Source Monitoring in Children With and Without Fetal Alcohol Spectrum Disorders

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Objectives  Deficits in memory are well-documented in children with fetal alcohol spectrum disorders (FASD); however, one aspect of memory not yet studied in children with FASD is source monitoring. This study examined overall source monitoring ability and performance profiles of children with FASD compared to controls.  Method  Participants included 19 children with FASD and 38 typically developing children (aged 6–12 years). Children were presented with auditory word lists and were required to recall the source of words for reality, external, and internal source monitoring tasks.  Results  Children with FASD showed poorer performance than controls across all three conditions in both recognition memory and memory for source. However, both groups exhibited a comparable pattern of performance across conditions. Specifically, performance was lowest on the internal task and highest on the reality task.  Conclusions  Information about source monitoring deficits further delineates the intricacies of memory deficits in FASD, and has implications for both assessment and intervention.

Key words  cognitive development; FASD; memory; prenatal alcohol exposure; source monitoring.

Fetal alcohol spectrum disorders (FASD), a continuum of congenital effects caused by maternal alcohol consumption during pregnancy, is a significant North American health and social concern with individual, familial, and societal implications (Chudley et al., 2005). With an estimated prevalence of 9–10/1,000 births in the United States and Canada (Chudley et al., 2005; Streissguth, 1997, 2007), FASD is a leading preventable cause of mental retardation, birth defects, and developmental delay (National Institute on Alcohol Abuse and Alcoholism [NIAAAA], 1990). In Canada, the annual cost for supporting individuals with FASD from birth to 53 years is estimated at $5.3 billion (Stade, Unjar, Stevens, Beyene, & Koren, 2006) and the lifetime cost of supporting an individual born with an FASD is estimated to be $1.1 million (Thanh & Jonsson, 2009) to $2 million (Lupton, Burd, & Harwood, 2004). These costs reflect increased use of educational, behavioral, and social services and the medical and justice systems, as well as lost personal and caregiver productivity.

A diagnosis under the umbrella of FASD is applied based on four main criteria: (a) growth deficiency in height and/or weight, (b) facial dysmorphology, (c) damage to the central nervous system (CNS), and (d) a confirmed history of prenatal alcohol exposure (Chudley et al., 2005). Although early research centered on the physical features associated with the full clinical syndrome, fetal alcohol syndrome (FAS), attention has shifted to understanding CNS damage and its neurobehavioral consequences across the spectrum. This is because there are no significant differences in neuropsychological impairment between individuals with and without facial stigmata (Mattson, Riley, Gramling, Delis, & Jones, 1998) and the neuropsychological sequelae have much greater functional significance than physical features.
In the pursuit toward developing and refining a neuropsychological profile for FASD, several areas of impairment have been identified, including deficits in intellectual function, learning, information processing, attention, and memory (for a review, see Kodituwakku, 2009). In particular, deficits in executive function (EF) have been described as playing a significant role in the functional deficits observed in those affected by FASD (Kodituwakku, 2009; Rasmussen, 2005). Memory deficits, which are related to EF and yet distinct, have been identified in individuals with FASD (Manji, Pei, Loomes, & Rasmussen, 2010), yet again understanding of the unique pattern of memory deficits is still emerging. One aspect of memory that has not yet been investigated in FASD is memory for source, or source monitoring. Memory for source is a type of episodic (as well as explicit and long-term) memory, and its process from sensory input into long-term storage is thought to be heavily dependent on EF and working memory (Johnson, Hashtroudi, & Lindsay, 1993).

**Source Monitoring**

The ability to derive the source of information is a critical cognitive process and an important everyday function (Johnson et al., 1993). When we use information to guide our actions, being able to successfully determine the source of information is often important; for example, not confusing unreliable sources with reliable ones. Johnson et al. (1993) have conceptualized a framework for understanding three basic types of source monitoring. Reality monitoring refers to the ability to distinguish between internally and externally generated information (e.g., “Did I say that or did Person A say that?”). External source monitoring involves discriminating between memories of information provided by at least two separate external sources (e.g., “Did Person A say that, or did Person B?”). Lastly, internal source monitoring refers to differentiating between at least two types of self-generated (internal) memories (e.g., “Did I say that, or think that?”). An interrelated component in many source monitoring tasks is old–new recognition wherein an individual must first recognize information as being something they have heard previously before they can determine the source of the information. Although they cannot be considered two completely different processes (since recognition does require source monitoring, to some extent), source identification and old–new recognition likely involve different processes and draw on different aspects of memory (Johnson et al., 1993). These abilities have been shown to dissociate in several populations. For example, children with autism spectrum disorder (ASD) have exhibited similar recognition performance as controls, but perform poorly on source monitoring tasks (Hala, Rasmussen, & Henderson, 2005).

