SUSTAINED ATTENTION TRAINING IN CHILDREN WITH FETAL ALCOHOL SPECTRUM DISORDER

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Canada

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By

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B.A. Specialized Honours, York University, 1996
M.Sc., Memorial University of Newfoundland, 1999

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Abstract

Objective: Attentional difficulties are the most commonly observed behaviours in children with FASD, and Attention Deficit Hyperactivity Disorder (ADHD) is often cited as a central feature of the profile associated with FASD. Attention deficits can be noted as early as infancy, or during the preschool years, and become critical when children enter the school system. Deficits in learning and memory are often secondary to an inability to attend effectively, which is not surprising given that attention is necessary for orienting toward relevant concepts or events. Without appropriate intervention, even mild deficits in this domain can have a significant negative impact on a child's development, as children grow missing important information in their immediate environment, having difficulty recalling events, making mistakes in daily tasks, and having difficulty with higher level cognitive processing such as problem solving and reasoning. Intervention research for children with FASD is limited to two published reports, with a glaring dearth in the area of attention. The purpose of the current study was to implement a cognitive-based intervention strategy that targeted attentional processes directly.

Participants and Methods: Twenty Labrador Inuit children (ages 6.8-11.9) were divided into 2 groups matched for age and non-verbal reasoning and randomly assigned to attention process training that focused on *sustained attention* (SA), or contact control (CC) conditions that included academic support and games. Pre- and post-treatment assessments were conducted with direct standardized measures of verbal and non-verbal reasoning (KBIT2 and CTONI) and attention (KiTAP and TEA-Ch), and indirect measures of attention and executive functioning (ADDES-3-SV and BRIEF teacher checklists). There were no significant differences between the treatment and contact-control groups on pre-training measures of attention or verbal and non-verbal reasoning. Children were trained using materials from Thomson and colleagues' *Pay Attention* program. All children participated in 12 daily 30-min individual training or support sessions, for approximately 3 weeks. On average, children completed all assessment and training sessions during a 5-6 week period (approximately 18-20 individual sessions).

Results: Significant treatment effects emerged on untrained visual and auditory *sustained attention* tasks, including improved performance on correct responses, errors of omission, and variability of response time. Gains from training *generalized* to a task tapping *selective* attention, with significant improvements in errors of commission following sustained attention training. In addition, training seems to have also generalized to higher-order *alternating* attention tasks, with increased correct response performance and reduced errors of commission. While teachers rated all children as having post-test improvements in attention and executive functioning behaviour, and hence reported no differential effects of treatment, significant treatment effects emerged on a widely utilized measure of non-verbal reasoning (CTONI), with a similar trend on the KBIT2 non-verbal performance subscale.

Conclusions: Given the high prevalence of attention deficits for children with FASD and the impact that these deficits have on many aspects of development, early intervention is critical for a better outcome for these children. Should we be able to target basic attention deficits through direct early intervention, we may be able to alter some of the secondary deficits associated with FASD throughout the teenage and young adult years. Based on the work conducted in this exploratory dissertation, it is concluded that *sustained attention* process training may be beneficial for children with FASD. While all children made nonspecific gains from participating in the current study, children undergoing direct *sustained attention* training made significant gains as a function of treatment on various untrained measures of attention. These beneficial effects generalized to a functional measure of non-verbal reasoning ability, with children's performance significantly improving on a widely utilized school-based instrument. Thus, it appears that direct training of attentional processes might provide a useful technique for use with the pediatric FASD population.

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Dedication

To Cary

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INTRODUCTION

Fetal Alcohol Spectrum Disorder (FASD) is an umbrella term used to describe a wide spectrum of physical, neurodevelopmental, behavioural, and learning disabilities due to prenatal alcohol exposure. FASD has been identified as the leading cause of developmental disability among Canadian children (Health Canada, 2003) and Fetal Alcohol Syndrome is the leading known cause of mental retardation in the US (Stratton, Howe, & Battaglia, 1996). FASD includes Alcohol Related Birth Defects (ARBD), Alcohol Related Neurodevelopmental Disorder (ARND), and full and partial Fetal Alcohol Syndrome (FAS; p-FAS). Canadian statistics are lacking, but the national rate of FAS has been estimated at 1-2 for every 1000 births, which means that more than 350 children are born with FAS on a yearly basis (Canadian Perinatal Surveillance System [CPSS], 1998). By definition, the rate of FASD is much higher. For example, the U.S. estimate is 9.1 per 1,000 live births (reported in Chudley et al., 2005).

FASD is a major public health concern and poses a special health challenge to communities which rank poorly on health risks, and social and economic measures. While FASD is not associated with a specific ethnocultural group, rates vary with culture and have been significantly associated with socioeconomic class and ethnic minority status (Zevenbergen & Ferraro, 2001). Marginalized women are often at greatest risk of drinking during pregnancy. Specific risk factors include lower SES, increased partner's drinking and drug use at time of pregnancy, reduced access to prenatal and postnatal services, inadequate nutrition and a poor developmental environment, social isolation, abuse, and history of severe childhood sexual abuse (Bingol et al., 1987; Sood et al., 2001).

Determinants of Outcome

Alcohol is a teratogen whose neurotoxic effects are differentially linked to the prenatal period of exposure: the sensitive or critical periods of development. For example, prenatal alcohol exposure will directly affect the developing organs (e.g., causing facial dysmorphia) during the period of organogenesis of the 1st trimester (Coles, 1994) and contribute to growth retardation and lower birth weight during the 3rd trimester (Larkby & Day, 1997). The severity of neurobehavioural symptoms related to FASD has been linked to level and duration of exposure, the longer and higher the concentration the more severe the cognitive impairment (Jacobson, Jacobson, Sokol, Martier, & Ager, 1993; Larroque & Kaminski, 1998; Streissguth, Barr, Sampson, & Bookstein, 1994a).

Like many teratogens alcohol is a necessary but not sufficient cause of FASD. Several factors play a role in determining the outcome of prenatal alcohol exposure, including dose of alcohol or Blood Alcohol Levels (BALs), which are directly related to alcohol intake patterns (e.g., binge drinking, chronic moderate drinking, occasional drinking); developmental timing of prenatal exposure (1st, 2nd, 3rd trimester, or continuous drinking); genetic or physiologic variables of mother and infant; interactions with psychological/physical variables (e.g., maternal depression, stress); interaction with nutritional factors; maternal characteristics such as age (risk increasing with middle age) and parity (risk increasing after the 1st affected child); alcohol metabolism or differences in the enzyme system related to the breakdown of alcohol (e.g., alcohol dehydrogenase deficiencies for example would interfere with the breakdown of acetaldehyde, which is 1000-fold more embryotoxic than alcohol); compounding effects or synergistic reactions with other drug use; and last, but not least, the quality of perinatal and postnatal environments (see Abel 1998 for review). These factors all play a role and are defined as either permissive or provocative. Permissive conditions involve predisposing behavioural, social, or environmental factors that create a differential reaction to alcohol exposure and provocative conditions include physiological/biological changes in the internal environment that increase vulnerability to alcohol's toxicity (e.g., nutrition, other drug exposure).

Albeit difficult to partial out the effects of permissive and provocative conditions, alcohol is thought to affect the fetus both directly by crossing the placenta, and indirectly through the production of acetaldehyde, serving to reduce cell populations both through cell death and decreased proliferation (Overholser, 1990). Cell and fetal growth are thought to be affected by malnutrition through the inhibition of nutrient uptake from the gastrointestinal tract and the inhibition of glucose, vitamin B6, and amino acid transport across the placenta (Overholser, 1990). It is speculated that alcohol also plays a role in hypoxia by constricting placental and umbilical blood vessels, inducing the formation of free radicals, and impairing maternal hepatic metabolism (Abel, 1998; O'Leary, 2002). An additional concern is the fact that chronic alcohol use increases the risk of infection in newborns due to a suppression of the adult immune system (Gauthier, Drews-Botsch, Falek, Coles, & Brown, 2005).

Possible neuronal mechanisms for alcohol effects include: impaired progression through the cell cycle; halted migration, neurotropic factor production, and myelination, due to impaired glial development; impaired cell adhesion; cell membrane alteration; impaired growth and cell division, and reduced cell survival due to altered production or responsiveness of related factors; altered regulation of intracellular calcium; and increased production of free radicals (see review by Riley, 1998). In addition, Kaufman reports that the risk of alcohol exposure to pre-ovulatory human eggs and recently fertilized embryos is "at least as harmful as exposure to this agent during pregnancy" (1997).

Phenotype of FASD

Features of FAS were first described by Lemoine (Lemoine and colleagues, 1968), but the term itself was not coined until 1973 by Smith and Jones, who studied 11 children of alcoholic mothers. A common triad of features was noted including a stereotypic pattern of facial dysmorphology (i.e., short palpebral fissures, thin upper lip, and an indistinct philtrum), pre- and post-natal growth deficiency, and central nervous system (CNS) abnormalities (Chudley et al., 2005). The term FASD refers to a spectrum of alcohol-related disabilities, the identification and diagnosis of which relies on these fundamental features. The range of expression is wide, from *normalcy* across domains at one end of the spectrum to severe growth delays, cognitive disabilities, neurodevelopmental defects, dysmorphic facial features, and sometimes even death at the other end (Mattson & Riley, 1998). Infants are often small for gestational age and continue to show deficiency in this area with age (Streissguth, Clarren, & Jones, 1985); teens and adults showing 2.1 and 1.4 SD below population means on height and weight respectively (Streissguth et al., 1991a). Mild CNS dysfunction may be particularly difficult to detect early on and identification/diagnosis can be missed during the early childhood years, becoming suspect only with the accumulation of more pronounced and thus more *visible* difficulties over the early school years.

Identifying and diagnosing children with FASD can be difficult due to the fact that the abnormalities that exist, when considered in isolation, are not unique or diagnostic of prenatal alcohol exposure. These deficits can and do occur in children whose mothers did not use alcohol during pregnancy or those who use other teratogenic substances (Clarren, et al., 1987), as well as in children with syndromes of multiple other etiologies (Abel, 1998). The key lies in identifying the pattern of abnormalities; the difficulty remains in utilizing a diagnostic paradigm that is neither too inclusive nor too exclusive of potentially affected children, in other words, one with high sensitivity and high specificity.

