University of Alberta

Executive Function Strategies used by Children and Adolescents with Fetal Alcohol Spectrum Disorder

by

Marnie Lenore Hutchison

A thesis submitted to the Faculty of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Master of Education

In

Psychological Studies in Education

Department of Educational Psychology

Fall 2011
Edmonton, Alberta

Abstract

The outcomes associated with prenatal alcohol exposure (PAE) are profound, affecting many aspects of cognitive, behavioural, and social development that can be seen in the day-to-day health and functioning of affected individuals. Executive dysfunction has been identified as a particular area of weakness for children with Fetal Alcohol Spectrum Disorder (FASD). Researchers using various neuropsychological tests suggest that children with FASD underperform on many executive functioning tasks; however, they do not tell us which strategies children with FASD are capable of using to aid executive function performance. Observational data was collected on the strategies used by seven children with FASD as they completed cognitively demanding computer games as part of a larger executive function intervention study. Results revealed that children and adolescents used any number of 25 different strategies to aid their executive functioning performance. Furthermore, they were able to increase the number of strategies they used spontaneously and decrease the number of strategies used through prompting over the course of the intervention. Overall, older participants used more spontaneous strategies and significantly fewer prompted strategies than younger children. These results suggest that children and adolescents with FASD can use a wide and varied battery of executive function strategies that if transferred outside of the intervention setting, could have a potentially positive effect on their daily functioning.

Acknowledgements

First, I would like to thank my supervisor, Dr. Jacquie Pei for giving me the opportunity to pursue this work. Jacquie, I appreciate that you encouraged me to think critically and independently and that you have prepared me so well for thinking about real world implications for research. As I move forward in my education, I will always view you as my mentor. I would also like to thank Dr. Lia Daniels for her support and assistance on this project and for giving me the opportunity to continue my education under her guidance. Thanks also to Dr. Marie-Claire Shanahan- my defense was a very positive experience and I have my committee to thank for a wonderfully thought-provoking conversation about my research.

I would like to recognize my parents, Jan and Carl Hutchison, and the rest of my family for your toleration and unwavering support of my academic pursuits. To my friends, thank you not only for listening to me talk about my research but for your advice, empathy, and hugs along the way. Finally, I owe endless appreciation to Jay Makela for your humour, love, and encouragement during times of stress and late nights. You and Louie have helped me to make this experience very memorable.

Table of Contents

List of Tables

List of Figures

CHAPTER ONE

Introduction

Fetal Alcohol Spectrum Disorders (FASD) is a non-diagnostic umbrella term used to describe the range of disabilities caused by consumption of alcohol during pregnancy (Astely, 2011). Health Canada estimates that 9 babies in every 1000 born in Canada have FASD (Health Canada, 2003). Not surprisingly, the range of disorders present significant costs to society, amounting to an annual national cost of $5.3 billion (Stade et al., 2009). Financial costs are only one way to measure the effect of prenatal alcohol exposure (PAE), however. The disorder is associated with numerous secondary disabilities: 60% have Attention Deficit Hyperactivity Disorder (ADHD), over 90% have mental health problems including clinical depression involving suicidal threats and attempts, 60% have been expelled from school, 60% have been in trouble with the law, 50% have been or are in jail, 50% have engaged in inappropriate sexual activity, and 30% have alcohol or drug problems (Streissguth, Barr, Kogan, & Bookstein, 1996; Streissguth et al., 2004). Counterpart to these secondary disabilities is a wide network of necessary supports including Child and Family Welfare, Corrections, Employment, Education, Health, Justice and Police Services as well as caregivers, clinicians, and researchers (Health Canada, 2003).

One of the most obvious indicators of prenatal alcohol exposure is dysmorphology, or physical abnormality; however most children prenatally exposed to alcohol do not show these signs (Rasmussen, Horne & Witol, 2006). Other diagnostic indicators suggestive of an FASD involve growth retardation and central nervous system neurodevelopmental abnormalities (Chudley, Conry, Cook, Loock, Rosales & LeBlanc, 2005). Prenatal alcohol exposure is also associated with a variety of deficits including below average intelligence (Mattson, Riley, Gramling, Delis & Jones, 1997), visual-motor integration (Uecker & Nadel, 1996), learning verbal and visual material (Wilford, Richardson & Leech, 2004), and social skills (Carmichael-Olson, Streissguth, Sampson, Barr, Bookstein & Theid, 1997). Also amongst these deficits are impaired executive function skills, which some believe to be the hallmark of the disorder (Kodituwakku, 2001). Executive functioning refers to an individual's ability to engage in higher-order cognitive processes under conscious control involved in thought and action in goal driven behavior (Welsh, Pennington, & Grossier, 1991; Zelazo & Muller, 2002). For individuals with FASD, problems with executive functions such as novel problem solving, planning behaviour before action, working with more than one piece of information in memory at a time, inhibiting behaviour in order to maximize effectiveness in a situation, or exhibiting flexibility in one's thinking and behaviour are all pronounced (Schonfeld, Paley, Frankel & O'Connor, 2006). These deficits are particularly debilitating as they have ramifications for one's ability to function independently in their everyday lives (Schonfeld et al., 2006).

A less researched aspect of executive function in the FASD population is metacognition, which is the knowledge, awareness, and control of cognitive processes (Flavell, 1979). Metacognition involves multiple components, including knowledge, experiences, goals (or tasks), and actions (or strategies) (Flavell, 1979). The study of metacognition, specifically metacognitive strategies, is better developed in children from other specific populations, such as those with learning disabilities (Borkowski Estrada, Milstead & Hale, 1989), ADHD (Antshel & Nastasi, 2008), and autism spectrum disorders (Bebko and Ricciuti, 2000). For instance, when presented with a list of words to memorize, typical children will rehearse the names to themselves and will also make use of categories by rehearsing words in groups that go together. Children from these special populations, however, do not generally use these strategies without assistance. Given their poor performance on measures of executive function and documented deficits on the metacognitive index on an executive functioning questionnaire (Rasmussen, McAuley, & Andrew, 2007), it would be expected that children with FASD also lack effective use of metacognitive strategies.

Meltzer (2007) writes that, "academic success is dependent on students' ability to plan their time, organize and prioritize materials and information, distinguish main ideas from details, shift approaches flexibly, monitor their own progress, and reflect on their work." These skills connect metacognition with executive function and as such, demonstrate the importance of examining metacognitive strategy use in children with FASD.

The Present Study

The present study was conducted within a larger intervention study that aimed to improve the executive function performance of children and adolescents with FASD. Specifically, the intervention targeted working memory, response inhibition, and sustained attention through cognitively demanding computer games. The purposes of this study were two-fold. First, this study intended to provide a descriptive account of the executive function strategies that children and adolescents with FASD could use by documenting what strategies children and adolescents with FASD used to aid their performance during the intervention. Second, this study sought to examine how children and adolescents used such strategies, whether through prompting or on their own (spontaneously). Such an analysis aims to provide insight into the capabilities of children and adolescents with FASD, despite their impaired functioning in this area.

CHAPTER TWO

Literature Review

The review of literature for this study is established in three areas: (a) background information on FASD, (b) executive functions as a cardinal deficit of FASD, and (c) metacognition.

History of FASD

During the late 1960's and early 1970's three groups of independent researchers began to unravel the morphological defects and developmental delays that can affect children prenatally exposed to alcohol (Lemoine, 1968; Ulleland, 1972; Jones & Smith, 1973). Recognition was based on case studies in which these independent researchers noted a similar pattern of malformations among infants born to alcoholic mothers. In the years 1973 and 1974, Smith, Jones and their colleagues published three articles on the pattern, recognition, and outcome of offspring of children prenatally exposed to alcohol. The first, *Pattern of Malformation in Offspring of Chronic Alcoholic Mothers*, reported a strong association between maternal alcoholism and abnormal morphogenesis in the offspring, particularly craniofacial, limb, and cardiovascular defects with prenatal-onset growth deficiency and developmental delay (Smith, Jones, Ulleland & Streissguth, 1973). Five months later, Smith and Jones published, *Recognition of the Fetal Alcohol Syndrome in Early Infancy*. Herein they assigned the disorder the name, Fetal Alcohol Syndrome (FAS), and relayed new observations of the syndrome in the newborn baby, including a cleft soft palate (Smith and Jones, 1973). The third article, *Outcome in Offspring of Chronic Alcoholic Women,* suggested that the frequency and magnitude of adverse outcomes (perinatal mortality of 17% compared to 2% in controls) in the pregnancies of chronically alcoholic women to be so detrimental, that "serious consideration should be given toward early termination of pregnancy in such women" (Jones, Smith, Streissguth & Myrianthopoulos, 1974).

Terminology and Diagnosis

Criteria for defining FAS were first standardized by the Fetal Alcohol Study Group of the Research Society on Alcoholism in 1980 (Rosett, 1980), and multiple versions of the terminology and diagnostic criteria have since emerged. Most notably, FASD is now used as an umbrella term to describe the full range of outcomes associated with prenatal exposure to alcohol, with FAS as the severest form. The first system, put forth by the Institute of Medicine of the National Academy of Sciences (IOM), outlined five diagnostic categories for FAS and alcohol-related effects (i.e., FAS with confirmed maternal alcohol exposure, FAS without confirmed alcohol exposure, partial FAS with confirmed maternal alcohol exposure, alcohol-related birth defects (ARBD), and alcohol-related neurodevelopmental disorder (ARND). Concerns arose with respect to vague parameters for diagnosis in each category and The Washington State FAS Diagnostic and Prevention Network built upon the IOM criteria to establish a rigorous, case-defined diagnostic coding system. The most recent edition, the 4-Digit Diagnostic Code, was published in 2004 (Astely, 2004). The four digits in the code reflect the magnitude of expression of the key diagnostic features of FAS, which have been identified as the following: (1) growth deficiency in weight and/or height; (2) characteristic FAS facial phenotype that may include short palpebral fissues, thin upper lip, flat nose, and smooth philtrum; (3) evidence of central nervous system (CNS) damage/dysfunction; and 4) confirmation of prenatal alcohol exposure. In Canada, the 4-Digit Diagnostic Code is used to describe, assess, and objectively measure alcohol exposure, growth, facial features, and brain damage while the terminology in the IOM criteria are used to describe the diagnosis (Chudley et al., 2005).

Ideally, a multidisciplinary team of professionals diagnoses an FASD. In such cases, a physician assesses growth deficiency, structural and neurological measures of the CNS, and physical features, while a psychologist and other allied professionals assess psychometric or functional measures of CNS function (Astley, 2004). According to the 4-Digit Diagnostic Code, CNS damage can be assessed in three areas: structural, neurological, and functional (Astley, 2004). Structural abnormalities of the brain are observable, physical damage to the brain or brain structures including microcephaly (small head size) or other abnormalities in brain structure (e.g., agenesis of the corpus callosum or cerebellar hypoplasia). Neurological problems are expressed as either hard signs (diagnosable disorders), such as epilepsy, or soft signs, such as impaired fine motor skills, neurosensory hearing loss, poor gait, clumsiness, poor hand-eye coordination, or sensory integration dysfunction (Chudley et al., 2005). Diagnosis also focuses on functional brain dysfunction in these children including cognition, academic achievement, adaptive behaviour/social skills, neuropsychological deficits, motor/sensory integration, language/social communication, mental health/psychiatric conditions, behaviour/attention/activity level, and development (Astley, 2004).