The development of source monitoring abilities has been fairly well studied in typically developing populations, and developmental patterns of performance have emerged. Foley and Johnson (1983) found that 6-year-old children were as good as 17-year-old adolescents at discriminating between self-generations (i.e., what they said) and external presentations (i.e., what another person said) in a reality source monitoring task, but were much less accurate at differentiating between internal presentations (i.e., what they thought) and self-generations (i.e., what they said) during internal source monitoring conditions. Children’s relative deficits in internal source monitoring may be attributable to a variety of factors. Spoken word and thought may be encoded more similarly in younger children than in older individuals, making the source of information difficult to distinguish (Foley & Johnson, 1983). Younger children may also subvocalize more than older individuals when ‘thinking’ a word, creating false memories of words spoken rather than thought (Foley & Johnson, 1983) and the reasoning abilities of younger children may be less sophisticated, hindering their capacity to reason through cues available in their memory to distinguish between performed and imagined information. Lindsay & Johnson (1991) suggest that people are more likely to confuse memories from similar sources than dissimilar ones, with children being particularly vulnerable to source similarity, and that internal source monitoring ability improves gradually as childhood progresses.

Less is known about the developmental trajectory of source monitoring abilities in children with developmental delay and no studies to date describe these abilities in children with FASD. ASD shares some similarities with FASD, including deficits in EF, cognition, social development, and adaptive skills (Bishop, Gahagan, & Lord, 2007). Hala et al. (2005) found that children with ASD were impaired on source monitoring tasks compared to their typically developing peers (despite no groups differences in recognition memory), and they exhibited the same pattern of performance as controls across the three types of source monitoring. Source memory deficits are consistent with overall EF impairment as source recognition involves more complex executive demands (e.g., the integration of a minimum of two executive dimensions such as inhibitory control and working memory) than simple recognition (Hala et al., 2005). Similarly, children with learning disabilities (LD) demonstrate unimpaired recognition memory compared
to controls, yet are deficient in source monitoring abilities (Lorsbach & Ewing, 1995).

Although standardized testing methods for evaluation of source monitoring have not yet been established, many researchers have explored source monitoring as it presents in clinical populations, such as patients with schizophrenia (for review, see Ditman & Kuperberg, 2005), amnesic patients and patients with frontal brain injury (for review, see Johnson et al., 1993), and aging individuals (e.g., Glisky & Kong, 2008). This has permitted greater understanding of the memory deficits present within these populations particularly as it impacts functioning and accurate recall of episodic events. Research in these populations has suggested that better understanding of source monitoring deficits can better inform the neuropsychological clinical interview as well as lead to more targeted rehabilitative strategies and sensitive indicators of treatment efficacy.

Memory Impairments in FASD

General memory deficits in children with FASD are well documented and occur in verbal, visual, and working memory modalities (see Manji et al., 2010, for a review). Impairments in encoding and retrieval of information (Mattson & Roebuck, 2002; Pei, Rinaldi, Rasmussen, Massey, & Massey, 2008; Willford, Richardson, Leech, & Day, 2004) and EF (Rasmussen, 2005) may be underlying factors contributing to these deficits.

Working memory is also thought to be a fundamental component of EF and some researchers have concluded that working memory impairment may be a core deficit in FASD (Kodituwakku, 2009; Rasmussen, 2005). Tasks that tend to be particularly difficult for children with FASD place a high demand on working memory, especially its central executive component (Kodituwakku, Handmaker, Cutler, Weathersby, & Handmaker, 1995).

**EF and Source Monitoring**

Several studies have connected damage to the frontal brain region with concomitant deficits in EF, which in turn have been associated with difficulty on source monitoring tasks (for a review, see Johnson et al., 1993). Performance on The Wisconsin Card Sorting Test (WCST), a measure of EF, correlates with performance on source monitoring tasks (Rybash & Colilla, 1994). Hala et al. (2005) suggest that demands on EF are greater for source monitoring tasks than they are for recognition, because recognition requires solely working memory, whereas source monitoring may require the combination of more executive domains including working memory, inhibition, and set-shifting.