There are several approaches to diagnosis, and all are based on the triad of criteria outlined above. In 1996, the US Institute of Medicine (e.g., Stratton et al., 1996) provided diagnostic recommendations that included ARBD, ARND, p-FAS, and FAS (Appendix A.1). For example, ARBD refers to alcohol-related birth defects and applies only to those who show physical anomalies, including skeletal, renal, cardiac, ocular and auditory malformations or dysplasias, and ARND refers to alcohol-related neurodevelopmental disorder and applies to individuals with evidence of CNS abnormalities such as microcephaly, structural abnormalities, and neurological hard or soft signs. Subsequently, the 4-digit Diagnostic Code proposed by Astley and Clarren (2000) relies on 4 parameters or diagnostic features each rated on a 4-point Likert scale (1-4 from absence to extreme expression of the feature): 1) Growth Deficiency, 2) FAS facial phenotype, 3) CNS damage/dysfunction, and 4) Gestational exposure (Appendix A.2). Last, following widespread consultation with multi-disciplinary professionals across the country, a subcommittee of the Public Health Agency of Canada's National Advisory Committee on FASD has incorporated features of these two approaches into a set of standardized guidelines for diagnostic use in Canada (Chudley et al., 2005). Based on these guidelines, a medical diagnosis is recommended within the context of a multidisciplinary assessment that must include comprehensive physical and neurobehavioural examination. For a diagnosis to be made, neurobehavioural assessment must unveil impairment in 3 or more domains, including hard and soft neurologic signs, brain structure, cognition (e.g., memory, executive functioning, abstract reasoning), expressive and receptive language, academic achievement, attention deficits and hyperactivity, adaptive behaviour, social skills, and social communication (Chudley et al., 2005). Recommendations from the subcommittee are listed in Appendix A.3. Of note is the fact that a diagnosis of *partial*-FAS or ARND does not necessarily indicate a less severe impairment in functioning than a diagnosis of FAS, due to the possibility of similar deficits in brain and cognitive domains. Typically, these children lack the abnormal facial features but have the associated brain damage (Mattson, Schoenfeld, & Riley, 2001).

Hundreds of research and review articles have been published on the syndrome since Jones and Smith first began to study the effects of prenatal alcohol exposure. This population exhibits a complex clinical profile with much individual variability. Comprehensive assessments reveal primary deficits across domains such as sensory, motor and socio-emotional functioning; visuospatial processing; learning and memory; arousal and attention; language and communication; and executive, problem-solving, and reasoning domains (for review see Kodituwakku, 2007). Collectively, executive domains are a set of basic cognitive processes that include short-term memory, planning and goal orientation, selective attention, sustained attention, attentional control including attentional switching and flexibility, resistance to interference, and inhibition (Kipp, 2005).

Attentional and executive functioning difficulties are the most commonly observed behavioural problems in children with FASD. Attention deficit hyperactivity disorder (ADHD) is often cited as a co-morbidity associated with FASD (e.g., Coles, 2001), and attention deficit/hyperactivity is identified as a central component which to consider in the diagnostic process (Chudley, et al., 2005). These types of deficits are noted early in infants and preschoolers with FASD, and become critical when children enter the school system. Not surprisingly, deficits in learning and memory are often secondary to an inability to attend effectively or orient toward relevant concepts or events (Zimmermann, Gondand, & Fimm, 2005).

Without appropriate intervention even mild deficits in this domain can have a significant negative impact on cognitive development. Children grow missing important information in their immediate environment, having difficulty recalling events, and making mistakes in daily tasks. Higher level cognitive processing, intellectual, academic, neuropsychological, and adaptive functioning are subsequently impacted (Kopera-Frye, Carmichael Olson, & Streissguth, 1997). Difficulties with inattention follow children into their young adult years (Zevenbergen & Ferraro, 2001), contributing to self-esteem issues and poor motivation (Kodituwakku, Kalberg, & May 2001). Ultimately, these difficulties can have far reaching and long-term consequences in areas of social adjustment and mental health (Clark, Lutke, Minnes, & Ouellette-Kuntz, 2004).

Indeed, it is well established that secondary disabilities are highly prevalent among individuals with FASD. For example, children are at greater risk of engaging in health-threatening behaviours such as substance abuse, smoking, and risky sexual behaviours (over 45%) and at greater risk for educational disruptions (over 43%), mental health problems (over 94%), and behavioural difficulties leading to legal trouble (over 42%) as reported by Streissguth and colleagues (Streissguth, Bookstein, & Barr, 1996). While prevalence rates for mental health problems are stable from childhood to adulthood among this population, there are differential findings with respect to manifestation across development, for example children and teens show a preponderance of attentional deficits (approximately 61%), and adults of increased depression (50%).

Clearly, this is a population in need of early intervention and prevention across all levels, primary, secondary, and tertiary (Leslie & Roberts, 2001). While it is widely recognized that intervention research can provide answers for treating specific cognitive disturbances and preventing secondary disabilities (Abel, 1998), the available FASD literature is limited in this regard. The current study represents one of the first research initiatives to examine the effectiveness of cognitive-based intervention for individuals with FASD, and the first to utilize a cognitive rehabilitation approach with this population. As will be discussed later, this work relies on evidence-based attention process training strategies that have been successfully implemented with children with ADHD (e.g., Kerns, Eso, & Thomson, 1999) and dyslexia (e.g., Chenault, Thomson, Abbott, & Berninger, 2006).

The remainder of this introductory section will 1) summarize the construct of attention, 2) review the attentional profiles of children with FASD, 3) review attention remediation approaches, and 4) summarize the FASD-related intervention research to date.

Conceptualizing Attention

Attention is a core function of cognitive performance, which, broadly defined, encompasses all of the mental processes, operations, and systems involved in the acquisition and use of knowledge (Flavell, Miller, & Miller, 1993). In addition to attention, cognitive functions involve perceptual, memory and learning, organizational, and reasoning and problem solving processes. Each process plays a vital role in the operation and development of the other processes, each affecting and being affected by the others (Flavell, et al., 1993).

The construct of attention has been theoretically and systematically explored for decades (e.g., James, 1890), and has been most commonly equated with "the amount of information that can be attended and responded to in some finite amount of time" (Kerns & Mateer, 1996, p.147). Attention involves an individual's ability to direct, focus, and sustain his/her interest to an environmental stimulus; animate or inanimate object, or event. The concept itself has changed dramatically over the years, from a unitary conceptualization to a multidimensional construct. Currently, several prominent cognitive processing models are based on a fundamental notion that has become widely accepted in neuropsychology: Attention is comprised of several distinct, yet interrelated, attentional subcomponents (e.g., Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991; Posner & Petersen, 1990; Sohlberg & Mateer, 1987; van Zomeren & Brouwer, 1994). Most researchers view attentional subcomponents as hierarchical, such that complex attention abilities like working memory, selective attention, or shifting attention, fall high in the attention taxonomy (Sohlberg & Mateer, 2001).

Several models address a number of common underlying components of attention (e.g., Mirsky et al., 1991; Mirsky, 1996; Sack & Rice, 1974; Sohlberg & Mateer, 1987), including *cognitive-processing, neuroanatomical, factor-analytic, clinical,* and *functional* models (as reviewed by Kerns & Mateer, 1996, and Sohlberg & Mateer, 2001). Models of attention overlap substantially and include functions related to sustaining attention, attentional capacity, shifting or controlling attention, and screening out irrelevant information[1] (see review by Kerns & Mateer, 1996; Sohlberg & Mateer, 2001). *Cognitive processing* models generally garner their data from typically developing subjects instead of clinical populations, and the effects of attentional demands on performance are studied in simulated, laboratory-based paradigms. Early models of attention focused on concepts such as vigilance, selectivity, automatic vs. effortful processing, dual-task performance and at a higher level, working memory (e.g., Baddeley, 1981, 1986) or

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[1] While similarities exist between factors of attention, differential nomenclature between models makes it difficult to draw face-value comparisons. For example, *focused* attention (i.e., defined as a basic responding to stimuli; Sohlberg & Mateer, 1987; 1989) is conceptually similar to *orienting* attention in one model (e.g., defined as selecting specific information from sensory input; Posner & Peterson, 1990), but quite different from the definition of *focused* attention in another model (e.g., defined by behaviours that represent active information processing over prolonged examination times and resembles sustained attention; Ruff 1986a, referenced in Richards & Casey, 1992). In this example, these components may be differentially viewed as 'phases' on the attentional continuum that depend on both "attention-getting" and "attention-holding" properties of a stimulus (particularly for infant-control methods; Cohen 1972, 1973 referenced in Richards & Casey, 1992), as well as internally mediated processes.

Another example can be furnished from two attentional components or processes that have often been equated; *sustained* attention and *vigilance* (Coull, Frith, Frackowiak, 1996). However, differences between these constructs depend on differences between the tasks utilized to measure performance; differences in the kind of cognitive performance assessed; and differences in the processes that underpin performance. According to Zimmermann and colleagues (2005) *vigilance* requires the detection of infrequent stimuli that are difficult to discriminate and are presented under extremely monotonous experimental conditions. Vigilance decrement is an important observation in vigilance paradigms, and refers to the decline in detection performance over the course of a task. *Sustained* attention is a broader concept that is not only necessary when information has to be processed continuously over extended periods of time, but also refers to a more comprehensive understanding of the task demands and a more in-depth processing of information. This concept includes features of vigilance and working attention or working memory (Sohlberg & Mateer, 2001; Zimmermann et al., 2005). Also considered a matter of concentration, sustained attention is compared to functional day-to-day behaviour (such as listening to a lecture over extended periods), and as such, has higher predictive validity than vigilance (Zimmermann et al., 2005).

working attention (Baddeley, 1993). Cognitive psychologists have systematically varied performance of a single task under varying attentional conditions (for example monitoring speed of response to visual targets with or without a useful hint about where the targets would appear, Manly et al., 2001), and interpreted attention based on behavioural performance. In this paradigm, an improvement in performance is interpreted as evidence of an attentional "top-down" process that exerts voluntary control over more automatic brain systems (Posner & Petersen, 1990) and modulates, for example, detection efficiency. Similarly, selective processing and response inhibition are concepts that can be inferred from performance on measures that require competing responses such as the Stroop task (Stroop Colour Word Interference Test; Stroop, 1935 as cited in Kerns & Mateer, 1996). Such experimental approaches have also been utilized in studies with clinical populations, particularly those with acquired brain injury, and have more recently been explored in tandem with information from functional imaging studies.