The magnitude of expression of each diagnostic feature is ranked independently on a 4-point Likert scale with 1 reflecting complete absence of the feature and 4 reflecting strong “classic” presence of the feature (Astley, 2004). When each of these impairments is present, the 4-Digit Code 4444 is used and FAS would be diagnosed (Astley, 2004). There are 246 possible 4-Digit Codes, suggestive of the wide array of outcomes associated with prenatal alcohol exposure (PAE).

It is important to note here that few children prenatally exposed to alcohol actually show all the facial features and growth deficiency to diagnose full FAS. This has important ramifications for children prenatally exposed to alcohol because individuals without facial dysmorphia are still at risk for a decrease in brain volume and serious cognitive and behavioural problems (Mattson et al., 1994; Mattson, Riley, Gramling, Delis & Jones, 1998). Mattson et al. (1998) explain that, "the degree of these deficits may be independent of the presence of physical features associated with FASD."

Common Outcomes Associated with FASD

Since the identification of FAS within the medical community, intensive research efforts have been geared towards understanding the impact of prenatal alcohol exposure on negative developmental outcomes in children. Many researchers have focused specifically on executive functioning as a cardinal deficit in FASD (Kodituwakku et al., 2009, Coles et al., 2002; Rasmussen, 2005). The term "executive functioning" refers to the higher-order cognitive processes under conscious control involved in thought and action in goal driven behavior (Welsh, Pennington, & Grossier, 1991; Zelazo & Muller, 2002). As an umbrella term, executive functions include a number of cognitive, emotional, and behavioural abilities. Some executive functions are inhibition, working memory, problem solving, flexible thinking, and fluency (Zelazo & Muller, 2002). In part, these skills allow one to regulate behaviour and emotions, begin a task and transition from one activity to the next, solve problems, organize, plan and set goals, assess one's own work, make wise judgments, inhibit inappropriate responses, and so on (Zelazo et al., 2002). These skills also help an individual to regulate behaviour by thinking before acting, by managing emotions in order to complete tasks, by behaving in a flexible manner, and by focusing on goals and avoiding procrastination (Dawson & Guare, 2004)

The study of executive function in adulthood suggests that these skills are strongly associated with the prefrontal cortex (Kodituwakku, Kalberg & May, 2001), located in the most anterior half of the frontal lobe of the brain. A distinction in the literature has been made between 'cool' cognitive aspects more associated with flexible thinking and rule use and 'hot' affective aspects more associated with social and emotional decision making abilities (Hongwanishkul, Happeney, Lee & Zelazo, 2005). The brain regions from which these executive functions stem was identified by determining whether patients with damage in specific brain areas show impaired performance on different executive function tasks (Kodituwakku et al., 2001). The dorso lateral prefrontal cortex mediates cool executive functions, while the orbitofrontal cortex, which is involved in responses to reward and punishment, mediates hot executive functions (Rasmussen, 2005; Zelazo & Muller, 2002)

Executive function and FASD. Smaller brain size, particularly in the frontal area, has been shown in fetuses (Wass, Persutte & Hobbins, 2001) and children and adolescents (Sowell et al., 2002) prenatally exposed to alcohol. Not surprisingly, individuals prenatally exposed to alcohol also demonstrate deficits on various tests of executive function including cognitive flexibility, response inhibition, planning, verbal reasoning, and concept formation (Mattson, Goodman, Caine, Delis, and Riley, 1999; Schonfeld, Mattson, Lang, Delis & Riley, 2001); attention, strategy use, set-shifting, and use of feedback (Kodituwakku, Handmaker, Cutler, Weathersby & Handmaker, 1995); and working memory (Rasmussen, McAuley & Andrew, 2007; Rasmussen & Bisanz, 2009). Also important to note is that deficits in executive function exist beyond those accounted for by IQ (Carmichael-Olsen et al., 1998; Kodituwakku et al., 2001; Mattson et al., 1999; Schonfeld et al., 2001) and are present in children across the spectrum of

FASD diagnoses (Mattson et al., 1999; Schonfeld et al., 2001; Kodituwakku, Kalberg & May, 2001). As such, understanding these deficits in individuals with FASD has become important for identification and diagnosis as well as intervention efforts for affected inidividuals. As mentioned, the majority of alcohol-affected children do not meet the physical criteria for FAS and relying on physical markers is not sufficient for identification of prenatal alcohol exposure. Hence, a call was made for research aimed at improving sensitivity and specificity of alcohol-related diagnoses (Riley et al., 2003) via understanding the neuropsychological profile of individuals with FASD.

A specific dose-dependent relationship between maternal prenatal alcohol ingestion and executive function has not yet been clearly identified (Sowell et al., 2002). Kodituwakku et al. (2001) explains that, "although moderate alcohol exposure (i.e., 7.0 to 13.9 drinks per week) may produce impairments of executive function, no relationship has been found between [dose]… and the degree of EF deficits in affected people." Despite a growing sense that, "there is no one neuropsychological profile for the individual with FASD" (Carmichael-Olson, 1998), ongoing investigation, based on the performance of children with FASD on measures of executive function, has begun to identify such a profile (Mattson et al., 2010). Using subtests from the Delis-Kaplan Executive Functioning System (D-KEFS) and the Cambridge Neuropsychological Test Automated Battery (CANTAB) among others, Mattson et al. (2010) were able to distinguish both children with and without the physical features of FAS from nonexposed controls. Tests that assessed executive function, including working memory, verbal fluency, planning, sequencing, cognitive flexibility, and emotional executive function, among others that assessed spatial processing, were deemed especially sensitive to prenatal alcohol exposure (Mattson et al., 2010).

According to the literature, children with FASD demonstrate particular deficits on measures of working memory and response inhibition (Burden et al., 2011). Working memory and inhibition are described as core executive functions and neuroimaging studies indicate they share the same common neural components (McNab, Leroux, Strand, Thorell, Bergman & Klinberg, 2008). Working memory allows one to hold and manipulate information in memory while response inhibition allows us to operate in complex situations with competing stimuli that demand our attention. A child with poor working memory capacity and response inhibition will struggle and often fail in activities such as reading, mathematics, and have other general learning difficulties (Alloway, 2006; Borella, Carretti & Pelegrina, 2010). Accordingly, deficits in these areas can present many challenges for children's school and daily living experiences. Since these executive functions will be observed in the present study, evidence from the performance of children and adolescents with FASD on cognitive, behavioural, and emotional measures of working memory and inhibition will be discussed next.

Working memory. The seminal model of working memory consists of three components, the central executive, phonological loop, and visospatial sketchpad (Baddeley, 1992). The central executive is the main component and is responsible for the simultaneous processing, manipulation, and preparation of information for storage (Baddeley, 1992). It also regulates the two memory stores or slave systems, the phonological loop and visuospatial sketchpad (Baddeley, 1992). According to Baddeley's model, the phonological loop is comprised of a phonological store, which can hold information in speech-based form for a few seconds before they fade, as well as an articulatory rehearsal process, which is analogous to subvocal speech and is used to rehearse and store verbal information from the phonological store (Baddeley, 2003).

Meanwhile, the visuospatial sketchpad stores and manipulates visual and spatial information. Researchers began to explore a pattern of memory impairment for children with FASD in the 1990's and since then, several studies have documented working memory deficits in this population, some suggesting that working memory might be a core deficit in FASD (Kodituwakku, Handmaker, Cutler, Weathersby & Handmaker, 1995). Over the years, evidence of impairment in all three areas of Baddeley's working memory model in children with FASD has accumulated.

At seven years of age, children were administered the Wechsler Intelligence Scale for Children – Third Edition (WISC-III). Streissguth and colleagues (1990) found that of all the intelligence test's subtests, PAE was most related to the forward digit span subtest from the working memory index, a test associated with the phonological loop. Several researchers validated this finding (Jacobson, Jacobson, Sokol, Chiodo, Berube & Narang, 1998; Carmichael-Olson, Feldman, Streissguth, Sampson & Bookstein, 1998) and found additional deficits on the backward digit span task, which is thought to be a measure of the central executive component of working memory (Rasmussen, 2005).

Rasumessen, Soleimani, and Pei (2011) used the CANTAB, a nonverbal computerized test battery to examine working memory, visual memory, and attention. Children with PAE scored lower than controls on the Spatial Working Memory (SWM) test and Spatial Span task (SSP), of which both depend heavily on intact spatial working memory. The SWM and SSP tests engage the visuospatial sketchpad of Baddeley's working memory model by requiring the participant to manipulate visual information. Weaknesses by children with PAE on these two tests led the authors to believe spatial working memory is a significant impairment for this population (Rasmussen et al., 2011).

Response Inhibition. Response inhibition is commonly conceptualized as the ability to suppress irrelevant information in order to facilitate efficient, goal-directed cognitive processing and behaviour (Fryer, 2009). The literature differentiates between behavioural and cognitive aspects of inhibition, defining "behavioural inhibition as the withholding of a prepotent response (e.g. motor inhibition, delay of gratification, impulse control) and cognitive inhibition as the active suppression of cognitions held in working memory (e.g. thought suppression, direct forgetting)" (Fryer, 2009). In the classroom environment, poor inhibition, and consequently inattention and impulsivity, can manifest as "responding before the task is understood, answering before sufficient information is available, allowing attention to be captured by irrelevant stimuli (i.e. distractibility) or failing to correct obviously inappropriate responses" (Schachar & Logan, 1990, p. 710)

Several researchers propose that response inhibition develops during a pivotal shift in cognitive development between ages five and seven. Schachar and Logan (1990) examined differences in both children (typical and non-typical) and adults on a laboratory test of inhibition, the stop-signal paradigm. The purpose of their study was twofold; first to assess the development of inhibitory control in typically developing children and second, to do so in children with Attention Deficit Hyperactivity Disorder (ADHD). The authors found that inhibition is well developed early on in typical children. By grade two, children completed the stop-signal paradigm with a similar rate of errors and speed as adults. As expected, children with ADHD demonstrated deficient inhibitory control over typical controls, and children with conduct disorder, learning disorders, and emotional disorders (Schachar & Logan, 1990).

Studies such as the one conducted by Schachar and Logan's contributes to the notion that inhibitory deficits are a key mechanism underlying inattentive and impulsive behaviours in ADHD (Fryer, 2009). This is important because attention problems are now considered to be a common characteristic of FASD and ADHD is the most frequent comorbid psychiatric disorder in FASD (Fryer et al., 2007; Coles, 2001). Results from a longitudinal study found PAE to be significantly related to attention and memory deficits in a dose-dependent fashion, meaning that as PAE increases so does the likelihood of poor performance on attention tasks (Streissguth et al., 1994). Evidence from this study suggests that it is also poor response inhibition that contributes to impaired performance on measures of attention for children with PAE.

The Wisconsin Cart Sorting Test (WCST) and Stroop tasks are two neuropsychological tests of inhibition that have been used with the FASD population. Kodituwakku et al. (1995) administered a neuropsychological battery including the WCST to 10 subjects with FAS/FAE and 10 controls. On the WCST, the FAS/FAE group made more perseverative errors and completed fewer categories than controls. Carmichael-Olson and colleagues (1998) found similar results. A small sample of adolescents with FAS was administered, among other neuropsychological measures, the WCST and their performance was compared to IQ matched controls (Carmichael-Olson, Feldman, Streissguth, Sampson & Bookstein, 1998). In addition to showing a higher percentage of errors, the FAS participants completed fewer WCST categories than did the IQ comparison controls. These findings suggest that, on the WCST, children and adolescents with FASD have difficulty inhibiting impulsive responding as well as with strategic planning and organizing, directing behaviour toward a goal, utilizing feedback and set shifting, and the employment of working memory capacities. The D-KEFS is often administered to individuals with FASD in studies of executive function and includes a test called the California Stroop Test. Children with FAS/FAE demonstrated poor response inhibition on this test in studies by Mattson et al. (1999) and Rasmussen and

Bisanz (2009). In both studies, children with FASD performed significantly below average.