Accuracy on source monitoring tasks may be determined by successful encoding (e.g., feature-binding, whereby the brain integrates specific features into a unified whole) of information that will help distinguish the source of information upon retrieval (Johnson et al., 1993). Errors in source monitoring could reflect specific deficits in the encoding process. Marrimarella and Fairfield (2008) purport that within the context of the source monitoring framework, individual aspects of the event are ‘feature-bound’ into a unified concept of the event, a process which is expedited by the efficient functioning of working memory during encoding. The authors suggest that working memory strategies (e.g., rehearsal) may maintain the elements of the event in working memory and the component processes of working memory (e.g., organization and inhibition) may facilitate effective feature binding important to successful source monitoring. If children with FASD have deficiencies in working memory, specifically related to the organization of information for encoding, it is logical to assume that their performance in source monitoring tasks would also be affected.

**Goals of Current Study**

Although much research has investigated broad areas of memory function in children with FASD, more specific memory constructs, including source monitoring, have been largely ignored. A deficit in source monitoring may underlie some behavioral and adaptive impairments that are observed in individuals with FASD (e.g., confabulation). One tenet of intervention research in this population is that remediation efforts tend to be most successful when they aim to accommodate underlying neurocognitive factors (Laugeson et al., 2007). As we are better able to understand the specific patterns of strengths and weaknesses in neuropsychological and memory function in this population, we may begin to better define targeted interventions (and even assessments) that will be increasingly specific and impactful for this population. In this study, we hoped to further increase our knowledge of working memory deficits in FASD by investigating potential source monitoring difficulties. Information about source monitoring deficits would not only further delineate the intricacies of working memory deficits in FASD, but also may indirectly help characterize the broader spectrum of EF impairments.

Therefore, the purpose of this study was to conduct a preliminary investigation into the source monitoring abilities of children with FASD compared to typically developing controls (TDCs). Based on observed dysfunction in global memory as well as EF, we predicted...
that children with FASD would show poorer performance on tests of recognition memory and source monitoring compared to age- and gender-matched controls. More specifically, we were interested in the pattern of performance across different types of source monitoring tasks and whether children with FASD would show the same pattern as typical children (i.e., best performance in reality monitoring; poorest performance in internal monitoring). We expected that our group of TDCs would follow this usual developmental pattern. Since gradated performance in typical children is mediated by encoding ability, and because there is a documented deficit in encoding in FASD, we hypothesized that children with FASD would follow a similar pattern as TDCs, although with significantly lower scores. This may help us understand whether the nature of source impacts the degree of this reported encoding deficit, particularly, as it pertains to the ability to recall learning sources. Information about source monitoring deficits will not only further delineate the intricacies of memory deficits associated with FASD, but may also indirectly help characterize the broader spectrum of EF impairments, ultimately contributing to the development and implementation of appropriate intervention efforts.

### Method

#### Participants

Fifty-seven children aged 6–12 years participated in the present study: 19 children (8 males) with FASD and 38 (19 males) control children. Socioeconomic status (SES) was measured using the Hollingshead (1975) four-factor index of SES, which is based on a composite of maternal and paternal education and occupational status. Education is coded on a scale of 1 (less than seventh grade) to 7 (graduate or professional training) and occupational status is coded on a scale that ranges from 1 (farm laborers and menial service workers) to 9 (higher executives, proprietors of large businesses, and major professionals). Additionally, information on parent marital status and household income was gathered (Table I). No significant differences between the groups were revealed in either age \[ t(55) = 0.158, p = .88 \] or SES \[ t(39) = 0.126, p = .90 \].

Children with FASD were recruited through an FASD Clinical Services Division of a large city hospital. A multidisciplinary diagnostic approach was used. A team of professionals (i.e., psychologist, speech–language pathologist, occupational therapist, social worker, and developmental pediatrician) executed an exhaustive review of information gleaned from standardized and

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**Table I. Participant Characteristics**