Neuroanatomical models seek to identify the neuroanatomical substrates and brain regions that subserve specific cognitive processes. For example, on the basis of functional imaging and lesion literature, Posner and Petersen (1990) argue that *attention* is an anatomically separate system from the data processing systems that can process incoming information even when attention is oriented elsewhere (akin to motor or sensory systems that interact with other parts of the brain but maintain a separate identity); that operations of attention are carried out by a network of anatomical areas, neither a localized nor a generalized function of the brain; and that the brain areas involved in attention carry out specific functions, which can then be specified in cognitive terms. As such, the attentional system is viewed as a set of subsystems that perform different but interrelated functions, for example *alerting* (maintaining vigilance or an alert state), *orienting* (selecting specific information from sensory input), and *executive control* (detecting signals for conscious processing and resolving conflict among responses) (Fan, McCandliss, Sommer, Raz, & Posner, 2002), all functions that have been prominent since early cognitive accounts of attention.

While knowledge of the anatomy of attention is incomplete, these networks of attention have been linked to separate brain regions (Fan, McCandliss, Fossella, Flombaum, & Posner, 2005). Based on continuous processing and vigilance task performance, which require different degrees of alertness and activate the frontal and parietal areas of the right hemisphere, the *alerting* system has been linked to the frontal and parietal areas of the right hemisphere and to the norepinephrine system (Fan et al., 2002). In conjunction with fMRI information, studies that manipulate orienting by presenting a cue that requires either the overt or covert directing of attention to the cued location, indicate that the *orienting* system is associated with areas of the parietal or frontal lobes (Fan et al., 2002). This subsystem is proposed to be dependent on the *posterior attentional system* that includes the posterior parietal lobe, the superior colliculus, and the lateral pulvinar nucleus (Sohlberg & Mateer, 2001). The *executive control* subsystem, useful for target selection and conflict resolution such as in Stroop-type tasks for example, depends on the midline frontal areas (including the anterior cingulate gyrus) and the lateral prefrontal cortex (Fan et al., 2002). The thalamus has also been associated with target selection analyzing both ascending information from the brainstem tracts and descending information from the cortex (e.g., Mateer & Ojemann, 1983, as cited in Sohlberg & Mateer, 2001).

Provisionally, these subsystems are organized into greater schemas of attention and associated with diverse attentional components: the alerting system with sustained attention, maintaining a specific processing set over time; the orienting system with spatial attention, moving or shifting attention in space; and the executive control or detecting system with selective attention[2], processing specific target characteristics regardless of location (Manly et al., 2001). This separation of functional/anatomical systems of attention from basic perception has led to a better understanding of the nature of cognitive deficits. Specifically, these may be predominantly or exclusively attentional in nature, and particular effects on functional performance will depend on the locus of damage (Manly et al., 2001).

Factor-analytic models of attention derive cognitive processing constructs from analyzing performance on psychometric tests that are believed to assess processes such as attention, memory, and executive functioning. Kerns and Mateer (1996) review measures that involve working memory and mental control (e.g., Digit Span Backwards

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[2] Primarily associated with activation of the anterior cingulate, the ability to shift or alternate attention is a related function of this circuit (Sohlberg & Mateer, 2001).

on the Wechsler adult and child intellectual assessment batteries; Wechsler, 1991[3]); timed measures that assess rapid processing of information (e.g., Paced Auditory Serial Addition Test; Gronwall, 1977[3]); visual or auditory target detection measures (e.g., the Cancellation Test; Mesulam, 1987[3]); measures that require competing responses (e.g., Stroop Colour Word Interference Test; Stroop, 1935[3]); measures that require visual attention shifts and rapid motor responses (e.g., Trail Making Test; Reitan & Davidson, 1974[3]); measures of attentional control and shift (e.g., Wisconsin Card Sording Test; Heaton, 1981[3]); and measures of working memory that require the maintenance of information in immediate memory with or without a delay (e.g., Digit Span Forward; Wechsler, 2003[3]).

Notably, work with clinical populations has led to the incorporation of clinical observations from atypical populations into theoretical models of attention. *Clinical* models of attention employ similar taxonomies (Sohlberg & Mateer, 2001), incorporating the concepts of focusing, sustaining, selecting, alternating, and dividing attention (Sohlberg & Mateer, 1987, 1989); focusing, sustaining, shifting, encoding, and stability of attention (Mirsky et al., 1991); and capacity, resistance to interference, deployment of attention, and mental manipulation (Mapou, 1995). For example Sohlberg and Mateer (2001) describe *focused* attention as the ability to direct attention to a specific stimulus; a primitive orienting response to external stimuli. *Sustained* attention involves the ability to maintain consistent behavioural responses over extended periods of time, continuous,

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[3] Reviewed by Kerns & Mateer, 1996

and repetitive activities and involves concepts such as vigilance, persistence, and at a higher level also incorporates the notion of working memory – or the ability to manipulate information while holding it in mind over extended periods. *Selective* attention requires the ability to focus on significant features of an event (i.e., maintain a behavioural or cognitive set) in the presence of distracting or competing stimuli (i.e., freedom from distractibility) and select information for higher level processing (e.g., studying in a common room with competing external stimulation – or internal worries, ruminations, etc). *Alternating* attention allows the change from one task/stimulus to another. This higher level capacity refers to mental flexibility and attentional control, and allows the shift of attention between tasks with different cognitive requirements. The ability to alternate attention is heavily reliant on working memory processes, such as for example, shifting between listening and note-taking in lectures. Last, *divided* attention is conceptualized as the ability to attend and respond simultaneously to multiple task demands, such as when driving a car and talking on a cell phone at the same time.

Based on detailed observations from the cognitive rehabilitation field that include analyses of task performance, errors, and subjective patient complaints, clinical researchers propose that attention is a hierarchical capacity, predicting that in order for one to succeed fully at higher-order levels of attention (e.g., alternating or dividing attention between tasks) lower-order levels of attention (e.g., focusing and sustaining attention) would need to be intact (Sohlberg & Mateer, 1987, 1989). This suggestion is in keeping with research that indicates that despite differences in attentional measures utilized (e.g., some described above: Continuous Processing tasks, the Cancellation test, the Stroop Colour Word Interference test, the Wisconsin Card Sorting task) each make some common demand on the capacity to actively self-maintain or sustain attention over shorter or longer time periods (Manly, Robertson, Anderson, & Nimmo-Smith, 1999).

An important question for the cognitive rehabilitation field is a description of how these cognitive processes may be used in day-to-day tasks (Sohlberg & Mateer, 2001). Newly emerging *functional* models seek to describe *everyday* attention, memory, and other cognitive processes by operationalizing these concepts into small functional units (for example task-analyzing prospective memory). This is an important part of rehabilitation assessment because even full batteries of attention that attempt to simulate real-world activities (e.g., the Test of Everyday Attention for Children; Manly et al., 1999) are not true functional assessments (i.e., they do not measure the individual's ability in a day-to-day task).

In sum, while theoretical differences exist between current attention models, most recent models include common concepts proposed to underlie similar functions (Mirsky et al., 1991; Posner & Petersen, 1990; Sohlberg & Mateer, 1987). Following an integration of current models with observations of attentional dysfunction from brain injured populations, key theoretical concepts with a high degree of clinical significance are proposed: 1) maintenance or sustaining of attention, 2) attentional selectivity, 3) attentional capacity, and 4) attentional control or shifting (Sohlberg and Mateer, 2001).

Moreover, while these functions appear to be subserved by separate neuroanatomical areas, they are highly interrelated and dependent on each other's intact functioning (e.g., Posner & Peterson, 1990; Sohlberg & Mateer, 1987).

Attentional Profiles of Children with FASD

Parents and teachers indicate that attentional problems are the most significant difficulties faced by children with FASD (Mattson & Riley, 2000; Roebuck, Mattson, & Riley, 1999), difficulties that are also readily apparent in adolescence and adulthood (Spohr, Willms, & Steinhausen, 1993; Streissguth, Randels, & Smith, 1991). Problems of attention, including attention deficit hyperactivity disorder (ADHD) are reported so frequently in this group that ADHD is often cited as a core feature of this population's profile (e.g., Coles, 2001; Kopera-Frye et al., 1997; Oesterheld & Wilson, 1997), and attention deficit hyperactivity is identified as a key component to assess in the diagnostic process (Chudley et al., 2005).

Clinical reports parallel parent and teacher evaluations. For example, Bhatara and colleagues (Bhatara, Loudenberg, & Ellis, 2006) conducted a chart review of 2,231 youths, reporting frequency distributions of ADHD by different levels of prenatal alcohol exposure. Cases were ranked by clinical exposure as per Astley and Clarren's recommendations (2000); Rank 4 (confirmed high exposure and a pattern that poses high risk – e.g., weekly binge drinking), Rank 3 (confirmed low level exposure – or level unknown), Rank 2 (unknown exposure), Rank 1 (confirmed lack of exposure). The most prevalent disorder noted was ADHD (41%), followed by learning disabilities (17%), oppositional-defiant/conduct disorder (16%), and disorders of mood, sleep, and problems with anger control (10%). For each associated disorder the *high risk* group was the most affected, followed by the *some risk* group, *unknown risk,* and *no risk* groups.