Working memory and response inhibition deficits in children with PAE have also been documented via EEG recordings. Recently, Burden et al. (2011) analyzed the changes in brain electrical activity of alcohol-exposed children and control children during a Go/No-go response inhibition task and continuous recognition memory tasks. The groups performed comparably on the tasks in terms of accuracy and reaction time, but alcohol exposed children showed altered neurophysiological processing of response inhibition and working memory suggesting a problem with the initial visual processing of stimuli and impairment in memory retrieval (Burden et al., 2011).

The studies described above pertain to what were earlier described as ‘cool’ executive functions. Children with FASD also demonstrate difficulty on measures of ‘hot’ or emotion-related executive function. Hot executive function connects motivation with decision-making and behaviours based on emotionally significant information (Kodituwakku, May, Clericuzio, & Weers , 2001). Kodituwakku et al., (2001) administered two tests of emotion-related learning to children with PAE and to normal controls. Children with substantial PAE exhibited more difficulty learning to discriminate between rewarding and punishing stimuli on the first task and greater variability in the amount of time it took to them to suppress the rule they had learned on the second task (Kodituwakku et al., 2001). Rasmussen and Wyper (2007) connect such poor decision-making skills and increased risk-taking behaviours amongst adolescents with FASD to the life-long problems associated with FASD such as trouble with the law, delinquency, substance abuse, and many more.

Further evidence of working memory and inhibition deficits in FASD come from parent- and teacher-rated behavioural measures of executive function. Rasmussen, McAuley, & Andrew (2007) found a distinctive pattern of impairment in 64 children aged 5 to 16 with FASD on the Behaviour Rating Inventory of Executive Function (BRIEF). The BRIEF is a parental and teacher rating scale of a child's executive function behaviours in everyday situations and settings. Children with FASD demonstrated normative weaknesses in all areas of executive function with mean T scores for each scale significantly higher than the normative mean of 50. Relatively, they showed the most difficulty on the Inhibit, Working Memory, and Initiate scales and least difficulty on Organization of Materials scale.

Metacognition

As we know, executive functions are interrelated abilities in self-monitoring, initiation, planning, goal-setting, memory, and self-awareness (Zelazo & Muller, 2002). In a similar vein, metacognitive skills are denoted to include the processes of awareness, evaluation, prediction, anticipation, and self-control (Bewick, Raymond, Malia, & Bennett, 1995). Educational psychologists have long promoted the importance of metacognition, a term that John Flavell originally coined in the late 1970's to mean "cognition about cognitive phenomena" or more simply "thinking about thinking" (Flavell, 1979). Indeed, a meta-analysis of the research literature on factors associated with learning by Wang, Haertel and Walberg (1990) found the scale that included metacognition to be most strongly associated with academic achievement. Highly rated items within the metacognition variable were those requiring comprehension monitoring, such as planning, monitoring the effectiveness of attempted actions, and testing, revising, and evaluating learning strategies (Wang et al., 1990).

So what exactly is metacognition? Several frameworks have been developed for understanding metacognition, however the seminal version has two constituent parts: metacognitive knowledge (or knowledge about cognition) and executive control (or monitoring of cognition). With respect to metacognitive knowledge, Flavell (1979) differentiates between the knowledge someone has about one's own cognitive functioning (e.g. the domains in which one is strong or weak), the knowledge of demands of different tasks (e.g. what makes a task difficult) and the strategies likely to be most useful in different task solving situations. Flavell (1979) notes that "these different types of knowledge can interact, as in the belief that one should use strategy A (versus strategy B) to solve task X (rather than task Y)" (p. 907). The other component of metacognition is executive control, which Flavell (1979) discusses in the context of "cognitive experiences" and the monitoring and regulation of one's own cognitive functioning. These are insights or perceptions that one experiences during cognition, such as, "I'm not understanding this." Both aspects of metacognition are reportedly important in school learning (Lucangeli & Cornoldi, 1997; Veenman, Kok & Blote, 2005) but for the purpose of this paper, metacognitive knowledge and specifically metacognitive strategies will be further discussed.

Researchers in cognitive psychology have linked executive function to the concept of metacognition, some referring to metacognition as the ultimate executive function (Bewick, Raymond, Malia, & Bennett, 1995). Eslinger (1996) concluded that metacognitive knowledge about tasks and strategies and flexible use of those strategies are included in the collection of executive function processes while others believe that executive function and metacognition are virtually the same thing (Borkowski & Kurtz, 1987; Borkowski et al., 1989; Hanten, Bartha & Levin, 2001). Notwithstanding different connections between the two constructs, both have been identified as critical components in learning and rehabilitative processes and Bewick et al. (1995) claim that, "therapeutic approaches which endeavor to provide explicit instruction of metacognitive and self-regulatory techniques appear to be the most efficacious avenue for executive function training with brain injured patients" (p. 368). Perhaps the most germane to this discussion; in a review of studies examining direct attention training for traumatic brain injury populations, Sohlberg and colleagues (2003) examined the question, "When does it work best, and for whom?' One of their key findings was that direct attention training might be more beneficial when administered in conjunction with metacognitive training (e.g. feedback, self-monitoring, and strategy training).

Metacognitive strategies. Summarizing the results of earlier studies, Oxley and Norris (2000) argue that there is a developmental progression to memory strategy use. Nonorganizational strategies are the first to be utilized, such as attention allocation (i.e. exerting appropriate effort), simple rehearsal (i.e. reciting names of items once), and repeated rehearsal (i.e. multiple recitations of a list). Organizational strategies such as clustering, sorting, and categorizing (i.e. sorting objects or words into groups) supposedly emerge later in development. Schneider et al. (2004) investigated verbal memory development and the acquisition of memory strategies in 100 kindergarten children. Children were tested on various memory measures two times, six months apart. Evidence from their longitudinal study suggests that effective use of multiple strategies can be seen in children as young as kindergarten age (Schneider, Kron, Hunnerkopf & Krajewski, 2004). Between test times one and two, a portion of Schneider et al.'s sample gained sorting, clustering, and rehearsal strategies and in turn, outperformed children who only used a single strategy or no strategy at all on outcome measures of memory (Schneider et al., 2004). This study demonstrates the benefits of metacognitive strategies on memory tasks.

Positive effects of verbalizing strategies have been documented on tests of inhibition in patients with schizophrenia. Like those with FASD, individuals with schizophrenia perform poorly on the WCST. Perry, Potterat, and Braff (2007) found that simply asking participants to verbalize their sorting strategy significantly enhanced performance on the WCST. They posit that WCST performance was improved indirectly via enhanced focus or attention to the WCST task, namely, developing a planning strategy, reasoning and hypothesis testing, and selective use of cognitive inhibition (Perry et al., 2007). Indeed, these are all important aspects of executive functioning that may have been capitalized on by verbalizing their sorting strategy.

Deficient strategy use is seen in multiple populations including those with learning disabilities (Borkowski, Estrada, Milstead & Hale, 1989) and autism (Bebko & Ricciuti, 2000). Pressley and Levin (1997) observed children with learning disabilities to have inefficient, inappropriate (i.e. use strategies that demand too much effort or do not help them to more easily solve problems) and less frequent use of learning strategies compared to controls. Bebko and Ricciuti (2000) observed children with autism to use rehearsal strategies, however their strategy use may be "slower to emerge spontaneously or be used less systematically than non-handicapped peers." Since these populations exhibit some executive function deficits similar to the FASD population, Loomes and colleagues (2008) proposed that children with FASD might be delayed in strategy use as well.

Metacognition and FASD. To date, there is limited data on metacognition and the FASD population; however, available research from the parent version of the BRIEF

(Rasmussen, McAuley, Andrew, 2007) corroborates Loomes et al.'s suggestion that children with FASD may be delayed in strategy use. Rasmussen and colleagues collected parent-rated data on 64 children with FASD, and found that children with FASD are reported to have particular difficulty on initiation of tasks and generating ideas, responses, and problem solving strategies (qualities belonging to the Metacognition Index of the BRIEF). They also found that older children with FASD show more difficulty relative to the norm than younger children on all scales of the BRIEF and significantly so on the Initiate and Working Memory scales (Rasmussen et al., 2007).

Research on strategy training within the FASD population is limited to a single experimental study by Loomes and colleagues (2008). Their study investigated whether teaching a verbal rehearsal strategy to children with FASD would improve memory capacity on a digit span task. Children with FASD were administered a modified version of the Working Memory Test Battery for Children (WMTB-C) across three sessions with the Experimental group receiving rehearsal instructions on the first session. The Experimental group showed a significant increase in digit span scores across the three sessions, but the Control group showed no increase, suggesting that rehearsal training positively impacted memory for numbers among children with FASD (Loomes, Rasmussen, Pei, Manji & Andrew, 2008). In this study, participants were also asked how he or she remembered the items on the task. Age was correlated with self-report of rehearsal use during both sessions, with only older children successfully articulating their rehearsal strategy use. Loomes et al. (2008) posit that older children with FASD demonstrate greater metacognitive awareness.

Loomes et al. (2008) focused on teaching children with FASD one metacognitive strategy, rehearsal. While they demonstrated it to be an effective working memory strategy for children with FASD, these children present with other areas of difficulty, particularly inhibition. Since Loomes et al.'s study focuses on one strategy, the study does not capture the demands in the everyday world of the child with FASD. Further research can build upon their preliminary work to better reflect the breadth of needs present in FASD. Furthermore, a significant amount of the metacognition literature is devoted to reading, writing, and mathematics; and although children with FASD may encounter difficulty with these subject areas, executive functions such as working memory, inhibition, and attention are thought to be central to the disorder. As such, evaluating whether children with FASD can use a range of other executive function strategies is warranted.

Purpose of the Present Study

The purpose of the present study was to add to the FASD, executive function, and metacognition streams of literature by taking a strength-based approach to executive dysfuntion in children with FASD. Metacognitive literature promotes building students' metacognitive strategies as a means to improve performance; however, few studies have examined such potential in children and adolescents with FASD and even fewer have done so in the context of executive function skills. Researchers using neuropsychological measures tell us that children with FASD underperform on measures of executive function, including working memory, inhibition, and attention. Thus, this study intended to provide a preliminary understanding of executive function strategies by observing children and adolescents with FASD as they completed a computerized training program engaging these executive function abilities. More specifically, I examined trends in the mode of strategy use over time (i.e., prompted or spontaneous) and the effect of age on prompted and spontaneous strategy use.

Research questions. 1. What strategies did children and adolescents with FASD use spontaneously during executive function training?

2. What strategies did children and adolescents with FASD use during executive function training games that engaged (a) working memory and (b) inhibition and attention?

3. Is there a change in the number of spontaneous strategies used over time during executive function training?

Hypothesis: Children and adolescents with FASD will increase the number of spontaneously used strategies over time.

4. Is there a change in the number of prompted strategies used over time during executive function training?

Hypothesis: Children and adolescents with FASD will decrease the number of prompted strategies used over time.

5. Was there a significant difference in the number of prompted and spontaneous strategies used between younger and older children and adolescents with FASD?