<table>
<thead>
<tr>
<th>Demographic characteristic</th>
<th>FASD ( n = 19 )</th>
<th>TDC ( n = 38 )</th>
<th>( p )-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (female) (%)</td>
<td>57.9</td>
<td>52.6</td>
<td>.707 (ns)*</td>
</tr>
<tr>
<td>Mean age (range)</td>
<td>9.05 (6–12)</td>
<td>8.97 (6–12)</td>
<td>.875 (ns)</td>
</tr>
<tr>
<td>Current living arrangement (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biological family</td>
<td>26.4</td>
<td>100</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Adopted</td>
<td>47.4</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Foster care</td>
<td>26.3</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Mean number of living situations (range)</td>
<td>2.74 (1–14)</td>
<td>1 (1–1)</td>
<td>&lt;.001 b</td>
</tr>
<tr>
<td>Comorbidities, ( n ) (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any comorbidity</td>
<td>16 (84.2)</td>
<td>38 (0)</td>
<td>N/A</td>
</tr>
<tr>
<td>Mental retardation</td>
<td>1 (5.3)</td>
<td></td>
<td></td>
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<tr>
<td>Learning disability</td>
<td>3 (15.8)</td>
<td></td>
<td></td>
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<tr>
<td>ADHD</td>
<td>10 (52.6)</td>
<td></td>
<td></td>
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<tr>
<td>Reactive attachment disorder</td>
<td>2 (10.5)</td>
<td></td>
<td></td>
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<tr>
<td>Depression</td>
<td>0 (0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Behavioral disorder</td>
<td>2 (10.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Language disorder</td>
<td>3 (15.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleep abnormalities</td>
<td>5 (26.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean SES (SD)</td>
<td>38.07 (6.13)</td>
<td>37.70 (9.98)</td>
<td>.901 (ns)</td>
</tr>
<tr>
<td>Caregiver education (percentage of both caregivers graduated high school)</td>
<td>92.9</td>
<td>96.6</td>
<td>600 (ns)</td>
</tr>
<tr>
<td>Income (percentage of less than $30,000)</td>
<td>23.1</td>
<td>14.3</td>
<td>486 (ns)</td>
</tr>
</tbody>
</table>

*Note. SES as determined by Hollingshead’s Four-Factor Index of Social Status. SES, education, and income information obtained from current caregivers. N/A = not applicable; ns = non-significant.

* Analyzed by chi-square analysis.

b Analyzed by ANOVA.
nonstandardized measures, rating scales, clinical observations, interviews, photographic analysis, and information from families, caregivers, teachers, community clinicians, and children and youth services workers. All participants with FASD had received a diagnosis according to the Canadian guidelines for FASD (Chudley et al., 2005) using the 4-digit diagnostic code (Astley, 2004). This system objectively ranks diagnostic information using a 4-point Likert scale in four key areas: growth deficiency, facial features, brain dysfunction, and alcohol use. A brain dysfunction code of 1 indicates no evidence of brain damage, 2 indicates mild to moderate delay of dysfunction, and 3 indicates significant dysfunction. A brain code of 4 is given only to patients with definite brain damage as evidenced by structural markers (e.g., microcephaly or structural abnormalities on MRI). To be assigned a brain code of 3, the patient must be significantly impaired across 3 or more neurobehavioral domains (sensory/motor, communication, attention, intellectual, academic achievement, EF, memory, adaptive functioning). A brain code of 2 would be given when current data did not support a ranking of 3 or 4, despite a strong history of significant cognitive and/or behavioral problems. All of the participants with FASD in the present sample were coded as Brain 2 or 3. For alcohol, a code of 1 indicates no risk, 2 = unknown, 3 = some risk, and 4 = high risk. All 19 participants with FASD had confirmed prenatal alcohol exposure, with alcohol use scores of 3 or 4, significant enough to lead to brain damage and acceptable for clinic admission. The clinic coordinator confirmed alcohol exposure using birth records, children and youth services documentation, birth mother report, or other reliable sources prior to acceptance into the clinic. Except for birth mother report, corroborative evidence of prenatal alcohol exposure was required. Rankings of growth deficiency and facial dysmorphology were made by a developmental pediatrician according to a 4-point Likert scale where 1 = unlikely, 2 = possible, 3 = probable, and 4 = definite. According to this coding system, 42.1% (8) of the children were diagnosed with Neurobehavioral Disorder, Alcohol Exposed; 31.6% (6) Static Encephalopathy, Alcohol Exposed; and 26.3% (5) with Partial FAS (all falling under the umbrella of FASD) (Table II).

Additionally, prenatal (e.g., genetic conditions, exposure to other known teratogens) and postnatal (e.g., multiple home placements, abuse) factors, which can also impact child outcomes, were ranked within this diagnostic system (Astley, 2004) and validated by both the social worker and the developmental pediatrician after an extensive review of prenatal history, birth documents, health records, children and youth services documentation, school records, and caregiver psychosocial interview on clinic day. This information was then disseminated among team members who jointly interpreted all test scores within the context of the child’s life and environment. Differential diagnoses were carefully considered. For prenatal and postnatal risks, a rank of 1 is equivalent to no risk, 2 to unknown risk, 3 to some risk, and 4 to high risk. Additional information gathered on participants with FASD included full-scale IQ (FSIQ). Participants with FASD had an average FSIQ of 90 (range 78–102).

