this issue, the manualized friendship
training program included parents as an integral component of the intervention, focused on ecologically valid social skills, and emphasized homework assignments for improved generalization (Laugeson et al., 2007). Due to significant difficulties with language, learning and memory, executive functions, and behavior problems in children with prenatal alcohol exposure, several adaptations were made to the original manualized intervention to improve the efficacy with this population (Laugeson et al., 2007). For example, didactic material was delivered with more basic language, broken down into simpler components, and presented in multiple formats. Alcohol-exposed children were given increased opportunities for role-playing and material rehearsal and were provided with “buzzwords” (i.e., key words that cue the longer behavioral sequence) and higher levels of verbal prompting. Frequent review of explicit rules, positive reinforcement techniques, and individualized behavior programs were utilized to minimize the impact of behavior problems on intervention goals. Future intervention studies would benefit from similar methods.

Results from the current study emphasize the need for early intervention and provide insight on possible mechanisms for observed difficulties in social functioning. In addition to targeting specific skills important for acquiring and maintaining friendships, interventions aimed at improving the social competence of children with prenatal alcohol exposure may benefit from direct instruction on social information processing skills. Improving how children process information may help them generalize and maintain intervention gains. As demonstrated by the current study, deficits in social information processing vary by situation type, and therefore interventions should target multiple social situations and contextual variability. While
intervention appears beneficial for school age children with prenatal alcohol exposure, the current study demonstrates significant deficits in social information processing and social functioning at this age. Prevention and early intervention programs beginning in preschool or kindergarten may be useful for this population. In addition, due to the large impact of parenting quality on social information processing, interventions would also likely benefit from additional parent training focusing on parents’ negative child-related beliefs (e.g., interpretation of child’s behavior as intentional), elevations in parenting stress or psychopathology, and child rearing skills and discipline styles (Haskett & Willoughby, 2006).

There are several limitations to the current study. Statistical analyses were limited by the large number of variables and their psychometric properties. Initially principal components analyses (PCA) were planned to reduce the number of variables followed by MANOVA analyses to compare group differences on correlated components. However, PCA results involved variables loading on multiple components and low interpretability. In addition, MANOVA analyses would not have added incremental information to univariate analyses since variables within steps varied significantly in their intercorrelations. A univariate ANOVA approach was therefore selected. An additional benefit of this approach is that univariate ANOVA is more robust to violations of normality (Maxwell & Delaney, 2004), which were present for a number of social information processing variables. However, one drawback with univariate analyses is that the large number of comparisons increases the probability of committing a type 1 error and inflating the true alpha values. In an attempt to reduce this error, significance test results were accompanied by effect size
calculations. Only those differences that were classified as a medium effect or larger were considered meaningful. Canonical correlation analyses also are affected by limitations that warrant discussion. Solutions for canonical variate pairs depend heavily on the variables included in the model, since the solution depends both on correlations among variables in each set and on correlations among variables between sets. In addition, variables that have very low or very high correlations can affect the interpretation of the individual canonical variates. For example, variables that correlate too highly (> .8 or .9) will often prohibit computation. If computation is possible and multiple variables correlate highly, standardized canonical coefficients may indicate that only one of the variables uniquely contributes to the formation of the canonical variate, even though all variables load strongly. Variables that are only minimally correlated do not add much to the model and reduce the power for detecting a significant effect. To try to reduce these effects, social information processing variables were only selected if they correlated with related constructs between .3 and .7. In addition, variables were only selected if correlations within groups were not markedly different. While this improved the solution mathematically, it resulted in different sets of variables representing the construct of social information processing. The variables contributing to the social information construct for each analysis were emphasized in an attempt to clarify these differences. When using canonical correlation descriptively, as was the primary purpose in the current study, there is no requirement that the variables be normally distributed, although analyses are enhanced when they are. However, inference regarding the number of significant canonical variate pairs proceeds based on the assumption of multivariate normality. Due to
violations of normality for some variables, significance testing results should be interpreted cautiously for these analyses (Tabachnick & Fidell, 2001). While caution is warranted in determining the number of significant variate pairs, all analyses produced sizable correlations for at least the first pair supporting the descriptive associations between sets of variables. Canonical correlation is a multivariate technique and the issue of sample size requires discussion. In general, about 10 cases are required for each variable included. For the majority of analyses, a total of 4 to 5 variables were included, which meets the suggested number of cases to variable ratio. Analyses examining the relationships between social information processing and social functioning in Group Entry or the TOPS-3 utilized 7 to 10 variables, which exceeds the recommended ratio.