Hypothesis: It was expected that older children and adolescents with FASD would use a greater number of spontaneous strategies and fewer number of prompted strategies than younger children with FASD.

CHAPTER THREE

Methods

Participants

This research was part of a larger intervention study geared towards improvement of executive functioning in children diagnosed with an FASD. Ethics was approved and obtained from the Department of Educational Psychology Research and Ethics Committee at the University of Alberta. The larger sample included twenty-one children and adolescents from the Edmonton Public School Board and eleven of these children and adolescents were participants in the present study. Of these children and adolescents, four did not complete the intervention. Therefore, the sample of the present study consists of seven children and adolescents with FASD (five male and two female). Three were in the younger age group (ages 8, 9, and 11) and four were in the older group (ages 12, 14, 15, and 16). As measured by the Wide Range Intelligence Test, the mean IQ of the present sample was 69.

Procedures

Data for the current study were collected during a larger study and involved observations during administration of a computerized executive function training intervention program, Cognitive Carnival. The intervention was administered in the school setting, over a twelve-week period with participants playing for approximately sixty to ninety minutes per week spread over two to three sessions per week.

Interventionists. Three research assistants (interventionists) observed participants over a period of twelve weeks. One interventionist observed three participants and the other interventionists observed two participants each. I have administered Cognitive Carnival to two other groups of children with FASD while the current administration was the first for one interventionist and second for the other. Interventionists formed positive relationships with a number of individuals at their respective schools including school administrators, teachers, and study participants. Often, interventionists would have first contact with the school secretary or receptionist who would lead the interventionist to a quiet room for the intervention to take place. Interventionists also had frequent contact with teachers to coordinate pull-out times and to discus pre-, mid-, and post-test measures for the larger study.

Interventionist training. Dr. Kim Kerns, neuropsychologist and co-creator of Cognitive Carnival, and her research assistant Jenny MacSween provided six hours of training on executive functioning, attention process training, and proper administration of Cognitive Carnival. Along with the project coordinator of the larger study, I received this training in January 2010 and the project coordinator trained the two other interventionists for this study in May 2010 and March 2011, respectively.

Description of Cognitive Carnival. Cognitive Carnival was designed to engage the executive function abilities of working memory, inhibition, and attention, and thus was seen as providing an optimal observational opportunity to view the strategies children and adolescents with FASD use to complete executive function tasks. Cognitive Carnival consists of three games (1) Liftoff, (2) Wheel and (3) Platform. Features common to each game include: use of a video game controller on a laptop computer; levels hierarchically organized by difficulty; internal and external rewards provided throughout game play; noise indicating omission and commission errors; and instructions presented prior to each level. Furthermore, each level requires greater than 90% accuracy to advance, however levels can be re-tried as many times as necessary.

Liftoff. Liftoff targets auditory and visual spatial working memory. The object of the game is to memorize and repeat a series of items according to the order and directions specified by the computer. Liftoff has a number of variables that increase the working memory load.

Location. The presented items vary in terms of their positioning on the screen. Items can be presented closer together (in a line or random) or farther apart.

Visual presentation. The presentation for visual items varies depending on the level. For example, in lower levels all items may appear on screen and flash one at a time in the desired order, while in higher levels items may pop up one at a time onto a blank screen and then disappear.

Auditory presentation. Similar to the visually presented items, auditory items vary in their presentation depending on the level. Auditory items may be presented while the visual items are present on the screen or while the participant views a blank screen.

Type of item. Items presented are letters from A-Z, or numbers from 1-9. These items appear within a variety of different shapes (e.g. circle, square, triangle, octagon) and colours (e.g. blue, red, green, yellow, purple) on the screen.

Speed. The time between presentation of each item decreases as levels increase.

Rule complexity. Instructions vary by level from repeating the presented sequence in order, backwards, in numerical order, in alphabetical order, and sometimes involve ignoring a certain shape and/or colour in the sequence.

Number of items. The number of items presented in sequence ranges from 2 to 7.

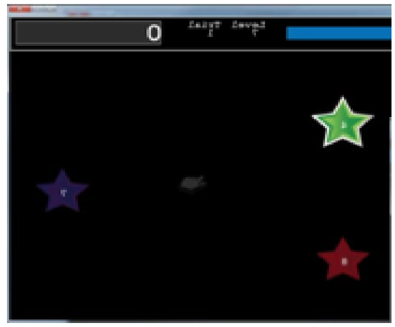

Figure 1. Screenshot of Liftoff during gameplay

Wheel. Wheel targets sustained attention and response inhibition. The object of the game is to remember one or more target items and to select that item as it appears on a spinning wheel. Wheel also presents a number of variables that engage sustained attention and response inhibition.

Length of time. The length of each level varies from three minutes in the lower levels to seven minutes in the highest level.

Type of Item. Targets include shapes of varying colours and three different teddy bears.

Speed. As levels increase, the speed at which the wheel turns increases.

Distractions. A number of distracter items pop up in various locations on the screen during game play. These items are identical to those featured on the wheel, and may or may not include the target item.

Rule complexity. Instructions vary in complexity from selecting only one target item, to selecting two items, to selecting an item only if it follows another specified item on the wheel (e.g. if a star comes three spaces after a circle, press the star).

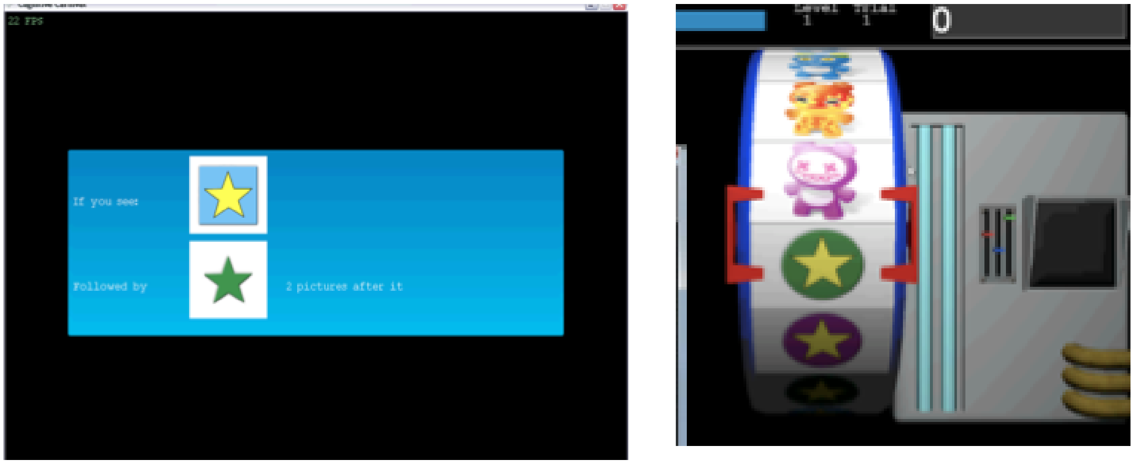

Figure 2. Screenshots of Wheel during gameplay

Platform. Platform targets auditory and visual working memory. The object of the game is to memorize a list of visually or auditory presented items and retrieve them from a brick ‘Mario world’. Platform has a number of variables that increase the load on working memory.

Number of items. The number of items to be memorized varies from 3 to 6, increasing in number as the levels increase in difficulty.

Type of item. Several categories of items are used throughout the game. These categories include fruit, sports balls, and circular flags. Though the categories used can change within the game, all items presented at a single time belong to the same category.

Distracters. Each level includes a number of distracter items belonging to the same category as the target items. For example, a participant asked to search for an apple, a banana, and an orange would find themselves moving through a level that also included other fruits like grapes, watermelons, and lemons.

Environment complexity. A number of objects including ladders, enemies, spikes, and platforms are present in each level to increase the complexity and difficulty of the environment. As the levels increase, the environments become more complex.

Visual presentation. Items that are presented visually to the participant are shown in a single line on the screen before the beginning of each level. The participant chooses when to begin the level, allowing them as much time as they wish to view the items.

Auditory presentation. Items with auditory presentation are spoken aloud by the computer before each level begins. The participant has the option to hit a button on the controller as many times as they wish to have the sequence of items repeated before starting the game.

Rule complexity. Instructions vary by level, and include asking participant to collect items in order or in reverse order.

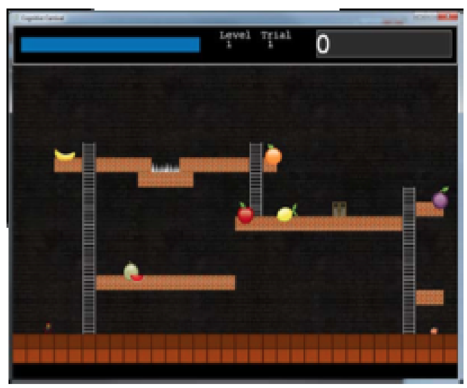

Figure 3. Screenshot of Platform during gameplay

Intervention Process. Interventionists were engaged in sessions with participants in a consistent but flexible manner. Rapport with participants was established before beginning the session and was sought throughout the entirety of the intervention. According to the school schedule, interventionists would retrieve the participant from the classroom or other area of the school and begin the intervention. Cognitive Carnival was developed with the intention of interventionists offering instructional scaffolding to support and promote performance. Support was individualized to each participant, based on his or her unique characteristics and experiences as well as to the specific task at hand.

When participants encountered difficulty on a game, they were taught to first identify the issue, for example, repeatedly forgetting a sequence. Discussion ensued regarding potential explanations for the participant experiencing difficulty, such as the sequence has become longer as the difficulty of the game has increased. For instance, in Platform, the number of items the participant must commit to memory increases after successful completion of the previous level. Thus, on level three the participant must remember and retrieve three items (e.g. banana, apple, grapes) but on level four the load increases to four items (e.g. plum, watermelon, banana, orange). Next the participant and interventionist engage in strategy planning. Here, the participant may choose a strategy of their own or the interventionist may suggest one, based on their understanding of what would be effective for the participant at that time. The interventionist may teach the strategy of ‘chunking’. That is, divide the string of four items into two (e.g. plum, watermelon) and (e.g. banana, orange). Participant dependent, the interventionist may need to prompt the use of the chunking strategy until participant competency increases and the strategy is committed to his or her metaphorical ‘strategy toolbox’. Interventionists noted on the protocol when each strategy was taught, prompted, used spontaneously, and mastered (see Table 1). Interventionists completed an Executive Function Metacognitive Strategy Protocol for each session and also tracked the number of minutes spent on each game that session. Interventionists also noted qualitative observations regarding behaviour, success, and remarks by the participant. At the end of each session, participants were rewarded with a small prize or a sticker to add to a chart that led to a gift certificate at the end of the intervention.

Table 1

Levels of Learning

Type of learning	Description
Taught	The strategy is taught to the child using examples.
Prompted	The child is reminded to use a strategy (i.e. "remember to say them out loud")
Spontaneous	The child performs the strategy independently without prompting
Mastered	The child consistently uses a strategy spontaneously without being prompted

Measures

Executive Function Metacognitive Strategy Protocol. In coordination with the project lead and coordinator of the larger study, I developed the strategy protocol. Strategies were listed based on working memory strategy literature (Oxley & Norris, 2000; Loomes et al., 2008) and previous experience administering Cognitive Carnival. The listed strategies were not inclusive, rather, were meant to serve as a checklist to be added to. As such, interventionists recorded strategies used by participants or suggested by the interventionist that were not on the original protocol. A protocol was completed each time Cognitive Carnival was administered to provide data on the strategies used by participants in their respective sessions. Flavell (1970) divides the progression of learning towards strategy mastery into three stages. The first stage is characterized by an inability to use the given strategy, the second is characterized by inconsistent use, and the third is characterized by spontaneous use of the strategy. The protocol includes categories for these stages of learning, labeled 'taught', 'prompted', 'spontaneous', and a fourth category, 'mastered', which entails consistent spontaneous use of the strategy. The frequency of strategy use was not recorded. Instead, the protocol served as a way to track what stage of learning participants were at for each strategy during each session.