Control participants were recruited through a local elementary school. The parents of 59 students (66%) gave consent for their children to participate in the study. Of this group, 46 students met the eligibility requirements for participation, including (a) absence of neurological condition and/or brain injury, (b) absence of maternal drinking and smoking during pregnancy, and (c) absence of complications during pregnancy and/or childbirth based on maternal report on a screening questionnaire. From this group, 38 students were selected for the inclusion in the control group based on closeness of match (gender and age) with participants with FASD. Each participant provided assent at the initiation of their testing session. All data collected for this study were obtained in compliance with regulations of an institutional review board.

### Materials and Procedures

Each participant completed a source monitoring task with three conditions. In the reality condition, the child and the
prime researcher were asked to repeat different prerecorded words from a digital tape recorder. In the external condition, the child observed the primary researcher and a second researcher repeating prerecorded words. Finally, the internal condition consisted of the child repeating prerecorded words out loud or thinking them in his/her head. The order of conditions was counterbalanced between participants. Following Hala et al. (2005), words included in the source monitoring task were taken from tables in the Variability in Early Communicative Development (VECD) (Fenson et al., 1994), and were considered to be understood and pronounceable by most typically developing 5- and 6-year-old children (based on VECD norms). Abstract words or words related to mental states were excluded.

At the beginning of each of the three conditions, participants were told they were going to play a game to see how well they could remember words. For each condition, children were told to listen to a man’s voice on a tape recorder instructing either the first or second researcher or the child to say words out loud or think them (i.e., only performed by the child in the internal condition) depending on the condition. Following these instructions, children were given four ‘practice’ words not on the stimulus list to rehearse the procedure. If the child did not follow instructions, corrective feedback was given. Following the practice trial for each condition, 20 stimulus words were presented. A memory test was then administered where the stimulus words were presented in a new random order along with 10 novel distracter words distributed amongst the stimulus words. No more than two words from either category were presented sequentially. After each item, the child was asked if the word was one they had heard previously or if it was a new word they had not heard yet (to assess old–new recognition memory). If the child recognized the word as ‘old’, they were asked a source memory question: either ‘who said the word?’ in the reality and external conditions, or ‘did you say the word out loud or did you think it in your head?’ in the internal condition. See Appendix A1 for further methodological details.

Data Analysis

Several repeated measures analysis of variance (ANOVA) were used for the analysis of memory performance across the three conditions (i.e., reality, external, internal) between TDC participants and those with FASD to examine group and condition effects in recognition and source memory. Group was the between-subjects variable and recognition and source scores as the within-subjects variables. Main and interaction effects were recorded.

Results

Recognition Memory Performance

Recognition performance was operationalized by summing total errors in the recognition phase and subtracting this from a total possible score of 20 (Farrant, Blades, & Boucher, 1998). Other than recognition errors (in other words, misses), only one other error type was possible: incorrectly identifying new words as old (false alarms). The mean total recognition score and mean number of errors for each type across group and condition are summarized in Table III. A mixed group (2) by condition (3) ANOVA with repeated measures for condition was used to test for overall group and condition differences in overall recognition memory. A main effect was found for group, with children with FASD performing significantly worse than TDCs, $F(1, 55) = 5.094, p < .05, \eta^2_p = .085$. There was no effect of condition or interaction.

Possible condition and group differences in specific error type were also evaluated using a separate group (2) by condition (3) repeated measures ANOVA. Children with FASD made significantly more false alarm errors, $F(1,55) = 5.061, p < .05, \eta^2_p = .085$, than TDCs. There was no effect of condition or interaction.

Table III. Mean Scores, Standard Deviations, and Confidence Intervals for Each Group Across Conditions

<table>
<thead>
<tr>
<th></th>
<th>Reality</th>
<th>External</th>
<th>Internal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recognition score, mean (SD) (95% CI)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDC</td>
<td>15.40 (2.22)</td>
<td>(14.51–16.28)</td>
<td>15.24 (2.94)</td>
</tr>
<tr>
<td><strong>False alarms, mean (SD) (95% CI)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FASD</td>
<td>0.89 (1.41)</td>
<td>(0.33–1.46)</td>
<td>0.68 (0.82)</td>
</tr>
<tr>
<td>TDC</td>
<td>0.61 (1.23)</td>
<td>(0.21–1.00)</td>
<td>0.37 (0.59)</td>
</tr>
<tr>
<td><strong>Source score, mean (SD) (95% CI)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FASD</td>
<td>0.84 (0.11)</td>
<td>(0.80–0.89)</td>
<td>0.76 (0.16)</td>
</tr>
<tr>
<td>TDC</td>
<td>0.88 (0.09)</td>
<td>(0.85–0.92)</td>
<td>0.79 (0.12)</td>
</tr>
</tbody>
</table>
Source Memory Performance