However, the relationship between FASD and attention remains to be more clearly defined. It is difficult to compare findings across studies for many reasons, not the least of which include: tremendous heterogeneity within the fetal alcohol spectrum; the heterogeneity of clinical and longitudinal samples; differences in level and pattern of exposure; differences in age, intelligence, and socioeconomic variables of study participants; methodological differences between studies; the use of a wide variety of tasks and measures that are often operationalized quite differently depending on respective underlying theories of attention; and problems of task impurity. For example, tasks with seemingly different demands on attention - such as a task that focuses on the counting of tones over brief periods or a task that focuses on monitoring rare targets over a lengthy time period, may both in fact, depend on a common underlying factor (e.g., sustained attention; Manly et al., 2001). In addition, individual differences across abilities such as motor skill, task comprehension, verbal ability, and perceptual acuity, may confound tests hypothesized to place different demands on attention (Manly et al., 2001).

Given these inherent difficulties, it is not surprising that the available literature presents varied outcomes when attentional components are differentially evaluated. While not all researchers have found attentional deficits in individuals with FASD (e.g., Boyd, Ernhart, Greene, Sokol, & Martier, 1991; Fried, Watkinson, & Gray, 1992; see review by Linnet et al., 2003), the majority report findings of pervasive attention deficits and ADHD-like symptoms as a significant characteristic in this population, regardless of diagnosis, FAS, p-FAS, or ARND (e.g., Coles, Platzman, Lynch, & Freides, 2002; Coles et al., 1997; Kerns, Don, Mateer, & Streissguth, 1997; Leth-Steensen, Elbaz, & Douglas, 2000; Mattson, Calarco, & Lang, 2006; Nanson & Hiscock, 1990; O'Malley & Nanson, 2002; Seidel & Joschko, 1990; Streissguth, Barr, & Martin, 1984; Streissguth et al., 1986; 1994; 1996).

Overall, several conclusions can be drawn from the research literature. First, findings of attentional difficulties are fairly robust; so much so that some researchers have proposed these to be a more sensitive marker of FASD than overall intellectual deficit or facial dymorphology, particularly for children with heavy prenatal exposure (Mattson & Riley, 2000). Second, it appears that attentional difficulties are independent of general intelligence (Kerns et al., 1997; Lee, Mattson, & Riley, 2004) or diagnosis (full FAS, pFAS or ARND; Lee et al., 2004). Third, attentional difficulties appear to be stable over time, as shown for example in longitudinal effects on sustained attention at ages 4, 7, and 14 (Streissguth et al., 1994); albeit in order to unveil deficits in attention, tasks must become more complex with increasing age. Fourth, while the body of literature that examines attention from a componential perspective is fairly small (i.e., differentiating between sustained, selective, alternating, or divided attention components), the available data confirms deficits across several of these components and related constructs (e.g., working memory, inhibition, impulsivity, freedom from distractibility, mental control and flexibility; e.g., Coles et al., 1997; Connor, Streissguth, Sampson, Bookstein, & Barr, 1999). Fifth, scores on empirically based tests, for example vigilance measures, have been found to be highly correlated with teacher & parent behavioural ratings, confirming the ecological validity of empirical data (Lee et al., 2004).

Processing Efficiency

Some authors suggest that poor performance in children with FASD is usually most evident on complex executive functioning tasks, particularly those that engage working memory (Kodituwakku, Kalberg, & May, 2001). Others propose that poor performance is due to a core impairment in more basic mechanisms, for example processing speed, as indicated by evidence that many of the tasks that rely on speed of response (either RT or through externally imposed time restrictions) are sensitive to prenatal alcohol (e.g., Jacobson, 1998; Kable & Coles, 2004; Ma, Coles, Lynch, LaConte, & Hu, 2003).

Impaired processing efficiency and deficits in processing speed are observed across development, in infancy (Jacobson, Jacobson, & Sokol, 1994; Jacobson, et al., 1993; Kable & Coles, 2004) and in later childhood and adolescence (Nanson & Hiscock, 1990; Streissguth et al., 1984; 1986; 1994). For example, fixation duration was longer for infants exposed prenatally to alcohol in a visual recognition memory task (Jacobson et al., 1994) and in a cross-modal transfer task (Jacobson et al., 1993), and longer reaction times (i.e., delays in visual gaze) were observed in a visual expectation paradigm (Jacobson et al., 1992). Nanson and Hiscock report slower speed of responding on visual sustained attention tasks and conclude that in contrast to typically developing peers, children with FASD have trouble investing, organizing, and maintaining attention over time; modulating arousal to meet situational demands; and inhibiting impulsive responses (1990).

In a heart rate (HR) habituation-dishabituation paradigm designed to assess the initiation, sustained, and shifting components of attentional regulation, outcome variables (i.e., magnitude of the response or change in HR, duration of the inhibition of the HR, and recovery of HR following the presentation of novel stimuli) were not differentially affected between two groups of high- vs. low-risk infants (Kable & Coles, 2004). However, a positive correlation was found between prenatal alcohol exposure and initial HR deceleration. Specifically, high-risk infants took a longer time to respond to visual and auditory stimuli at onset (i.e., required a longer time to meet HR deceleration criteria), but were not significantly impaired in their ability to sustain a decelerative HR response. This suggests a slower initiation of attention, or initiation of the orienting response to targets, indicating impairment in the speed with which prenatally-exposed infants encode information (Kable & Coles, 2004). On further examination, these authors suggest that the slower processing speed may be in fact, due to an inability to inhibit initial acceleration response to stimulus onset, a phenomenon characteristic of younger and more immature nervous systems.

In correspondence with findings in older children (Nanson & Hiscock, 1990), these authors rate high-risk infants as having significantly higher arousal levels than low-risk infants. This inability to regulate the arousal system quite possibly results in slower processing speed in response to auditory and visual information. As such, inconsistencies in outcome on sustained attention tasks may be due to variable underlying levels of arousal (as influenced by age, motivation, and task difficulty such as complexity and duration) that affect the ability to regulate attention and perform successfully on various tasks (Kable & Coles, 2004).

Slower processing speed and deficient processing efficiency were also observed in school-aged children with FASD on Sternberg-type tasks; the original Sternberg memory scanning (1966, 1969), visuospatial (mental rotation), and magnitude comparison (number comparison and arrow discrimination) (Kail, 1988; Kail & Park, 1992 discussed in Burden, Jacobson, & Jacobson, 2005). Processing efficiency was interpreted by examining increases in response latencies across increasingly difficult task demands (reflecting additional cognitive effort and represented by linear increases in RT with increasing task difficulty). Shallow RT slopes indicate more efficient processing, whereas steeper RT slopes indicate less efficient processing. In contrast, the intercept of the RT curve was interpreted as representing overall processing speed, which should not differentiate between specific task components (Burden et al., 2005). A hierarchical linear modeling procedure was utilized to investigate the effect of prenatal alcohol exposure on both processing speed and processing efficiency. Following inclusion of potentially confounding variables on task performance (e.g., SES, parity, education, crowded living conditions), Burden and colleagues (2005) report that prenatal alcohol exposure was related to an overall slower processing speed (as exhibited on several Sternberg tasks) and to a deficit in processing efficiency (as exhibited on the number comparison task), but not to accuracy (i.e., no relationship was found between prenatal exposure and number of correct responses). Prenatal alcohol exposure had a greater impact on processing speed for tasks that require greater cognitive effort (e.g., memory scanning, mental rotation, arrow discrimination tasks) but not on more automatic processing tasks (e.g., a modified colour Stroop task). While these findings are consistent with the notion that prenatal alcohol exposure affects higher-order cognitive tasks (for example those that involve working memory; Kodituwakku et al., 2001), it is possible that impaired higher-order processing (such as working memory deficits) may be accounted for by impaired processing speed (Burden et al., 2005). Notably, these effects were similar for children who had been exposed to low-moderate doses and those who had been exposed to heavy doses of alcohol, indicating that alcohol can affect processing ability even at low levels.

Attentional Components

The negative impact of prenatal alcohol on processing speed and efficiency (possibly caused by abnormal, delayed, or reduced myelination; Archibald et al., 2001) can also be manifested through deficient performance on tasks that attempt to isolate attentional components (e.g., sustained, selective, alternating, divided). For example, in a series of studies that were designed to assess the pervasive impact of prenatal alcohol on a broad range of performance measures, Streissguth and colleagues describe significant deficits in sustained attention, including slowed response times and distractibility at 4-, 7-, and 14-year follow-up. These studies involved the Seattle longitudinal cohort, including a sample of over 460 children born to a group of mothers with very low rates of perinatal risk indicators other than drinking during pregnancy (Streissguth et al., 1984; 1986; 1994). These mothers were not alcoholic mothers, but could be classified as *social drinkers*. Impairments were reported on several measures, with greater effects associated with increased drinking in pregnancy. The most significant deficits at 14-year follow-up were found on the CPT Vigilance (a measure of sustained attention over time), the TALLAND Letter Cancellation (perceptual-motor speed and a measure of the ability to focus attention and screen out distractions), and the Stepping Stone MAZE (a complex spatial pattern for assessing short-term memory).

Findings from the Seattle studies indicate that increasingly more difficult or complex tasks are required to detect long-term effects of prenatal alcohol exposure with older populations. For example, while the simpler X task of the CPT had been sensitive to prenatal alcohol exposure at earlier ages (Streissguth et al., 1986; Streissguth, Martin, Barr, & Sandman, 1984), tasks that required sustained attention over more complex decision making parameters (e.g., the AX task of the CPT that requires children to withhold a response to a letter "X" unless it is preceded by a letter "A"), were more sensitive in detecting the effects of prenatal exposure at 14-years. Similarly, the Stepping

Stone MAZE test, a short-term memory test that requires manipulation of more complex information, was a more sensitive indicator of exposure at 14-years than the simple short-term recall requirements of the DIGIT SPAN and SEASHORE (Streissguth et al., 1994); both tests that had been found to be among the most sensitive measures at 7-year follow-up (Streissguth, Bookstein, Sampson, & Barr, 1989). In other words, the expression of a common underlying deficit in attention can vary depending on the age of the individual at the time of assessment and the tasks utilized to assess this construct[4].