An observational approach rather than self-report approach was taken due to concerns of weak executive control and expressive language skills in the FASD population (Coggins et al., 2007). Furthermore, a problem with measures of metacognition requiring children to describe and justify their actions is that children can verbalize only a selective part of their thought (Bosson, 2010). Indeed, Loomes et al. (2008) found only older children with FASD were able to verbalize their metacognitive actions. As such, behavioural evidence of strategy use was used and in cases when interventionists could not detect what strategy participants were using, participants were asked to report their actions to the best of their ability.

Inter-rater reliability. For reliability purposes, interventionists communicated frequently through email and bi-monthly meetings to update the Executive Function Metacognitive Strategy Protocol with additional strategies and to discuss the intervention.

Data Analysis

Seven participants completed 720 minutes of executive function training. Taught and prompted strategies were grouped and entered as ‘prompted’ and spontaneous and mastered strategies were grouped and entered as ‘spontaneous’. The 720 minutes were collapsed into 4 approximately equal times periods of 180 minutes each and the highest level of learning for each strategy was recorded for each time period.

CHAPTER FOUR

Results

This study fits within a larger intervention study that aimed to improve executive function skills in children and adolescents with FASD through a computerized executive function training program. The goals of the present study were to uncover what strategies children and adolescents with FASD used, and how they used these strategies, over the course of the intervention. The study addressed five research questions, two descriptive and three quantitative.

Question One

The first question asked what strategies participants were able to use spontaneously, that is used by the participant without any prompting, during the intervention. The participant may or may not have been prompted to use these strategies at one point during the intervention, but these data represent the times that participant used the strategy spontaneously. Table 2 presents descriptions for each strategy that participants used spontaneously during the full course of Cognitive Carnival. The descriptions and examples were constructed based on interventionists' observations.

Table 2

Observed Strategies

Strategy	Used spontaneously by # of participants	Description	Example
Clarify directions	7	Read and clarify key directions that affect performance	"What do I have to do again"; "Ignore stars right?"
Rehearsal	7	Recite list of items	"Apple, orange, banana; apple orange banana"
Touching screen	7	Point to items as they appear on the screen	The blue star lights up and the participant touches it, then touches

			the next item to appear
Nonverbal memorization	7	Rehearsing sequence of items in their head	Blue, green, red - subvocally
Substitute	7	Replaces the item with something else	Remembers a feature of an item (e.g. apple → red)
Listing/Stacking	7	Stacking items onto the last heard item until the end of the sequence	"W, W-Q, W-Q-B, W-Q-B-S"
Count and discriminate yes/no	7	Count pictures according to the rule and discriminate whether the next picture is what it is supposed to be	"1, 2, 3, yes, 1, 2, 3, no, 1, 2, 3, no, 1, 2, 3, yes"
Press B to repeat sounds	7	Uses the option to hear the sequence of items again	B-J-U-I-V, press B, B-J-U-I-V
Visualization	6	See the sequence of items in their head	Picturing items (symbols/letters/shapes etc.) in their mind
Rehearsal and pause	6	Recite list of items and ensure correct rehearsal before starting retrieval task	Orange, grapes, watermelon, banana. Orange, grapes, watermelon, banana. Pause. Begin game.
Trace on screen	6	Trace the outline of the items on the screen	Finger on screen from item to item as they appear
Shorten span	6	Limit the amount/complexity of information to memorize	Remember first letter of time (e.g. apple → A)
Choose safest route	6	Avoids features of game that would end the characters life	Resists trying to kill distracter items
Spatial memorization	6	Nonverbal memorization of the placement of the items on the screen	Green star top left, blue circle middle, etc.
Positive self talk	5	Regulate emotion and encourage effort	"I can do this"
Repeat sounds individually (aka	5	Reciting names of items once	Computer: A Child: A

simple rehearsal)			Computer: J Child: J
Put controller down/Pause	4	Sets controller aside or press pause during game	Press pause to take time to regain composure to prevent (increasing) frustration
Chunking	4	Divide sequence of items into smaller chunks	Orange Banana Grapes Plum is remembered as Orange Banana / Grapes Plum
Deep Breathing/Relaxation	3	Taking time to regain composure to prevent or follow frustration	Take 3 long deep breaths before trying again
Compare to where they started	3	To enlighten progress, encourage effort, and reduce frustration	"When I started I had trouble with three items, now I can do five"
Delay speaking	3	Wait to speak with interventionist until finished task	Plays wheel in silence
Set goals (points or levels)	2	Engages in goal setting	Make it to X points, or X level, or X %
Trace on table	2	Traces the shape of the outline of the items on the table	From middle, to top right, to mid left
Count on fingers	2	Assign items to fingers	Tennis ball to pinky, basketball to ring finger etc.
Close eyes/cover screen	2	To ensure correct memorization	Rehearse, cover, rehearse, uncover and check items for correct memorization
Elaboration	1	Associates an item with something else	Apple-pie, orange-juice, etc.

Question Two

The second research question asked what strategies were used to aid working memory and response inhibition and attention, respectively. Table 3 presents the observed strategies according to the game (and accordingly the executive function) the strategy was used for. Strategies were considered to aid working memory if they were used on Liftoff and Platform while strategies were deemed to aid response inhibition and attention if they were used on Wheel. Some strategies were used on all three games and six strategies were also considered 'other' because although they were during games that engaged the specified executive functions they were not working memory, response inhibition or attention strategies specifically.

Table 3

Observed strategies according to executive function

Working Memory (Liftoff and Platform)	Response Inhibition and Attention (Wheel)	Other
Chunking	Choose safest route	Clarify directions
Clarify directions	Clarify directions	Compare to where they started
Compare to where they started	Compare to where they started	Controller down
Controller down	Controller down	Deep breathing
Count on fingers	Deep breathing	Positive thinking
Deep breathing	Delay speaking	Set goals
Elaboration	Discriminate/count	
Nonverbal memorization	Positive self talk	
	Rehearsal	
Positive thinking	Rehearsal and pause	
Press B	Set goals	
Rehearsal	Visualization	
Rehearsal and pause		
Repeat sounds individually		
Set goals		
Shorten span		
Spatial memorization		
Stacking		
Substitution		
Touch screen		
Trace on screen		
Visualize		

Questions Three and Four

The third and fourth research questions ask whether there would be a change in the number of different strategies used spontaneously (third) and through prompting (fourth) over the course of the intervention. To answer these questions, repeated measures

ANOVA were run in SPSS 18.0. The descriptive statistics for the number of prompted and spontaneous strategies are presented in Table 4.

Table 4

Descriptive Statistics for Prompted and Spontaneous Strategies by Time

Variables	Mean	Standard Deviation
Prompted		
Time 1	*4.57*	*2.63*
Time 2	*4.71*	*4.07*
Time 3	*5.00*	*4.04*
Time 4	*2.57*	*1.90*
Spontaneous		
Time 1	*9.29*	*2.81*
Time 2	*11.43*	*2.82*
Time 3	*12.29*	*2.98*
Time 4	*12.86*	*2.61*

Note: $N = 7$

It clearly shows that participants demonstrated the highest number of prompted strategies at Time 1 and the lowest number of prompted strategies at Time 4. Meanwhile, participants demonstrated the lowest number of spontaneous strategies at Time 1 and the highest number of spontaneous strategies at Time 4. To determine whether these changes (i.e., decreases in prompted and increases in spontaneous) were statistically significant, prompted and spontaneous strategies were analyzed with separate one-way repeated measures ANOVA (RM-ANOVA) with Time as the repeated within-subjects factor. One of the core underlying assumptions in the univariate RM-ANOVA procedure is that of sphericity. Sphericity refers to the equality of the variances of the differences between levels of the repeated measures factor and requires that the variances for each set of difference scores be equal. If sphericity is observed, the RM-ANOVA procedure provides a powerful test about repeated measures. For each of the following RM-ANOVA, Maucheley's Test of Sherpicty did not reach significance and therefore, sphericity was assumed.

Spontaneous Strategy Use. A RM-ANOVA (Spontaneous x Time) was conducted on the data for spontaneous strategies. This analysis was to determine the effect of time on the number of different strategies used spontaneously during Cognitive Carnival. There was a significant effect of time $F\ (3, 6) = 3.525$, p=.036, such that the number of strategies used spontaneously significantly increased over the course of Cognitive Carnival administration. An examination of the group means suggests that the mean number of spontaneous strategies was highest on time 4, followed by time 3, time 2 and lowest on the time 1. Table 5 summarizes the results of the RM-ANVOA analysis.

Table 5.

Repeated measures Analysis of Variance - Spontaneous

Effect	MS	df	*F*	*p*
Time	17.18	3	3.53	.036*
Error	4.873	18		

* p < .05.

Prompted Strategy Use. A RM-ANOVA was conducted on the data for prompted strategies. This analysis was to determine the effect of time on number of different strategies used through prompting during Cognitive Carnival over time. Despite the mean changes in prompted strategy use decreasing over time, the effect was not statistically significant, F=(3, 6) = 2.35, p>.05. The mean number of prompted strategies was highest on Time 3, followed by Time 2, Time 1, and the lowest on Time 4. Table 6 summarizes the results of the RM-ANOVA analysis.

Table 6.

Repeated measures Analysis of Variance – Prompted

Effect	MS	df	*F*	*p*
Time	8.62	3	2.35	.107
Error	3.68	18		

Question Five

The final research question examined the relationship between age and strategy use. To test the hypothesis that older participants would use more strategies spontaneously and less prompted strategies than younger participants, I used correlations. Correlations between age and number of different observed prompted and spontaneous strategies in each time period are presented in Table 7. Age was significantly correlated with the number of prompted strategies used during time period 1 only, whereby a strong negative correlation indicated a decrease in required prompted strategies as age increased. Table 8 depicts the means and standard deviations for prompted and spontaneous strategies according to time period and age. As hypothesized, on all time periods, older children used more spontaneous strategies and fewer prompted strategies than younger children. To determine whether these differences (i.e., fewer prompted and more spontaneous strategies for older participants) were statistically significant, I computed separate two-way RM-ANOVA with Time as the repeated within-subjects factor and Age as the between-subjects factor. The between-subjects effect of age was significant for prompted strategies, $F(1,5) = 9.23$, $p=.029$ but not for spontaneous strategies, $F(1,5) = .756$, $p>.05$.