Another limitation is that children with prenatal alcohol exposure were recruited retrospectively for this study. While retrospective studies have many advantages, they are heavily influenced by ascertainment bias. Families are more likely to seek services and participate in research projects if their children exhibit some clinically relevant manifestation of the exposure. While retrospective studies consistently find deficits in social functioning, one research group has failed to find deficits in social functioning in a prospectively identified cohort at ages 6 and 15 (Coles et al., 1991; Howell et al., 2006). Possible explanations for this discrepancy between studies include differences in ascertainment method (e.g., lower exposures, fewer children with FAS), the demographics of populations sampled (e.g., African American children from low socioeconomic backgrounds), and differences in
caregiver expectations. Future studies examining the social functioning of prospectively identified children may help clarify these discrepancies.

Since social skills improve dramatically with age and the types of relevant social situations vary across age groups, the age range for this study was limited to children between the ages of 7 and 11. However, findings from the current study may not be generalizable to other age groups, such as preschool children or adolescents. While Group Entry and Provocation situations are common social problems faced by elementary school children, children may face many other types of social situations (such as interactions with adults), and research suggests that performance may vary significantly over different situational contexts (Dodge et al., 2002). A further limitation is that children’s social cognition was measured through hypothetical vignettes rather than observation. A child may know what he or she should say or do, but in a real situation may act differently (Vitaro & Pelletier, 1991). One possible explanation for this is that children are more likely to consciously process information during a hypothetical task than in real life, which could result in different outcomes. In addition, social desirability may play a role (Runions & Keating, 2007). When working with an adult research assistant, children may give a pro-social or competent response since they believe that is what the researcher expects. For example, one child with prenatal alcohol exposure in this study gave many pro-social and competent responses during the social information processing interview, but had many problems at school with aggressive and disruptive behavior and even pinched the examiner and yelled obscenities at her when she was told she would not receive the incentive until the end of the session.
While there are limitations, this is the first study to comprehensively assess the social information processing skills of school-age children with prenatal alcohol exposure. Future work can build on the current findings and improve our understanding of the brain-behavior relationships underlying social cognition in this population. Structural and functional imaging studies examining differences in brain structure and function during social tasks could provide more direct evidence of brain-behavior relationships. In addition, looking at social information processing skills in alcohol-exposed individuals of varying age groups would allow for a better understanding of social difficulties across the lifespan and improve generalizability. It will also be important to look at a wide range of social situations to examine additional contextual factors related to social information processing. As discussed above, studies utilizing a prospective design are also important in understanding the social functioning of children with prenatal alcohol exposure and will help reduce the influence of ascertainment bias, although children tend to be less affected and deficits may be subtle. In addition, comparison of clinical populations that have similar behavioral characteristics as alcohol-exposed children, such as children with ADHD, may aid in improving diagnostic specificity. Similar to other domains of functioning, children with prenatal exposure in the current study varied substantially in their social information processing abilities. Examining other variables in relation to social information processing such as level and pattern of prenatal exposure, genetic differences, living environment (e.g., adoptive vs. biological), history of maltreatment, family beliefs and values, attachment, and quality of parenting among others, may aid in identifying risk and protective factors that may be useful for intervention. Use of
other social modalities, such as direct observation, may also provide useful information. Finally, additional research designing and empirically testing interventions targeting social information processing and social functioning is needed.

In summary, the current study of children with prenatal alcohol exposure demonstrated significant impairments in social information processing in all six domains of Crick and Dodge’s reformulated model (Crick & Dodge, 1994) across Group Entry and Provocation situations. Areas of impairment differed by the type of social situation, which is consistent with previous reports of the situational specificity of social information processing (Dodge et al., 2002). Specifically, alcohol-exposed children had difficulty on the goal, response generation, and response evaluation steps in Group Entry situations, and difficulty with encoding, attribution, response evaluation, and enactment during Provocation situations. Strong correlations with a measure of critical thinking and problem solving skills provide support for the concurrent validity of the social information processing measure. In addition, social information processing variables were significantly related to measures of intelligence, executive functioning, social functioning, depression, and disruptive behavior. Deficits in social information processing in children with prenatal alcohol exposure are likely related to alterations in brain structure and function as well as postnatal environmental factors. Such deficits are likely to result in significant problems with everyday functioning and poor quality of life. Social skills deficits, including deficits in social information processing, are amenable to intervention and results from the current study may help in improving interventions for children with prenatal alcohol exposure.
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