While tasks thought to measure the focus and sustain components of attention were most strongly related to performance at 14 years, deficits across these domains were consistently reported in this group of children between birth and late childhood; including poor ability to withhold a response to redundant stimuli during the neonatal period (Streissguth, Barr, & Martin, 1983), and slower processing speed as demonstrated by slower reaction time on the continuous processing measures and a longer duration to correct errors on a stylus maze task during childhood (Streissguth, Barr, & Martin, 1984). In fact, when task complexity is taken into account, most of the prenatal alcohol effects observed on these measures at 14 years were enduring effects that had also been observed during the first 7 years of life. These included effects on laboratory assessments such as increases in errors of omission (inattention) and commission (impulsivity) at 4 years (Barr, Streissguth, Darby, & Sampson, 1990; Streissguth, Barr,

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[4] These results are in keeping with findings from animal studies (Goodlett, Bonthius, Wasserman, & West, 1992) and more recent reports with children (e.g., Burden et al., 2005), and may explain some of the variation in the literature.

Sampson, Darby, & Martin, 1989; Streissguth et al., 1984) and 7 years (Sampson, Streissguth, Barr, & Bookstein, 1989; Streissguth, Barr, & Sampson, 1990; Streissguth et al., 1986; 1989); classroom behaviour at 11 years (Carmichael Olson, Sampson, Barr, Streissguth & Bookstein, 1992); and neurobehavioural functioning of adolescents at 14 years (Streissguth et al., 1994).

The outcome variables with highest salience for alcohol were False Alarms, ratio of False Alarms to Total Responses for the AX task, and variability (or Standard Deviation of Reaction Time - SDRT) across simple to more difficult continuous performance or sustained attention tasks (X, AX, and DX respectively) (Streissguth et al., 1994). Interestingly, high variability of RT has been suggested to be an important indicator of deficient attention (van der Meere, Gunning, & Stemerdink, 1996), possibly representing micro-lapses in attention (Mirsky & Cardon, 1962; Mirsky & van Buren, 1965 as cited in Kopera-Frye et al., 1997). These results have been reported in patients with a variety of illnesses including patients with brain injury (Stuss et al., 1989), children with hyperactivity (Cohen & Douglas, 1972), children with minimal brain damage and learning disabilities (Sroufe, Sonies, West, & Wright, 1973), children with ADHD (Seidel & Joschko, 1990), and more recently, children and adults with alcohol exposure (e.g., Connor et al., 1999; Kerns et al., 1997; Streissguth et al., 1994).

In complementary research, children with FASD were found to have the greatest deficits across encoding and shifting components of attention (Coles et al., 1997). These authors concluded that children in the FASD group did not appear to be affected on components of sustained attention. However, it is noteworthy that 52% of the dysmorphic alcohol-exposed group and 25% of the non-dysmorphic alcohol-exposed group (altogether 29 children) could not complete a continuous processing performance task (CPT), indicating that a significant proportion of these children did in fact show difficulty sustaining their attention. These findings (particularly for the dysmorphic group) are similar to those for children with a diagnosis of ADHD, 16 of 27 (60%) of whom could not complete the CPT in this study. In addition, as observed by Connor and colleagues, several practice trials had been utilized with each attention task, trials that were not administered to the subjects who were unable to complete the tasks, in effect eliminating the low end of the distribution and biasing the sample toward higher functioning participants (1999). Remarkably, because many of the children in the FASD group were adopted or placed in continuous care early in life, their perinatal and postnatal environments appear to have been quite stable, offering a somewhat protective element. As such, any findings of impaired processing may be even more indicative of primary alcohol-induced difficulties as the often maladaptive environmental conditions on outcome appear to have been reduced.

Recently, Lee and colleagues (2004) were able to classify 9-17 year-old children and teens with or without FAS but with heavy prenatal exposure and typically developing controls on the basis of two widely utilized measures of attention: the WISC-

III Freedom from Distractibility Index (Wechsler, 1991[5]), which is purported to assess children's ability to maintain attention during testing (Sattler, 1991[5]) and the Attention Problems scale of the Child Behavior Checklist (Achenbach, 1991[5]) that provides a functional report of behavioural problems such as inability to concentrate or pay attention over time. These authors found that children were 3.9 times more likely to have prenatal exposure for every 15-point (1 SD) decrease on the Freedom from Distractibility Index, and 36.6 times more likely to have prenatal exposure for every 10-point increase (1 SD) on the Attention Problem scale. In addition, on a computerized measure of continuous performance or sustained attention (the Test of Variables of Attention; Leark et al., 1999[5]), children in the exposed group had significantly greater errors of omission and commission than the control group, falling below 1 SD of the norms for these measures.

Deficits in sustained attention have been confirmed across both visual (e.g., Coles et al., 2002; Jacobson et al., 1993, 1994; Mattson, Lang, & Calarco, 2002) and auditory (e.g., Connor et al., 1999; Mattson, et al., 2002) processing domains. For example, Coles and colleagues report that dysmorphic adolescents with FASD display specific deficits in the visual modality while auditory processing remains relatively unimpaired (2002). In this study, dysmorphic teens had greater rates of total errors and greater errors of commission on visual sustained attention tasks than control, non-dysmorphic, or special

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[5] Reported in Lee et al., 2004

education groups; greater errors of omission than control and non-dysmorphic groups; and a greater false alarm rate than the other three groups.

Similarly, Mattson and colleagues (2002) report specific deficits across visual attention measures, but relatively spared auditory attention. These authors compared children with FASD to non-exposed controls in a paradigm that examined visual and auditory focused or sustained attention and inter-modal auditory-visual shift of attention. Results indicate consistent and significant deficits in children's ability to focus and sustain attention across the visual domain regardless of inter-target interval length (i.e., ITI ranged from 450ms to 30s), and similar deficits in the auditory domain but only across longer inter-target intervals (i.e., >10s). When required to shift modalities, these children showed a general slowing of response time but spared accuracy of responses[6].

In contrast, Kerns and colleagues (1997) found impaired auditory processing across sustained, selective, alternating, and divided attention tasks, in a group of 16-27 year-olds with FAS. Half of the subjects, the average-IQ group (90-118), performed within the acceptable range for simple sustained attention (i.e., a simple auditory target detection task) however, this group fell well below the norms on more complex sustained attention tasks. Similar results were found for simple and complex alternating, and divided attention tasks. The below-average-IQ group (70-86) had considerably more

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[6] While these results appear to be in contrast with earlier reports of impairments in shifting attention in children with FASD (e.g., Coles et al., 1997) these authors suggest that the differences are likely due to the operationalization of the *shift* parameter. For example, the Wisconsin Card Sorting Test utilized in the Coles and colleagues study requires a conceptual set shift between salient features of a stimulus that is not dependent on external cuing, whereas the tasks used in this more recent study focus on an inter-modal shift that is dependent on explicit external cuing.

variability in response times on the simple auditory target detection task and performed very poorly relative to the average-IQ group and relative norms on more complex measures of sustained attention, not one of the participants being able to complete the complex sustained attention tasks. Similarly, on the hierarchically more complex parameters of alternating and divided attention, only one participant was able to complete the alternating subtest, and only 5 of 8 participants were able to complete the simple divided attention task, their average scores falling significantly below average norms.

Notably, even the average-IQ group, while demonstrating relatively unimpaired basic levels of attention (such as responding to simple targets) and arousal, performed below expected norms on measures that required more complex processing and higher levels of mental control. This finding emerged even on lower order components of attention such as sustained attention. Although this group performed better than the below-average-IQ group, both groups were more negatively affected by distracters and requirements for rapid processing of information than would have been expected (Kerns et al., 1997).

In a young adult sample (ages 19-23) Connor and colleagues (1999) report attentional impairments across both visual and auditory domains; with the strongest impairment across auditory processing measures. Several components of attention were evaluated, including sustained, selective, alternating, and divided attention. Focused and sustained visual attention tests included the Letter Cancellation Test (a visual measure; Talland, 1965[7]) and the Continuous Processing Task (CPT) of the National Institute of Mental Health Attention Battery (visual and auditory task; Mirsky et al., 1991[7]). More comprehensive auditory measures of attentional functioning included the Consonant Trigrams Task (CTT; Peterson & Peterson, 1959[7]) and the Attention Process Training[7] (APT) test, a measure that is based on the hierarchical model of attention proposed by Sohlberg and Mateer (Mateer, Sohlberg, & Youngman, 1990; Sohlberg & Mateer, 1987, 1989), to assess sustained, selective, alternating, and divided attention components.

These authors report 29 outcome scores including correct response, RT means and standard deviation, and commission and omission error scores. Impaired performance was found across visual attention tasks as reflected by lower correct responses, increased errors of omission and commission, and increased mean and standard deviation of RT. Similar results were found on auditory task performance across sustained, selective, alternating, and divided attention parameters. For example, young adults with FASD made significantly more errors of omission and had higher SD of reaction time than the control group across all attention components on the auditory CPT; had fewer correct responses across all attention components on the APT test; and had significantly fewer correct responses on all conditions of the CTT. Overall, results indicate that these individuals have more errors of omission than commission (although both outcome scores were significant) and seem to be inattentive rather than simply

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[7] Reported in Connor and colleagues (1999)

impulsive (Connor et al., 1999). Not surprisingly, subjects with the poorest scores on visual and auditory attention processing had among the lowest IQ scores (70-83), whereas the subjects with moderate attention deficits across these domains showed a wide range of IQ scores (84-113). In addition, these authors suspect heterogeneity in the FASD population based on the finding that a small subgroup of subjects exhibited exceptionally large deficits across both modalities and shared very high SDs of reaction time in the auditory task.