Table 7

Correlations between age and number of observed strategies across type of strategy and session

	Age
Spontaneous Time 1	.58
Spontaneous Time 2	-.05
Spontaneous Time 3	-.005
Spontaneous Time 4	-.12
Prompted Time 1	-.81*
Prompted Time 2	-.67
Prompted Time 3	-.37
Prompted Time 4	-.57

*. Correlation is significant at the 0.05 level (2 tailed)

Table 8

Means and Standard Deviations for Prompted and Spontaneous Strategies by Time and Age

		Prompted		Spontaneous	
	n	M	SD	M	SD
Pre-test					
Time 1 Young	3	6.67	2.08	8.00	3.61
Old	4	3.00	1.83	10.25	2.06
Total	7	4.57	2.64	9.29	2.81
Time 2 Young	3	8.33	3.51	11.00	2.65

Old	4	2.00	1.41	11.75	3.30
Total	7	4.71	4.07	11.43	2.82
Time 3 Young	3	7.33	5.13	11.33	4.16
Old	4	3.25	2.36	13.00	2.16
Total	7	5.00	4.04	12.29	2.98
Time 4 Young	3	4.33	1.53	12.33	.58
Old	4	1.25	.50	13.25	3.59
Total	7	2.57	1.90	12.86	2.61

CHAPTER FIVE

Discussion

The purposes of this study were two-fold. First, this study intended to provide a descriptive account of the executive function strategies that children and adolescents with FASD could use spontaneously during tasks that engaged executive function abilities. Second, this study sought to differentiate participants' abilities to use these strategies with help (prompting) or on their own (spontaneously) and see whether there were changes in how they used such strategies over the course of the intervention. In this section, the results from the current investigation will be interpreted and discussed in relation to past research and theory. As well, limitations, directions for future research, and implications of the present study will be highlighted.

Executive Function Strategies

The results of this study reveal that children and adolescents with FASD have available to them a large and varied battery of strategies to aid their performance on executive function tasks. The finding that rehearsal was acquired and used spontaneously by 100% of the participants by the end of the intervention lends credence to the existing body of research that suggests rehearsal is a readily available working memory strategy for children and adolescents with FASD (Loomes et al., 2008). In addition to rehearsal however, there were 25 other strategies that were used by these individuals. Every participant did not use every strategy but eight were used at least once spontaneously by all participants, five were used at least once spontaneously by seven participants, two were used at least once spontaneously by six participants, two were used at least once spontaneously by five participants, two were used at least once spontaneously by four participants, three were used at least once spontaneously by three participants, four were used at least once spontaneously by two participants, and one was used at least once spontaneously by one participant (see Table 2).

The fact that a group of children and adolescents with FASD were able to use on their own, an average of twelve different strategies that aided executive function performance by the end of the intervention is important given that executive function deficits represent a substantial challenge for those with FASD. This data cannot indicate that these strategies resulted in improvements in memory or executive function performance; however, practicing a variety of strategies that may support executive functioning is, in the least, considered a helpful technique (Hulme & Mackenzie, 1992).

Working Memory Strategies. Twenty-one out of 25 strategies were used during games that engaged working memory (see Table 3). Based on descriptions by Oxley and Norris (2000), children with FASD were able to use both nonorganizational (i.e., rehearsal) and organizational strategies (i.e., elaboration). Participants used both visual and auditory working memory strategies, which is welcomed given the prevalence of verbal and visual-spatial memory deficits in children with FASD (Manji, Pei, Loomes & Rasmussen, 2009). Since positive long-term effects can be seen six months after brief rehearsal training in children with Down syndrome and mental retardation (Brown, Campione & Murphy, 1993; Broadley & MacDonald, 1993) and ten days later in children with FASD (Loomes et al., 2008), I am optimistic about the long-term effects after 12 weeks of consistent training with working memory strategies. It would be necessary to follow-up with these participants to see whether they maintained their repertoire of strategies in the long term and whether they were able to generalize the use of such strategies to other settings, such as mathematics.

Response Inhibition and Attention Strategies. The intervention games also set the stage for participants to use strategies to help them inhibit responses and maintain focus. The response inhibition and attention strategies were important for participants to successfully complete levels of the intervention, such that they were required to suppress their immediate reaction and ignore competing stimuli. Strategies such as clarifying directions prior to beginning a task and pausing to ensure correct memorization are important aspects of the decision making process. By engaging in these strategies participants may be demonstrating awareness that monitoring their actions can improve their performance, which reflects effective decision-making skills. Decision making and risk taking are presumed to underlie high rates of secondary disabilities in FASD (Streissguth et al., 2004; Rasmussen & Wyper, 2007), thus it is hoped that the use of these strategies would carry over and in turn impact the participants' performance in other realms. Again, follow-up would be necessary to assess for such generalization.

Other Strategies. Participants were also prompted to use and spontaneously used other strategies, such as deep breathing, putting the controller down, goal setting, and positive thinking. According to their functional impact, these might be considered self-regulatory or emotion-related executive function strategies. During a previous administration of Cognitive Carnival, a participant with FASD was observed, but not empirically documented, to have successfully adopted effective self-regulatory actions. At the beginning of the intervention, he would react to failure with a behavioural outburst that included flopping his body on the ground. By the end of the intervention this participant would set the controller on the table, take a deep breath, and attempt the task again. Such a dramatic behavioural change was not observed in the present sample, however most participants were able to independently use emotion-related strategies during Cognitive Carnival. The progressively more difficult nature of the game is similar to certain educational demands that are placed on students in the classroom. Learning to react to difficulty with effective strategies will help these children to have a better school experience. It appears that research geared towards exploring how children and adolescents with FASD react to emotionally stimulating situations would be beneficial.

Spontaneous Strategies

The results of this study supported the prediction that participants would show a significant increase in their use of spontaneous strategies over the course of the administration of the intervention. As a group, participants showed an increase in their use of spontaneous strategies over time. By the end of 180 minutes of gameplay, participants could use an average of 9 different strategies spontaneously and by the end of 720 minutes of gameplay, participants could use an average of 12 different strategies spontaneously.

Broadley, MacDonald and Buckley (1994) believe "the long term aim of any training program is to bring the individual to the point where the material used can be generalized and applied to other tasks with similar demands, or to maintain the strategy in the given task." Despite not being able to confirm the first aim, the data from the present study fulfill the latter, maintenance piece of their goal. Table 9 shows the progression in strategy use for a 9-year-old female participant. She maintained her strategies from the beginning of the intervention and increased the number and complexity of strategies over time. For example, rehearsal was acquired during the first 180 minutes and involves repeating a sequence of items (i.e. A-A, Q-Q, R-R, B-B, AQRB). Meanwhile listing/stacking, which was acquired in the second half of the intervention is a more advanced form of rehearsal that involves holding larger sequences in working memory for more time (i.e. A-A, Q-AQ, R-AQR, B-AQRB, AQRB).

Table 9

Example of one participant's strategies

	Prompted	Spontaneous
Session 1		
180 minutes	Clarify directions, touch screen, press B, repeat individual sounds, deep breath, put controller down, positive thinking, choose safest route, listing/stacking	Visualize, nonverbal memorization, rehearsal, rehearsal and pause
360 minutes	Clarify, deep breath, substitution, choose safest route, discriminate/count, cover screen	Rehearsal, rehearsal and pause, touch screen, nonverbal memorization, shorten span, press B
540 minutes	Deep breath, put controller down, delay speaking, choose safest route, cover screen, discriminate/count	Rehearsal, rehearsal and pause, touch screen, nonverbal memorization, press B, listing/stacking, repeat individual sounds, clarify directions, shorten span, substitution
720 minutes	Chunking, visualize, put controller down, set goals	Rehearsal, rehearsal and pause, touch screen, nonverbal memorization, shorten span, press B, listing/stacking, delay speaking, discriminate/count, repeat individual sounds, clarify directions, close eyes

Prompted Strategies

The results of this study indicate that participants required prompting on fewer strategies at the end of the intervention than the beginning, however the decrease was not a statistically significant one. By the end of 180 minutes of gameplay an average of 4 strategies were prompted and by the end of 720 minutes of gameplay, an average of 2 strategies were prompted. Many of the strategies that were prompted at 180 minutes were used spontaneously at the end of the intervention. An example of this change can be seen in Table 9. The observed decrease in the number of prompted strategies throughout the intervention may speak to the participants gaining autonomy with the intervention program or to a learning curve whereby they had internalized the prompted strategies and by the end of the intervention, learned to do them on their own. The decrease was not linear however, with an increase in prompted strategies from time period two to three. Increasing task complexity, whereby participants reached a point in which they required assistance to perform or assistance to decrease frustration, may have caused such a spike in prompted strategies. A deeper understanding of the learning process with respect to metacognitive strategies would be helpful to decipher what exactly contributed to fewer prompted strategies.

Age

The present findings supported the hypothesis that older children with FASD would use more spontaneous strategies and fewer prompted strategies than younger children with FASD. These results fit the literature on the developmental progression of metacognitive strategies in typical children, such that a major shift in strategy knowledge occurs between kindergarten and grade six (Schneider, 2008). The difference between the two age groups was significant for prompted strategies only, however. Since older children began and consistently used more spontaneous strategies than younger children, it appears that the intervention may have been less cognitively demanding for older children and/or interventionists may have deemed older children to require fewer prompts to use strategies to aid their executive functioning performance. A larger sample of participants with FASD with a greater spread in age would allow researchers to make more detailed conclusions regarding age differences and strategy acquisition and application.

Linking The Present Research and Past Theory

Earlier, the seminal research by John Flavell was referenced to explain metacognition. Flavell defines metacognition as including two main elements, (1) metacognitive knowledge, which subsumes person, task, and strategy variables and (2) metacognitive experience (or awareness). In the present study, metacognitive strategies have been considered as the primary outcome variable of interest; however, it could be argued that the participants also made gains in metacognitive awareness. Flavell says that metacognitive experiences can activate strategies, as in "you sense (metacognitive experience) that you do not yet know a certain chapter in your text well enough to pass tomorrow's exam, so you read through it once more (strategy)" (p. 908). This was touched on briefly within the section on the discussion of the response inhibition and attention strategies. There, goal setting and clarifying directions were conceptualized as strategies that involved conscious decision making in order to improve performance. In other words, participants were monitoring their performance. This leads to the question, "What aspect of metacognition did Cognitive Carnival promote in children and adolescents with FASD?" For now, we have evidence that children and adolescents with FASD gained strategies to aid executive function performance over the course of the twelve-week intervention. It is unclear however, whether these strategies were a function of (1) conditioning, (2) increased metacognitive awareness, or (3) a combination of both. I propose that using strategies based on an internal awareness of cognition would be a higher level skill than using strategies based on conditioning, and would result in greater benefits (i.e., generalization). The present study sought to examine metacognitive strategies specifically, but further research that assesses the performance of children with FASD on all aspects of a metacognitive theory would provide a more holistic understanding.

Limitations

The present study produced some important findings, but there are some notable limitations that prevent it from drawing more detailed conclusions, and thus will be important to address for future research. A potential shortcoming in this study is the mode of data collection. The present data is based on the number of different strategies used within specified time periods rather than the number of times the aforementioned strategies were used. The former answers whether a specified strategy occurred during the time period whereas the latter answers how often the strategy occurred over the time period. Recording the frequency of strategy use may have provided a richer dataset to derive conclusions about the development of strategy acquisition; however recording frequency data was not necessary to answer the present research questions.

A second limitation of the present study is that the potential for positive effects of strategy use remain unmeasured in this sample. Other researchers have seen children demonstrate correct use of learned strategies six months post training. Based on the greater intensity and duration of the present intervention, we can assume that strategy use would be seen post-intervention. However, the results from the present investigation cannot confirm this assumption. Pre-, mid-, and post-measures of executive functioning were assessed as part of the larger intervention study; however, these measures were not used as part of this investigation. Further examination into the relationship between strategy use and executive function improvements would help to validate metacognitive strategy research for the FASD population.