Source memory scores were calculated by creating a 'discrimination proportion' score, wherein the sum of the number of words correctly identified for source is divided by the total number of words correctly identified as old (i.e., the recognition score). This score ranges from 0 to 1, with a higher score indicating a greater ability to correctly report source. Mean source score proportions are presented in Table III. A mixed group (2) by condition (3) ANOVA with repeated measures for condition was used to test for overall group and condition effects in memory for source. There was a main effect of group, with children with FASD performing significantly worse than TDCs, F(1, 55) = 6.995, p < .05, ηp² = .113. Overall, there was a main effect of condition, F(2, 110) = 11.654, p < .01, ηp² = .175, with the internal condition being the most difficult followed by external, but there was no interaction.

Relation of IQ to FASD Performance

There were no significant correlations between IQ and recognition/source scores for the FASD group, p > .2 for all correlations.

Discussion

Although memory deficits are broad and well-documented in children with FASD, source monitoring abilities have not yet been examined in this population. Children with FASD in the current study demonstrated impairments in both recognition and source memory when compared to their typical peers. This finding suggests a gross memory deficit in children with FASD rather than a specific impairment in the source monitoring domain, which is consistent with the diffuse brain damage associated with prenatal alcohol exposure as well as the presentation of varied memory challenges in children with FASD. The current findings do not suggest that deficits in recognition and source memory are related to below average IQ in the FASD group.

Analysis of recognition performance revealed that children with FASD tended to struggle to differentiate between old and new information, relative to controls. Essentially, children with FASD are learning and remembering less information as compared to their typical peers, which is consistent with previous research (Manji et al., 2010). In terms of source monitoring, TDCs and children with FASD exhibited a similar developmental pattern with performance being highest in the reality condition and lowest in the internal condition. However, children with FASD experienced significant difficulties compared to controls on all tasks of source monitoring. Children with FASD also made significantly more false alarm errors (identifying new information as old) than controls, suggesting the synthesis of memories from events that never occurred, or possibly indicating intrusion of words heard in situations outside the testing session with a poor source trace. That is to say, in addition to remembering less information quantitatively, the quality of the information remembered (i.e., source) by children with FASD was much poorer than controls, and in some cases, is completely fictitious.

It has been suggested that successful recognition performance may depend on encoding and retrieval of contextual information (Lorsbach, Melendez, & Carroll-Maher, 1991), which may be facilitated by feature-binding (Marrimarella & Fairfield, 2008). Both encoding (Pei et al., 2008) and retrieval (Mattson & Roebuck, 2002) difficulties have been documented in children with FASD. The findings of this study suggest that what may underlie poor encoding and retrieval and thus poor recognition performance may be difficulties related to integrating relevant contextual information surrounding a verbal event and organizing this information into a unified and meaningful memory concept. Failure to organize and contextualize information will likely cause errors in retrieval, which is expedited by these component processes. Plainly, children with FASD may not encode enough material relevant to a semantic event or organize what material they do encode sufficiently enough to be able to efficiently and accurately find these memory links in their minds when asked a general memory question.

Errors in recognition and source memory may have a common etiology. Researchers have suggested that accuracy in source monitoring is also determined by successful encoding (again, such as feature binding) (Marrimarella & Fairfield, 2008), and therefore failure to encode and elaborate the appropriate contextual information would hinder the identification of memory origin. Difficulty gaining access (i.e., retrieval) to source information would also inhibit successful source monitoring performance. Lorsbach and Ewing (1995) suggested that children with LDs who exhibited deficits in source monitoring may fail to identify or use the appropriate retrieval cues stored alongside the source memory when attempting to gain access to their source memories. Therefore, more specific impairments in elaboration (contextualization) and organization may cause difficulties on two tiers. First of all, failure to organize material meaningfully creates issues with remembering material (which is a well-documented occurrence in children with
FASD), but second, what is remembered is remembered poorly—in this specific instance, the origin of the material—is not recalled.