The human FASD literature is replete with findings of impaired attentional processing, which are also supported by animal models (e.g., Clarke & Schneider, 1997; Hausknecht et al., 2005). Importantly, the varying behavioural manifestations of neuropsychological attentional deficits have to be examined within a life-span developmental approach (Kopera-Frye et al., 1997). Animal studies point to attention-related deficits in habituation, state-regulation, response inhibition, overall activity, and learning deficits (e.g., Girard, Xing, Ward, & Wainwright, 2000; Goodlett, Kelly, & West, 1987; Matthews & Simson, 1998). Human studies point to attention-related deficits that are age dependent. For example, deficits in habituation, state regulation, sleep-wake cycling, and speed of information processing are commonly reported in young infants (e.g., Jacobson et al., 1992; Jacobson, Jacobson, & Sokol, 1994) while activity levels, adaptive behaviour, overall attention, ability to focus and sustain attention, select, alternate, and divide attention have been reported in groups of older children and adults (see review by Kopera-Frye et al., 1997).

Ameliorating Attention Deficits

Attentional deficits are a primary concern for children and adults with a wide array of psychiatric and neurological problems (Halperin, 1996), including individuals with localized trauma due to acquired brain injury and individuals with diffuse effects due to organic brain injury such as that caused by prenatal alcohol exposure. Aside from pharmacological interventions (such as methylphenidate, which is the most commonly used medication for ADHD in Canada and the US; referenced in Chevalier, Poissant, Bergeron, & Girard-Lajoie, 2003), the types of interventions that have been developed for children with attentional deficits generally involve behavioural management or cognitive-behavioural therapies (Barkley, 1990; Reid & Harris, 1993). Behavioural interventions utilize classroom-based contingency programs (e.g., Pfiffner & Barkley, 1990), home-school contingency programs (e.g., Abramowitz & O'Leary, 1991), peer-mediated contingency programs (e.g., Lentz, 1988), and response cost programs (e.g., Evans, Ferre, Ford, & Green, 1995). Cognitive-behavioural therapies (CBT) teach children problem-solving techniques to apply to their own behaviour (e.g., Abramowitz & O'Leary, 1991). Both types of interventions can be successful only when teacher and parent training complements child training, but generalization of skills outside the treatment programs has been found to be lacking. Abikoff (1991, reported in Semrud-Clikeman et al., 1999) suggests that these treatments lack the ability to establish internalized self-regulatory skills that can support the generalization and maintenance of positive outcomes. In fact, CBT does not appear to offer effects beyond those obtained when medication and behavioural parent training is offered (Braswell et al., 1997 cited in Semrud-Clikeman et al., 1999).

More recently, cognitive rehabilitation approaches that have been traditionally utilized with adults with attention deficits due to brain injury (e.g., Sohlberg et al., 2000), have been implemented with children (e.g., Chenault et al., 2006; Chevalier, et al., 2003; Cho et al., 2002; Kerns et al., 1999; Roland & Guay, 2001; Semrud-Clikeman et al., 1999.). Cognitive-based interventions are of several types: Environmental, providing contextual support depending on the disability (e.g., audio taped books for reading disabilities); Compensatory, whether through the application of internal strategies (e.g., self instructional statements for when attention drifts; Webster & Scott, 1983 mental strategies as a means of increasing cognitive control; Chevalier et al., 2003) or external support (e.g., cuing strategies such as visual or activity schedules); and Direct training of cognitive processes, such as memory training or attention process training, aimed at reducing specific deficits (e.g., Kerns et al., 1999; Semrud-Clikeman et al., 1999). More recent advances have included cognitive training tasks delivered in Virtual Reality (VR) paradigms (e.g., Cho et al., 2002). These latter approaches that target training of cognitive processes directly are based on Luria's (1980) concept that repeated activation or training can result in a reorganization of function (cited in Semrud-Clikeman et al., 1999). Repeated activation of attentional systems through graded attention tasks is hypothesized to facilitate changes in attentional functioning (Cicerone et al., 2000; Sohlberg & Mateer, 2001), which are thought to be maintained by underlying and corresponding changes in neuronal activity (Kerns et al., 1999). These effects can be measured through changes in trained and untrained psychometric measures and changes in daily functioning that are dependent on attentional capacity. Biofeedback paradigms targeting learned self-control of slow cortical potentials (e.g., Heinrich, Gevensleben, Freisleder, Moll, & Rothenberger, 2003) and multidimensional approaches using visual-motor imagery training in which auditory, kinaesthetic, and visual modalities are engaged during attention tasks (e.g., Chevalier et al., 2003) have also shown promising results.

To date, evidence is not sufficient to recommend any one cognitive intervention for any particular client or setting. However, despite inherent limitations of conducting research with clinical populations (e.g., heterogeneity of clients, differential intervention approaches, differential outcome measures), cognitive interventions have been found to be significant in improving specific neuropsychological processes, particularly attention, memory, and executive functioning (see review by Carney et al., 1999). More germane to the current discussion, following a comprehensive review that examined evidence from 171 studies of TBI and stroke in adult populations, Cicerone and colleagues (2000) recommend direct attention training specifically, as an effective Practice Guideline. Given this recommendation, and given the scope of the current work, studies of direct training of attention are discussed herein for adult and child literatures.

Attention Training: Adult Literature

The adult literature has concentrated mainly on disorders of attention secondary to brain injury or neurological disease (Sohlberg & Mateer, 2001). Improvements on training tasks have been demonstrated consistently including maintenance of attention during testing sessions, improved accuracy and speed of visual search, and improved performance on tasks involving stimulus/response demands (e.g., Ben-Yishay, Piasetsky, & Rattock, 1987; Wood & Fussey, 1987). More importantly, some researchers have reported improved outcomes on unpracticed psychometric measures of attention, particularly neuropsychological tests specific to the attentional component trained (e.g., sustained, alternating, divided) and sometimes other domains of attention (e.g., Gray, Robertson, Pentland, & Anderson, 1992; Sohlberg & Mateer, 1987; 1989).

Attention training paradigms have included computerized attention training programs (e.g., Middleton, Lambert, & Seggar, 1991) and individually-devised visual and auditory programs designed to target specific attention subcomponents (Sohlberg & Mateer, 1987; Sohlberg, McLaughlin, Pavese, Heidrich, & Posner, 2000). For example, Attention Process Training (APT; Sohlberg & Mateer, 1986) utilizes hierarchically organized activities that emphasize the ability to sustain attention across both simple and more complex task parameters (e.g., alternating or divided attention) that are repeated until mastery is achieved. Similar to Barkley's definition (1996; cited in Semrud-Clikeman et al., 1999) this strategy views attention as the ability to sustain or maintain attentional focus over shorter or longer time periods and varying task or environmental demands. Several researchers have reported that APT is successful with adults with traumatic brain injuries (e.g., Ruff et al., 1994; Sohlberg, Mateer, & Stuss, 1993) and that effects can generalize to improve memory, learning, and some executive control abilities (Mateer & Sohlberg, 1988; Neimann, Ruff, & Baser, 1990; Ruff, Baser, & Johnson, 1989; Sohlberg et al., 2000). While focus is placed on restoring basic attentional capacities through repeated practice, some authors have also incorporated adjunct techniques such as feedback, reinforcement, and strategy teaching, into the practice programs (e.g., Niemann, Ruff, & Baser, 1990; Novack, Caldwell, Duke, & Berquist, 1996; Ponsford & Kinsella, 1988).

For example, Niemann and colleagues (Niemann, Ruff, & Baser, 1990) randomly assigned 26 participants to either attention training or memory training over a 9-week period for a total of 36 hours. Computerized attention tasks trained focused, alternating, and divided attention across both visual and auditory domains. In addition, subjects were provided with comprehensive feedback and strategy teaching during each session. While both groups improved, results show significantly greater improvement for the attention training group on several components of attention: visual selective and sustained attention (as measured by the d2 cancellation test; Brickenkamp, 1975[8]); auditory selective and sustained attention and information processing (as measured by an auditory serial addition task and the PASAT[8]); visual and auditory divided attention (as measured by the combined visual digit-digit matching task and auditory target

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[8] Reported in Niemann et al., 1990

selection task of the Divided Attention Test; Sbordone et al., 1983[8]); and more complex, alternating attention (as measured by the number-letter matching task with an alternating component, of the Trail Making Test, Part B; Lezak, 1983[8]).

More recently, Sohlberg and colleagues (2000) utilized a cross-over design to train 14 subjects with attention and working memory deficits due to acquired brain injury, for 10 weeks of APT and 10 weeks of brain injury education. Pre- and post-training assessments were utilized to determine the effectiveness of training on vigilance, orienting, and executive functioning as well as tasks of daily living. Most subjects made improvements, but while brain injury education was effective mainly for self-reports of psychosocial functioning, the APT program improved self-reports of cognitive functioning and showed a stronger effect on overall executive attention tasks. In fact, brain injury education was most effective in improving self-reports of psychosocial functioning and cognitive functioning when it was delivered subsequent to the APT program.

Improvements in attention were also found by Sohlberg and Mateer (1987) following APT activities that targeted sustained, selective, alternating, and divided attention but not after training sessions that focused on visuospatial processing, in a multiple baseline design for 4 subjects with TBI in 7-9 weekly sessions across 4-8 weeks (Sohlberg & Mateer, 1987). Similarly, Strache (1987) compared two attention training interventions that targeted concentration in 45 subjects with mixed trauma and vascular etiology, with a control group that was receiving general rehabilitation. Subjects received 20 treatment sessions, subsequent to which both attention treatment groups showed significant improvements on several attention measures, including improvements in reaction time and sustained attention. These effects were found to generalize to measures of memory and intelligence with subjects showing significant gains in word fluency, closure tasks, and memory functions such as immediate verbal recall and recognition for verbal memory.

Measuring improvement on typical "everyday" functioning is arguably the most significant indicator of attentional performance and success of attention training protocols (Sohlberg & Mateer, 2001). Further study is needed in the area of generalizability to daily functioning; however improved performance has been reported in some instances, such as reading ability (Raskin & Mateer, 1993, cited in Kerns et al., 1999; Wilson & Robertson, 1992); everyday memory functioning (Mateer & Sohlberg, 1988); driving skills (Sivak, Hill, & Olson, 1984a; Sivak et al., 1984b); and independent living and return to work (Mateer, 1992; Mateer & Sohlberg, 1988; Mateer et al., 1990). Results are positive, however it is important to note that many interventions also include tasks designed to facilitate awareness, emotional response to errors of attention, and self-regulation.