Another possible limitation of the present study is that of inter-rater reliability among interventionists. Efforts to obtain inter-rater reliability among interventionists occurred outside of the observation sessions (i.e. email and other forms of personal communication). Within the intervention session, however, data collection was subjective to each interventionist. Despite objective criteria for coding strategies as prompted or spontaneous, future research would benefit from less subjective measures such as videotaping or cross-coding sessions.

Lastly, because it is part of a larger intervention study, the present study was bound by certain limitations, including the design and sample. The longitudinal nature of the intervention study resulted in significant attrition of the sample size for the present study. Despite 11 children starting the intervention, only seven remained at the halfway point. It is important to note certain risks that come with using ANOVA and a small sample size. In particular, small sample size increases vulnerability to violating the assumptions of normality, outliers, and unequal population variances. For normality, the F-test will not be seriously affected however, unless sample sizes are less than five. Outliers tend to increase the estimate of sample variance, thus decreasing the calculated F statistic for the ANOVA and lowering the chance of rejecting the null hypothesis. This may have contributed to some of the insignificant RM-ANOVA results. The most potentially damaging assumption violation occurs when the population variances are unequal. For RM-ANOVA we calculate Mauchley's sphericity and my results suggest that this assumption was not violated (Howell, 2007).

Small sample size is a common issue in research on FASD (Rasmussen, 2006) and even though the sample size was small at seven, it was powerful enough to detect significant differences in strategy use over time. Nevertheless, these data should be considered a preliminary indication of executive function strategies for children with prenatal alcohol exposure. Due to the delayed-treatment control design of the larger intervention study, a comparison group of typically developing children was not included in this study. Many studies with the FASD population fail to include a matched control group however. Rasmussen and Bisanz (2009) cite several difficulties of obtaining a matched control group that mainly surround the difficulty of matching on many other negative life factors associated with FASD. Including a control group of typically developing children would have provided reference with respect to the number and type of strategies that would typically be used during such an executive function intervention and should be considered for future research.

Additional Directions for Future Research

The use of executive function strategies should be more intensively researched with particular attention paid to the following research directions. First, the sizeable number of strategies acquired was strictly observed within the intervention setting. Optimistically, participants would carry over their acquired strategies to the classroom, perhaps using them for mathematics and other scholastic needs. Issues with transfer of learning have been documented in the FASD literature however (McInerney, 2007) and it is plausible that gains made during the intervention remained in that setting. Quantitative measures of metacognitive strategy use in the classroom should be used to assess generalization of strategies outside of the practice setting. Along the same lines, the effect of strategy acquisition on executive functioning performance should be assessed.

The present research approaches the topic from a strength-based perspective, that is, what executive function strategies can children with FASD use? Another valuable perspective will be to address what children with FASD cannot do in terms of executive function strategies. Examining the number and type of executive function strategies used by children and adolescents with FASD compared to typical developing children and to children with other disorders that impact executive functioning, such as ADHD, autism, and learning disabilities might allow researchers to identify whether children with FASD demonstrate a unique profile of metacognitive strengths and weaknesses.

This research also highlighted the abilities of children with FASD to engage in some emotion regulation strategies. The aim of the overall executive functioning intervention was not to improve these specific abilities in children with FASD; however, as an interventionist I viewed the emotion regulation strategies to be necessary for some participants to in turn use the working memory, response inhibition, and attention strategies, which aided their performance. Important next steps should involve exploring metacognitive strategy use within an emotion-focused rather than cognition-focused context in children with an FASD. This is particularly important because children with FASD exhibit significantly lower emotional control than their typically developing peers (Rasmussen, 2007).

Implications and Conclusions

Notwithstanding the above limitations and future considerations, the present study contributes to the literature in many ways. As noted earlier, this study observed children and adolescents with FASD as they played a computerized executive function intervention. Participants used a number of executive function strategies to aid their performance and over the course of the 12-week intervention, mean increases in the number of spontaneously used and mean decreases in the number of prompted strategies were observed. The majority of the strategies aided working memory performance with the rest supporting response inhibition and attention as well as general emotion-regulation strategies. These findings contribute to three areas of research including FASD, metacognition, and executive function literature, respectively.

This research presents information that is important for researchers (to direct future research as discussed above) and for clinicians and caregivers (to inform recommendations and enlighten ways to assist the child with FASD). Dawson and Guare (2004) note that interventions to treat problems with executive skills fall into two categories. The first type of intervention involves making accommodations to the environment while the second type of intervention is personal and involves teaching executive skills and motivating students to use their pre-existing executive skills (Dawson & Guare, 2004). The recommendations that clinicians suggest for the child with FASD generally involve the former, making changes to the environment. The present findings however, support the notion that these children and adolescents with FASD have the ability to acquire and maintain the use of strategies to aid the completion of cognitively demanding tasks. This is important because although the child with an FASD has incurred brain damage, efforts to equip them with skills that can improve their independent functioning should not be ignored.

Furthermore, these findings help to fill the gaps in extant metacognitive literature that has mainly focused on academic skills and other special populations, by underscoring the relevance of metacognitive training with (a) children with FASD; and (b) executive function tasks. Results from the current study have implications for our understanding of the executive function deficits associated with FASD and the role metacognitive training plays in setting the stage for improving those competencies. These findings reveal that there are many strategies to aid executive function performance, and with training, children with FASD can increase their autonomy in using these strategies.

Such skills may also be particularly important for the academic, social and emotional, and adaptive functioning of children with FASD. It is hoped from this investigation that researchers, clinicians, and parents alike will acquire a greater understanding of the potential positive influence that building metacognitive skills has on the cognitive performance of children with FASD.

References

Alloway, T.P. (2006). How does working memory work in the classroom? *Educational Research and Reviews, 1,* 134-139.

Antshel, K.M., & Nastasi, R. (2008). Metamemory development in preschool children with ADHD. *Journal of Applied Developmental Psychology, 29,* 403-411.

Astely, S. (2011). Clinical Assessment of Individuals with Fetal Alcohol Spectrum Disorders (FASD). *Encyclopedia on Early Childhood Development.*

Baddeley, A. D. (1992). Working memory. *Science, 255,* 556-559.

Baddeley, A.D. (2003). Is working memory still working? *European Psychologist, 7,* 85-97.

Bebko, J.M., & Ricciuti, C. (2000). Executive functioning and memory strategy use in children with autism: The influence of task constraints on spontaneous rehearsal. *Autism, 4,* 299-320.

Bewick, K.C., Raymond, M.J., Malia, K.B., & Bennett, T.L. (1995). Metacognition as the ultimate executive: Techniques and tasks to facilitate executive functions. *NeuroRehabilitation, 5,* 367-375.

Burden, M.J., Westerlund, A., Muckle, G., Dodge, N., Dewailly, E., Nelson, C.A., Jacobson, S.W., & Jacobson, J.L. (2011). The effects of maternal binge drinking during pregnancy on neural correlates of response inhibition and memory in childhood. *Alcoholism: Clinical and Experimental Research, 35,* 1-14.

Borkowski, J.G., Estrada, M.T., Milstead, M., & Hale, C.A. (1989). General problem-solving skills: Relations between metacognition and strategic processing. *Learning Disability Quarterly, 12, 57-70.*

Borella, E., Carretti, C., & Pelegrina, S.L. (2010). The specific role of inhibitory efficacy in good and poor comprehenders. Journal of Learning Disaibilities, 43, 541.552

Borkowski, J.G., Estrada, M.T., Milstead, M., & Hale, C. A. (1989). General problem-solving skills Relations between metacognition and strategic processing. *Learning Disabilities Quarterly, 12,* 57-70.

Carmichael-Olson, H., Streissguth, A.P., Sampson, P.D., Barr, H.M., Bookstein, F.L., & Theid. (1997). Association of prenatal alcohol exposure with behavioural and learning problems in early adolescence. *Journal Am Acad Child Adolesc Psychiatry, 36,* 1187-1194.

Carmichael-Olson, H., Feldman, J.J., Streissguth, A.P., Sampson, P.D., & Bookstein, F.L. (1998). Neuropsychological deficits in adolescents with fetal alcohol syndrome: Clinical findings. *Alcoholism: Clinical and Experimental Research, 22*, 1998-2012.

Chudley, A.E., Conry, J., Cook, J.L., Loock, C., Rosales, T., & LeBlanc, N. (2005). Fetal alcohol spectrum disorder: Canadian guidelines for diagnosis. *Canadian Medical Association Journal, 172*, S1-S21.

Coggins, T.E., Timler, G.R., & Olswang, L.B. (2007). A state of double jeopardy: impact of prenatal alcohol exposure and adverse environments on the social communicative abilities of school-age children with fetal alcohol spectrum disorder. *Lang Speech Hear Serv Sch 38*, 117–127.

Coles, C.D., Platzman, K.A., Lynch, M.E., & Freides, D. (2002). Auditory and visual sustained attention in adolescents prenatally exposed to alcohol. *Alcoholism Clinical and Experimental Research, 26*, 263-271.

Dawson, P., & Guare, R. (2004). *Executive skills in children and adolescents: A practical* *guide to assessment and intervention.* New York: The Guilford Press.

Eslinger, P. J. (1996). Conceptualizing, describing, and measuring components of executive function: A summary. In G. R. Lyon & N. A. Krasnegor (Eds.), *Attention, memory, and executivefunction* (pp. 367–395). Baltimore, MD: Paul Brookes.

Flavell, J.H. (1979). Metacognition and cognitive monitoring. *American Psychologist, 34,* 906-911.

Flavell, J. H. (1970). Developmental studies of mediated memory. In H. Reese & L. Lipsitt (Eds.), Advances in child development and behaviour (pp. 181–211). New York: Academic Press.

Fryer, S.L. (2009). Characterization of BOLD response patterns during inhibitory control in individuals with prenatal alcohol exposure. (Unpublished doctoral dissertation). University of California, San Diego.

Fryer, S. L., McGee, C. L., Matt, G.E., Riley, E.P., & Mattson, S.N. (2007). Evaluation of psychopathological conditions in children with heavy prenatal alcohol exposure. *Pediatrics, 119*, e733-e741.

Hongwanishkul, D., Happaney, K.R., Lee, W.S.C., & Zelazo, P.D. (2005). Assessment of hot and cool executive function in young children: Age-related changes and individual differences. *Developmental Neuropsychology, 28,* 617-644.

Howell, D. (2007). *Statistical Methods for Psychology.* Belmont, California: Thomas Wadsworth.

Jacobson, S.W., Jacobson, J.L., Sokol, R.J., Chiodo, L.M., Berube, R.L., & Narang, S.

(1998). Preliminary evidence of working memory and attention deficits in 7-year-olds prenatally exposed to alcohol. *Alcoholism: Clinical and Experimental Research* 22,

Jones, K.L., & Smith, D.W. (1973). Recognition of the fetal alcohol syndrome in early infancy. *The Lancet,*

Jones, K.L., Smith, D.W., Streissguth, A.P., & Myrianthopoulos, N.C. (1974). Outcome in offspring of chronic alcoholic women. *The Lancet,* 1076-1078.

Kodituwakku, P.W., Handmaker, N.S., Cutler, S.K., Weathersby, E.K., & Handmaker, S.D. (1995). Specific impairments in self-regulation in children exposed to alcohol prenatall. *Alcoholism: Clinical and Experimental Research, 19,* 1558-1564.

Kodituwakku, P.W., Kalberg, W., & May, P.A. (2001). The effects of prentatal alcohol exposure on executive functioning. *Alcohol Research & Health, 2,* 192-198.

Lemoine, P., Harrousseau, H., Borteyru, J. P., & Meneut, J. C. (1968). Les enfant des parents alcooliques: Anomolies obervee ́s, a`propos de 127 cas. *Ouest Medical, 21*, 476–482.