**Implications**

The findings of the present study support the observation of a global episodic memory problem in children with FASD, as well as a more specific deficit in source monitoring. Although errors in source monitoring are daily events for most individuals and possess minor implications, the ramifications of pervasive source monitoring difficulty and memory problems for individuals with FASD can be serious as well as frustrating. Failures in source monitoring may be related to commonly observed problems in individuals with FASD, such as difficulties with real-life functioning and adaptive behavior, social relationships and school, perceived lying and discipline, and emotional functioning. For example, poor source monitoring abilities may make it difficult for individuals with FASD to recall from where they received information and discriminate reliable from unreliable sources (e.g., health advice from a doctor vs. a tabloid), perhaps making them more susceptible to being misled and acting based on invalid information. For instance, researchers have identified the importance of source monitoring abilities within the justice system, noting that source monitoring training may be one way to increase accuracy of information obtained from adolescents during forensic interviews (Ryan, 2010).

Difficulty differentiating actions from thought (e.g., whether one actually turned off the stove or just thought about turning it off) could clearly affect adaptive functioning as well as successful social interaction (e.g., whether they told a story or thought about it) and health (e.g., whether they took their medication or only thought they did). Insufficient internal source monitoring and metacognition may functionally manifest in problems related to the discernment of real-life events from fantasy and the incorporation of fiction as fact. These challenges may contribute to the common perception that individuals with FASD engage in many negative behaviors, such as deception and laziness. It is often difficult to distinguish whether deceptive behaviors are a result of deviancy and manipulative tendencies and if laziness is the cause of poor effort and motivation, or rather just a reflection of organic confusion and confabulation. Not always knowing from where one’s beliefs, knowledge, and memories originate—or if they have a basis in reality at all—may have serious behavioral and emotional implications for individuals with FASD. Research has linked source monitoring deficits to thought interference and subsequent functional difficulties that exists within significant psychiatric disorders (e.g., Startup et al., 2008) and those with prefrontal brain injury (e.g., Johnson et al., 1993). Beginning to extend this work to explore the ways in which differential development of source monitoring may best be measured within clinical settings may provide opportunities to address functional concerns observed in the FASD population.

The significant memory difficulties associated with this population, especially impairments in source monitoring, can lead to confused, inappropriate, or emotionally labile behaviors. It is imperative that we understand the etiology of these behaviors in order to provide appropriate discipline and intervention. Educationally, consideration of how to explicitly contextualize information to support metacognitive function and underscore learning sources would be important. Additionally, high levels of communication between home and school and other environments the individual is engaged in may help to establish the source of information, and ensure consistency between settings in a supportive rather than punitive fashion.

**Limitations and Future Directions**

In order to address any of these speculations, further research is needed, especially with larger and more diverse samples. A number of methodological issues arise when conducting research on memory and EF of children with FASD. Although age, gender, and SES were similar between groups in the present study, many variables that may affect the results are difficult to control including family variables (e.g., home environment), and education (e.g., memory strategies learned in the classroom or educational intervention and support). Additional limitations include the lack of geographical and cultural representativeness of participants in this study because participants were recruited from one clinic (FASD) and one elementary school (controls) in one city. One strength of this study is that the FASD sample was clinically recruited, which ensured reliability and validity of diagnosis. However, the results are not as easily generalizable to the wider population of individuals with prenatal alcohol exposure (PAE) who have not had access to clinical services. The relatively small sample size, especially in the FASD group, limited the power and extent of some of our analyses. However, small sample sizes are not unusual in FASD research and even with reduced power we were still able to detect significant group differences. Additionally, cross-sectional studies have revealed that typical children tend to increase in internal source monitoring ability with age. Unfortunately, our small sample size and age range did
not permit us to examine this relationship in our FASD group, thus denying us the opportunity to determine if children with FASD possess a true deficit in source monitoring, or if they are simply delayed. A lack of imaging data to support neurological correlates underlying source monitoring function is also a limitation, and future studies may wish to address this.

The present study addressed source monitoring deficits in a research setting with no correlative neuro-behavioral measures. It would be of value to examine these deficits in real-life situations, or attempt to relate them more concretely to measures of behavior, emotion, cognition, sensory abilities, or metacognition. Metacognition may be an exceptionally interesting avenue of future research and has been relatively uninvestigated in this population. Successful source monitoring depends greatly on metacognitive knowledge, because it requires individuals to be able to have insight into the mental states and abilities of themselves and of others, as well as be aware that information can be obtained from different sources and in a variety of ways (Farrant et al., 1998). It is possible that poor source monitoring performance in children with FASD may in part reflect deficiencies metacognition (Lindsay & Johnson 1991). Future research should also attempt to tease apart the global memory deficit from source deficits, as well as investigate the generality of source monitoring deficits by using both verbal and nonverbal (e.g., source memory for actions) modalities which could provide new depth to the body of research investigating memory impairments in individuals with FASD.