Understandably, because of significant heterogeneity across sample populations, experimental paradigms, and outcomes measured (e.g., trained attention tasks, untrained same-level attention tasks, untrained higher-order attention tasks, functional skills, etc), reviews of the adult attention remediation literature provide equivocal results with respect to effectiveness. For example, in a meta-analysis of 26 studies Park and Ingles (2001) conclude that post-training performance improves significantly on training tasks, however, effects on untrained measures are not evident. These authors suggest that treatment effects may therefore be due to the acquisition of specific task-related skills rather than process training of attention. In contrast, Cicerone and colleagues (2000) conclude that attention training is beneficial beyond the effects of nonspecific cognitive stimulation for subjects with TBI or stroke. Based on their review, these authors recommend that interventions should include training across different stimulus modalities, levels of complexity, and response demands, including therapeutic activities such as monitoring subjects' performance, providing feedback, and teaching strategies.

More recently, in a review of Class I and Class II studies examining direct attention training for TBI populations, Sohlberg and colleagues (2003) answered critical questions relevant to research outcomes, and more specifically to the application of research outcomes to clinical practice. These authors conclude that the narrow question "Does it work?" oversimplifies the complexities of direct attention training on multiple levels, and recommend that instead this focus should be replaced by "When does it work best, and for whom?". Consistent with this premise, this review highlights the wide variety of study characteristics in the literature, for example acute rehabilitation samples (e.g., Novack, Caldwell, Duke, Bergquist, & Gage, 1996; Ponsford & Kinsella, 1988) versus outpatient populations (e.g., Gray et al., 1992; Niemann et al., 1990;

Sohlberg & Mateer, 1987; Strache, 1987) or severe to very severe injury samples (Novack et al., 1996; Ponsford & Kinsella, 1988; Sohlberg & Mateer, 1987) versus moderate to severe injury samples (Niemann et al., 1990) versus samples with mild to moderate difficulties with attention regardless of brain injury (Gray et al., 1992).

Key elements are discussed in filtering the attention intervention literature and determining applicability or potential efficacy for clinical practice: 1) Participants (e.g., diagnosis and etiology, injury severity, age, level of education); 2) Attention training protocol (e.g., focus and rationale, treatment duration and frequency, treatment setting, treatment providers, standard or individualized training programs matched for strengths and needs, additional interventions to the delivery of attention training tasks such as reinforcement and/or strategy training); 3) Outcomes measured (e.g., tests or psychometric measures suggesting changes in attention impairment, tests or measures suggesting changes in activity or participation such as attention demanding skills like driving, or changes in perception or rating of ability by client and/or caregiver, clinical significance/meaning, maintenance or generalization of reported changes); 4) Methodological concerns or alternative explanations for the outcomes (e.g., study design, treatment comparison to alternative or no treatment conditions, reliability or validity); and 5) Clinically applicable trends across different attention remediation studies (e.g., robust findings that would warrant a change in practice).

Overall, studies showing robust changes will continue to provide answers about candidacy for direct attention training, features of direct attention training, and expected outcomes of direct attention training. First, from the TBI population, clients with intact vigilance and those with post-acute or mild brain injuries seem to benefit whereas outcomes for clients with impaired vigilance and those in the acute phase or those with severe brain injury are more questionable (Sohlberg et al., 2003). Second, direct attention training may be more beneficial when administered in conjunction with metacognitive training (e.g., feedback, self-monitoring, and strategy training), when programs are individualized to the client's level of impairment, when treatment is distributed across practice trials with at least one training session per week, and when tasks are administered in a hierarchical fashion that emphasizes training of complex attention tasks such as sustained attention and working memory, selective, alternating, and/or divided attention, rather than focusing on simple vigilance or reaction time solely (Sohlberg et al., 2003). Last, while improvements are reported in attention-based skills with direct training, it is possible that training tasks may promote acquisition of specific skills only and outcomes may be task-specific. Functional applicability or generalization to untrained impairment level tasks and/or participant level tasks is not consistent across studies to date (Sohlberg et al., 2003). Outcomes have been attributed to specific practice tasks (e.g., review by Park et al., 1999), to improved cognitive functioning, especially in complex attention/executive functioning and working memory (e.g., review by Sohlberg et al., 2003), or to improved ability to compensate for deficits and adaptation of strategies for allocating attentional resources more effectively (e.g., review by Cicerone et al., 2002).

While much of the adult work has involved research with brain-injured populations, similar results have also been reported for individuals with other neurological disorders including stroke (e.g., Sturm et al., 2003; 2004; Sturm & Wilmes, 1991), aphasia (Coehlo, 2005; Sturm, Wilmes, & Orgass, 1997), and schizophrenia (Kurtz, Moberg, Gur, & Gur, 2001). To date, the adult literature has not focused on attention training for adults with developmental or organic deficits in attention (e.g., ADHD, FASD). It has been recommended, however, that APT applications utilized with the TBI or stroke populations could be a useful strategy for adults with a history of developmental disorders of attention (Sohlberg & Mateer, 2001). In fact, a growing body of literature suggests that these techniques may be effective for children and adolescents with ADHD and other disorders.

Attention Training: Pediatric Literature

Research dedicated specifically to remediating attention deficits in children includes three pediatric subgroups; child survivors of cancers affecting the CNS, children with traumatic brain injury, and children with ADHD (see review by Penkman, 2004). For example, significant improvement toward normalization was observed on a continuous processing task following a 2hr/wk 6-month cognitive remediation program with a 9yr old child with a brain tumor (Butler, 1998). Improved outcomes generalized to arithmetic skills (2 grade levels) and sentence memory (2 scaled scores). While results are promising, this study did not involve a control group that could account for competing hypotheses (e.g., measurement effects, passage of time), and hence effects are difficult to interpret.

Subsequently, the efficacy of this remediation program was assessed in 21 children with pediatric cancer randomized to treatment and waitlist control groups (Butler & Copeland, 2002). Following a 6-month training period, children who participated in cognitive training improved significantly on several measures of attention and concentration, including digit span, continuous processing, and sentence memory. However, unlike the previously reported outcomes, treatment effects did not generalize to a measure of academic performance (e.g., WRAT3 Arithmetic sub-test).

Through the use of cognitive training that is believed to develop attention control through movement, Chevalier and colleagues (2003) trained school-aged children with ADHD with visual-motor imagery exercises (inspired by mental training of high level athletes), with a goal to improve sustained attention and vigilance. The Attention Education Program (AEP) was designed to enhance participation of children in cognitive-motor learning in which movement is a core component of problem solving. Multidimensional auditory, kinaesthetic, and visual modalities were engaged during the learning tasks, with a goal to develop children's awareness of attention and planning. Following 25 training activities delivered over a period of six months, participants in the AEP group showed improved reaction times and reduced errors on a continuous processing task. While functional significance of these findings is not assessed systemically, and clinical significance is not addressed, these results appear to be supported by teacher feedback gathered from follow-up focus groups.

Brett and Laatsch trained teachers in administering rehabilitation programs that targeted attention subcomponents such as alertness, attention, and concentration; perception and memory; and executive processes (1998). Ten adolescents were trained through computer programs and flashcards, for approximately 12 hours over a 6-month period. At post-test, a significant improvement was observed on memory tasks, but no other outcome measure, and it is suggested that the lack of significant effects across attention and executive functioning was due to the type of outcome measures employed. Specifically, outcome measures were comprised of non-verbal and abstract problem solving tasks that lacked sensitivity for basic attentional processing (Penkman, 2004).

Recently, researchers have expanded computerized attention programs to resemble more realistic classroom environments, through the use of Virtual Reality classrooms (Cho et al., 2002). Cognitive training sessions parallel the demands required by typical ADHD assessment tools, such as continuous processing tasks, however, are delivered in a repeated and hierarchical fashion. Children with social and behavioural problems (but no ADHD diagnosis) were subjected to 8 sessions of VR attention training of increasing difficulty (e.g., required to repeat a continuous processing task 60 times to a criterion of 95% correct and then progress through to longer tasks). Positive results were reported with increases in rates of correct responses and decreases in perceptual sensitivity and response bias. Cho and colleagues (2002) conclude that attention training in a VR paradigm is effective in improving sustained attention. Notably, however, participants reported that training on a desktop VR station was tedious and uncomfortable and that they were bored and unmotivated, all key components for effective interventions. Effect sizes and measures of functional outcomes were not reported in this study, and while it is possible that a paradigm that would increase motivation and engagement of participants would likely yield clinically significant outcomes for attention training through VR, this is unclear from the current research.

In a series of unrelated studies, the effect of APT was examined in children and adolescents with attention deficits due to various etiologies, including TBI (Thomson, 1995; Thomson & Kerns, 2000), ADHD (Semrud-Clikeman, Harrington, Clinton, Connor, & Sylvester, 1998; Semrud-Clikeman et al., 1999), and dyslexia (Chenault et al., 2006). For example, Thomson (1995) reports promising results with a group of high-school students with attention deficits due to moderate to severe head injury. Following attention process training 3 times/week for 12 weeks, teens showed systematic improvement in sustained attention, and in reading speed and mathematics problem-solving speed on the Children's Paced Auditory Serial Addition Test, the Analytical Reading Inventory, and math work sheets. Significant improvements were reported following attention training on tests of attention and home-based behaviours of a 9-yr-old; on various neuropsychological tasks performed by a 17-yr-old; and on tasks of attention, executive functioning and memory in school-age children with mild traumatic brain injury (Thomson & Kerns, 2000). Similarly, improvements were found on visual and auditory tasks following a small group training paradigm that examined the effectiveness of APT materials and problem solving instruction for 33 10-yr-olds with ADHD over a period of 18 weeks (Semrud-Clikeman et al., 1999).