Loomes, C., Rasmussen, C., Pei, J., Manji, S., & Andrew, G. (2008). The effect of rehearsal training on working memory of children with fetal alcohol spectrum disorder. *Research in Developmental Disabilities, 29,* 113-124.

Lucangeli, D., & Cornoldi, C. (1997). Mathematics and metacognition: What is the nature of the relationship? *Mathematic Cognition, 3*, 121-139.

McInernery. R.J. (2007). Transfer of learning in children with fetal alcohol spectrum disorder. (Unpublished doctoral dissertation). University of Victoria, Victoria, BC.

Mattson, S.N., Riley, E.P., Gramling, L., Delis, D.C., & Jones, K.L. (1998). Neuropsychological comparison of alcohol-exposed children with or without physical features of fetal alcohol syndrome. *Neuropsychology, 12,* 146-153.

Mattson, S. N., Riley, E. P., Jernigan, T. L, Garcia, A., Kaneko, W. M., & Ehlers, C. L. (1994). A decrease in the size of the basal ganglia following prenatal alcohol exposure: A preliminary report. *Neurotoxicology and Teratology, 16,* 283-289.

Mattson, S.N., Roesch, S.C., Fagerlund, R.A., Autti-Ramo, I., Jones, K.L., May, P.A., Adnams, C.M., Konovalova, V., & Riley, E.P. (2010). Toward a neurobehavioral profile of fetal alcohol spectrum disorders. *Alcoholism: Clinical and Experimental Research, 34,* 1640-1650.

Mattson,S.N.,Goodman,A.M.,Caine,C, Delis,D.C, &Riley.E.P.(1999). Executive functioning in children with heavy prenatal alcohol exposure. *Alcoholism, Clinical and Experimental Research, 23(11),* 1808-1815.

McNab, F., Leroux, G., Strand, F., Thorell, L., Bergman, S., & Klinberg, T. (2008). Common and unique components of inhibition and working memory: An fMRI within-subjects investigation. *Neuropsychologia, 46*, 2668-2682.

Oxley, J.D., & Norris, J.A. (2000) Children's use of memory strategies: Relevance to voice output communication aid use. *Augmentive and Alternative Communication, 16,* 79-94.

Perry, W., Potterat, E.G., & Braff, D.L. (2007). Self-monitoring enhances Wisconsin Card Sorting Test performance in patients with schizophrenia: Performance is improved by simply asking patients to verbalize their sorting strategy. *Journal of the International Neuropsychological Society, 7,* 344-352.

Rasmussen, C. (2005). Executive functioning and working memory in Fetal Alcohol Spectrum Disorder. *Alcoholism: Clinical and Experimental Research, 29*, 1359-1367.

Rasmussen, C., McAuley, R. & Andrew, G. (2007). Parental ratings of children with fetal alcohol spectrum disorder on the Behaviour Rating Inventory of Executive Function (BRIEF). *Journal FAS International*

Rasmussen, C. & Bisanz, J. (2009). Executive functioning in children with Fetal Alcohol Spectrum Disorder: Profiles and age-related differences. *Child Neuropsychology*, *15,* 201-215.

Rasumessen, C., Soleimani, M., & Pei, J. (2011). Executive functioning and working memory deficits on the CANTAB among children with prental alcohol exposure. *Journal of Popular Therapy and Clinical Pharmacology, 18*, 44-53.

Riley EP, Guerri C, Calhoun F, Charness ME, Foroud TM, Li T-K, Mattson, SN, May PA, Warren KR (2003) Prenatal alcohol exposure: advancing knowledge through international collaborations. Alcohol Clin Exp Res 27:118–135.

Rosett, H. L. A clinical perspective of the fetal alcohol syndrome. *Alcoholism: Clinical and Experimental Research* 4: 118, 1980.

Schachar, R., & Logan, G.D. (1990). Impulsivity and inhibitory control in normal development and childhood psychopathology. *Developmental Psychology, 26,* 710-720.

Schneider, W., Kron, V., Hunnerkopf, M., & Krajewski, K. (2004). The development of young children's memory strategies: First findings from the Wurzburg longitudinal memory study. *J. Experimental Psychology, 88,* 193-209.

Schonfeld, A.M., Paley, B., Frankel, F., & O'Connor, M.J. (2006). Executive functioning predicts social skills following prenatal alcohol exposure. *Child Neuropsychology, 12,* 439-452.

Schonfeld, A. M., Mattson, S. N., Lang, A. R., Delis, D. C , & Riley, E. P. (2001). Verbal and nonverbal fluency in children with heavy prenatal alcohol exposure. *Journal of Studies on Alcohol, 62(2),* 239-246.

Smith, D.W., Jones, K.L., Ulleland, C.N., & Streissguth, A.P. (1973). Pattern of malformation in offspring of chronic alcoholic mothers. *The Lancet,* 1267-1271.

Sohlberg, M., Avery, J., Kennedy, M. R. T., Coelho, C, Ylvisaker, M., Turkstra, L., & Yorkston, K. (2003). Practice guidelines for direct attention training. *Journal of Medical Speech-Language Pathology, 11,* 3, xix-xxxix.

Sowell, E. R., Thompson, P. M., Mattson, S. N., Tessner, K. D., Jernigan, T. L., Riley, E. P., & Toga, A. W. (2002). Regional brain shape abnormalities persist into adolescence after heavy prenatal alcohol exposure. *Cerebral Cortex, 12,* 856-865.

Stade, B., Ali, A., Bennett, D., Campbell, D., Johnston, M., Lens, C., et al. (2009). The burden of prenatal exposure to alcohol: revised measurement of cost. *Canadian Journal of Clinical Pharmacology, 16*, 91-102.

Streissguth, A.P., Barr, H.M., & Sampson, P.D. (1990) Moderate prenatal alcohol exposure: Effects on child IQ and learning problems at age 7 ½ years. *Alcoholism: Clincial and Experimental Research, 14,* 662-669.

Streissguth, A.P., Sampson, P.D., Carmichael Olson, H., Bookstein, F.L., Barr, H.M., Scott, M., Feldman, J., & Mirsky, A.F. (1994). Maternal drinking during pregnancy: Attention and short-term memory in 14-year-old offspring – A longitudinal prospective study. *Acoholism: Clinical and Experimental Research, 18,* 202-218.

Streissguth, A.P., Barr, H.M., Kogan, J., & Bookstein, F.L. (1996). Understanding the occurrence of secondary disabilities in clients with fetal alcohol syndrome (FAS) and fetal alcohol effects (FAE). *CDC Final Report # CCR008515*.

Streissguth, A., Bookstein, F.L., Barr, H.M., Sampson, P.D., O'Malley, K., Young, J.K. (2004). Risk factors for adverse life outcomes in fetal alcohol syndrome and fetal alcohol effects. *Developmental and Behavioral Pediatrics, 25*, 228-238.

Uecker, A., & Nadel, L. (1996). Spatial locations gone awry: Object and spatial memory deficits in children with fetal alcohol syndrome. *Neuropsychologia, 34,* 209-223.

Veenman, M.V.J., Kok, R., & Blote, A.W. (2005). The relationship between intellectual and metacognitive skills in early adolescence. *Instructional Science, 33*, 193-211.

Wang, M. C, Haertel, G. D., & Walberg, H. J. (1990). What influences learning? A content analysis of review literature. *The Journal of Educational Research, 84(1),* 30-43.

Wass, T. S., Persutte, W. H., & Hobbins, J. C. (2001). The impact of Prenatal Alcohol Exposure on frontal cortex development in utero. *American Journal of Obstetrics and Gynecology, 185,131-141.*

Welsh, M.C., Pennington, B.F., & Grossier, D.B. (1991). A normative-developmental study of executive function: A window of prefrontal function in children. *Developmental Neuropsychology, 7*, 131-149.

Wilford, J.A., Richardson, G.A., & Leech, S.L. (2004). Verbal and visuospatial learning and memory function in children with moderate prenatal alcohol exposure. *Alcohol Clin Exp Res, 28,* 497-507.

Zelazo, P. D., & Muller, U. (2002). Executive function in typical and atypical development. In Goswami, Usha (Ed). *Blackwell handbook of childhood cognitive development*. Malden, MA: Blackwell, 2002:445-69.

Appendix A

EF Intervention Metacognitive Strategy Checklist

Strategy	Taught	Prompted	Spontaneous	Mastered
Clarify directions				
Visualization				
Deep Breathing/Relaxation				
Put controller down/Pause				
Set goals (points or levels)				
Chunking				
Positive self talk				
Rehearsal				
Rehearsal and pause				
Touching screen				
Nonverbal memorization				
Compare to where they started				
Tracing on screen				
Shortening span				
Elaboration				
Substitution				
Chooses safest route				
Listing/Stacking				
Spatial memorization				
Tracing on table				
Counting on fingers				
Delayed speaking				
Discriminates yes/no				
Press B to repeat sounds				
Repeat sounds individually				

Observations:

Appendix B

EF Intervention Metacognitive Strategy Legend

Use L for Liftoff, W for Wheel, and P for Platform. Note the letter in the appropriate box when the child is taught the strategy, performs the strategy when prompted (i.e. “remember to say them out loud”), performs the strategy on their own without being prompted (spontaneous), and when you feel they have mastered that strategy (i.e. they continually use the strategy without being prompted and it becomes automatic for them)

Clarify directions: “What do I have to do again”; “Ignore stars right?”
Visualization: Picturing symbols/letters/shapes etc. in their mind
Breathing/Relaxation: Taking time to regain composure to prevent or follow frustration
Put controller down/pause: Taking time to regain composure to prevent or follow frustration
Set goals: Make it to X points, or X level, X %
Chunking: Orange Banana Grapes Plum is remembered as Orange Banana / Grapes Plum
Positive self-talk: “I can do this”
Rehearsal: Repeating list while doing task
Rehearsal + pause: Ensures correct rehearsal before starting task
Touching screen: Points to objects on screen while listening/before starting task
Nonverbal memorization: Memorizing in their head vs out loud (rehearsal)
Compare to where they started: As a means to see progress and level of difficulty
Tracing on screen: Similar to touching screen, but keeps finger on screen to trace
Shortening span: Reduces/ the amount of information to memorize. Ex.Apple → A or leaves last number/letter off of liftoff list because they will remember it and don’t need to rehearse it
Substitution: Remembers features instead of name. Ex. Apple → red
Elaboration: Apple → my favourite fruit is apple so I’ll remember it first
Choose safest route: In platform, chooses to go to door when finished, jumps certain way to be safe
Stacking: Rehearse a continual list of the letters as they hear them, such as "W, W-Q, W-Q-B, W-Q-B-S”
Spatial memorization: Keep in mind where they saw the number or letter flash and then look in that area again when all of the items appear
Tracing on Table (instead of screen) - Traces the outline of the letters/number when the voice says them
Counting on fingers - Assigns each letter to one of his fingers when the voice says them.
Delayed speaking: Wait to talk until done task is finished to speak to interventionist
Discriminates yes/no: In wheel, says “yes” when they should press green and “no” when they shouldn’t. “Yes, no, no, no, no, yes”
Press B to repeat sound: In platform, uses the B button to hear again
Repeat sounds individually: In liftoff, says the letter/number right after the voice. “B-b, X-x, T-t”

Add different/new strategies to the bottom of the chart as they are taught or used

Note student quotes of interest. For example, “I never thought I could get this far”