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**Conflicts of interest:** None declared.

**Appendix A1**

The following contains a detailed description of the source monitoring procedure used in the present study, which follows the procedure used by Hala et al. (2005) and Farrant et al. (1998).

**Reality Condition**

**Presentation of Stimuli**

The child and primary researcher (R1) sat across from each other facing the audio tape player; the secondary researcher (R2) sat off to the side. The child was given a red block and R1, a blue block. R1 introduced the procedure using the following script:

We are going to play a word game to see how you remember words. A man on a tape will tell us to same some words out loud and we have got to say them nice and clearly. Sometimes he’ll tell you to say them because you’re holding the red block, and sometimes he’ll tell me to say them because I’m holding the blue block. After we’ve said a word nice and clearly, we must be quiet to hear the next word. Are you ready?

The tape was played and the male voice introduced the stimulus words. For each word, the voice indicated whether the child or R1 was to say the word [i.e., “Person with the red/blue block, say (stimulus word)”]. The child and R1 each repeated 10 words.

**Memory Test**

R1 introduced the testing phase of the condition with the following instructions:

Now I want you to show me how good your memory is. Next, you will hear the man say lots of words one by one. Some of the words are “old” words that we’ve just heard on the tape [points to tape] and some are ‘new’ words we haven’t heard yet. I want you to listen very carefully to the word and after each word I will ask you a question.

On the new tape track, the same male voice spoke the new list of words that included the 20 stimulus (“old”) words and 10 “new” distracter words. After each word, R1 stopped the tape and asked the recognition question, “Was that one of the old words we heard on the tape, or a new word you haven’t heard before?” If the child answered “new”, R1 started the tape again to move to the next word. If the child answered “old,” R1 asked the source question: “Did you say the word or did I say the word? Tell me who said it and put your finger on your block if you said the word (point to red block) or my block if I said it (point to blue block).”

After the child responded, R1 started the tape again and the same instructions and questions continued for all 30 words. R2 recorded the responses to each question.
External Condition
Presentation of Stimuli
R1 and R2 sat beside each other facing the tape player, across from the child. R1 held the blue box, and R2 held the red box. R1 introduced the procedure:

We are going to play a word game to see how you remember words. A man on this tape will tell R2 (named) and I to say some words out loud and you’ve got to listen very carefully. Sometimes he’ll tell R2 to say them because she is holding the red block, and sometimes he’ll tell me to say them because I’m holding the blue block. So watch and listen very carefully. Are you ready?

The tape was played and the male voice spoke the external condition stimulus words. After each word, the voice indicated which researcher was to say the word by instructing, “Person with the red/blue box, say (stimulus word).” The researchers each repeated 10 words according to the instructions.

Memory Test
The instructions for the memory test were given by R1. For the recognition test, the instructions and questions were identical to the reality condition. If the child responded that a word was “old,” R1 paused the tape and asked the following source question:

Did R1 (named) say that word or did I say that word? Tell me who said it and put your finger on the red block if R1 said the word (point to red block) or put your finger on the blue block if I said the word (point to blue block).

This procedure continued for all 30 words on the tape, while R2 recorded responses.

Internal Condition
Presentation of Stimuli
In this condition, the child sat facing the audio tape player while both researchers sat off to the side. The colored blocks were not used in this condition, as the child was the only agent required to say or think the words in the presentation phase. R1 gave the following instructions:

We are going to play a word game to see how you remember words. A man on this tape will tell you to say some words out loud and he will tell you to think some words in your head. When he tells you to say a word out loud you can just say the word, but when he tells you to think the word in your head, you must think it quietly in your head so no one else can hear. Are you ready?

The tape was played and the male voice spoke the stimulus words. After each word, the voice instructed the child to either say the word out loud or think it in their head [i.e., “Say (stimulus word) out loud” or “Think (stimulus word) in your head”]. The child was instructed to say 10 words out loud and think 10 in his/her head.

Memory Test
For the recognition test, the instructions were identical to the reality and external conditions. If the child responded that a word was “old” R1 paused the tape and asked the following source question: “Did you say that word out loud, or did you think that word in your head?” The order of wording of the test question was alternated across trials.

References