In more recent research, *Pay Attention* materials were designed specifically for use with children (Thomson, Kerns, Seidenstrang, Sohlberg, & Mateer, 2001), similar to the APT materials of Sohlberg and Mateer (1986). Kerns and colleagues examined the effect of the *Pay Attention* materials in fourteen 7-11 year olds diagnosed with ADHD (1999). While both training and control groups improved significantly on a number of measures, children who received direct attention training demonstrated significantly greater gains on a number of untrained measures of attention, including sustained and selective attention (Mazes subtest of the WISC-III, the ACT, the Day-Night Stroop, and the Underlining Test) and a measure of academic efficiency (Math worksheets). A trend towards improvement in inattention and impulsivity was reported by teachers for the treatment group when compared to the control group.

The *Pay Attention* materials were also utilized in a paradigm examining the effect of attention training on composition instruction in children with dyslexia (Chenault et al., 2006). Fourth to sixth grade children with dyslexia without generally documented ADHD who received attention training responded better to subsequent composition instruction than children who had been assigned to a reading fluency training group. In the first phase children received ten 25-min individual training sessions followed by a second 55-min group writing instruction session. At post-test one, both groups showed similar levels of improvement across measures of attention and reading regardless of type of training; attention or fluency. However, at post-test two, children in the attention process training group showed significantly more improvement in writing than children who had received reading fluency training, prompting these authors to conclude that attention process training facilitated children's ability to progress through the subsequent written composition session. In addition, while both groups of children improved significantly on an oral verbal fluency measure, children in the attention training group showed significantly more improvement on this test.

Despite the difficulties of conducting research with clinical populations, difficulties that sometimes translate into methodological problems in some of the studies discussed (e.g., AB designs without control groups, heterogeneous etiology of attention deficits across client populations), results seem promising (Penkman, 2004). Exploratory clinical research has provided an opportunity for more recent well-designed child studies (e.g., Chenault et al., 2006; Kerns et al., 1999) that can attest to the efficacy of attention process training with children with attention difficulties, regardless of etiology. Based on the available literature, it is expected that direct training of attention subcomponents could be a valuable treatment for improving sustained, selective, and higher levels of attention and cognitive efficiency in children with attentional deficits that are organic in nature.

Intervention with the FASD Population

Prospective studies show that symptoms of children with FASD who are not exposed to any kind of intervention strategy will remain constant over time (e.g., Streissguth et al., 1994). Thus there is a clear need to address primary and secondary disabilities for this population. While it is widely recognized that intervention research can provide answers for treating specific cognitive disturbances and preventing secondary disabilities, the empirical literature examining effective interventions with the FASD population is limited. Aside from a couple of very recent initiatives (to be discussed shortly), anecdotal reports, and clinical and educational wisdom are the basis for making decisions regarding secondary and tertiary prevention for children and adults with FASD. For example, in a very recent review of the intervention and rehabilitation literatures for FASD, Kalberg and Buckley (2007) provide *good sense* environmental and compensatory approaches that are routinely advocated for many atypically developing children. These involve building external supports into the learning and daily living environment of the child with FASD. Such accommodations include systematic teaching and structuring tools, such as visual structure, environmental structure, task/activity structure, and consistency.

Given the nature of FASD, these children are often raised in difficult early environments that exacerbate the secondary disabilities associated with this disorder (Abel, 1998). In support for the importance of external accommodations, some authors have observed improvements in symptoms and fewer later psychosocial problems in some children with FASD who come from supportive and stable home environments (Aronson & Olegard, 1987; Spohr, Willms, & Steinhausen, 1993). This environment-outcome connection indicates that children with FASD may benefit from early intervention by learning strategies that compensate for cognitive and behavioural challenges (Weiner & Morse, 1994). For example, Weiner and Morse report on two pilot programs that suggest that early intervention may maximize a child's potential: Bierich (1978) found that learning improved subsequent to long-term fine-motor occupational therapy which reduced children's hyper-excitability; and unpublished pilot data by Zaleski (1984) suggests that preschool children with FAS who participated in an intensive early intervention program that focused on teaching parents strategies to engage and stimulate children, showed significant gains in intelligence scores at 6 months, when compared to a group of children whose parents received support only.

There are a handful of comprehensive intervention projects currently in progress such as the Moving Families Forward Research Program (e.g., Carmichael Olson, 2006) and the Cognitive Control Therapy work currently conducted by Kalberg and colleagues (as cited in Kalberg & Buckley, 2007), however to this author's knowledge there are only two empirical studies that have been published that describe direct intervention strategies for children with FASD. Recent works from UCLA (O'Connor et al., 2006) and the University of Alberta (Loomes, Rasmussen, Pei, Manji, & Andrew, in press) offer empirically based information for the effectiveness of social skills and verbal rehearsal training respectively.

In the first example, using an approach that explicitly teaches social skills, O'Connor and colleagues (2006) have found robust effects for children with FASD subsequent to participation in a parent-implemented Child Friendship Training (CFT) program. Based on social learning theory, this program explicitly targets behaviours important in situations such as forming a social network, exchanging information with peers, entering into preexisting peer groups, initiating peer play activities, avoiding conflict, and negotiating social interactions. Children with FASD enrolled in the CFT Program showed significant gains in knowledge of appropriate social behaviour, improved social skills, and decreased problem behaviours, immediately following treatment and at three-month follow-up.

Second, based on evidence that rehearsal training can be effective for children with Down's syndrome (e.g., Laws, MacDonald, & Buckley, 1996), those with learning difficulties (e.g., Hulme & Mackenzie, 1992) and those with cognitive delays (e.g., Belmont & Butterfield, 1971), Loomes and colleagues (in press) aimed to teach 4-11 year-old children with FASD verbal rehearsal in order to increase verbal recall following a 10s delay. Thirty-three children were tested at pre- and post-tests using a digit span memory task with a maximum span of 7 numbers. For post-test 1, experimental children were instructed to whisper the numbers over and over *in their head* prior to the digit span task. For post-test 2 (between 6-21 days later), experimental-group children were reminded of the strategy taught during the previous visit and were asked to utilize this strategy again during the digit-span task. Children completed the same digit span tasks as in post-test 1 with a 10s delay for recall. These authors found no main effect of session; however, a Group x Session interaction was nearly significant. Follow-up analyses indicated that children in the experimental group had greater recall across the three sessions whereas their peers in the control group did not, with an average number recall that increased from 3 to about 3.7 numbers. In addition, a higher percentage of children in the experimental group showed behavioural evidence of rehearsal than children in the control group (i.e., moving lips, whispering, or repeating the stimuli; Loomes, et al., in press).

Given widespread neuropsychological impairments in memory, attention, executive functioning, visual-spatial abilities, intelligence, processing speed, academic achievement, and language (Carmichael Olson, Feldman, Streissguth, Sampson & Bookstein, 1998; Mattson & Riley, 1998; Rasmussen, 2005; Streissguth, Barr, Sampson, & Bookstein, 1994), deficits which cause significant difficulties on a daily basis for children with FASD, their caregivers, and their educators, there are numerous options for innovative intervention programs. The most commonly reported difficulties across attentional domains remain unaddressed. These primary deficits translate into difficulty with learning from mistakes, understanding cause and effect, poor judgment, socially inappropriate behaviour, completing tasks, and inconsistent skill performance. For example, ADHD in children with FASD has been linked to co-morbid developmental and psychiatric conditions (e.g., emotional and behavioural disorders such as anxiety, mood, and conduct disorders), and medical complications (O'Malley & Nanson, 2002).

Given the high prevalence of attention deficits in this population and the impact of these deficits on many aspects of development, early intervention is critical for a better outcome for these children. Should we be able to target basic attention deficits through direct early intervention, we may be able to alter some of the secondary deficits associated with FASD throughout the teenage and young adult years (Abel, 1998).

Not surprisingly, environmental and compensatory interventions are beneficial strategies for the day-to-day functioning of these children (Connor & Streissguth, 1996). Positive behavioural intervention (through Applied Behavioural Analysis) may also benefit individuals with FASD, similar to benefits observed in children with Autism Spectrum Disorders (e.g., Lovaas, 1987; McEachin, Smith, & Lovaas, 1993). In addition, it has been suggested that cognitive rehabilitation techniques – such as attention process training – could be of direct significance to this client population (Connor & Streissguth, 1996). Given the importance of attention to learning and daily functioning, and given the promising results of attention process training with children with attention dysfunctions due to various other etiologies, the current study focuses on a cognitive rehabilitation approach that directly trains attentional processing.

CURRENT RESEARCH

While some of the studies discussed addressed several aspects of attention, including sustained, selective, and divided attention, others addressed only one aspect (e.g., sustained attention). Similarly, the focus of the current exploratory work is on one of the most fundamental subcomponents of attention: sustained attention. This decision was based on several considerations: 1) confirmed sustained attention difficulties for children with FASD; 2) clinical work that indicates that intact lower order cognitive abilities such as sustaining attention are necessary for higher order processing (e.g., alternating or dividing attention; Sohlberg & Mateer, 1987); 3) empirical evidence that indicates that all attentional tasks load onto a common ability to sustain attention over shorter or longer periods, despite increasingly complex task demands and therefore differential higher-order demands (Manly et al., 2001); 4) reports that lower order sustained attention training improves both untrained measures of sustained attention and more complex aspects of attention (Sturm, Willmes, Orgass, & Hartje, 1997; reported in Kerns et al., 1999); and 5) previously conducted pilot work by the current investigator, wherein a full APT program delivered to 6 children with FASD, revealed that a significant amount of training time (in a training-to-criterion paradigm) had to be dedicated to sustained attention tasks prior to being able to train more complex attentional components.

The current study seeks to determine the effectiveness of individual sustained attention training in young children with FASD by utilizing APT strategies previously successful with other client populations. In line with recent recommendations (Sohlberg et al., 2003), progression through direct attention training sequences was individualized based on the strengths and needs of each child. In particular, while all children were administered similar sustained attention training protocols (i.e., all children started with basic level tasks) the time allocated to each task and the complexity[9] of materials utilized was individually determined. Additionally, in keeping with best practice guidelines for direct attention training, treatment involved distributed practice trials with at least one training session per week (i.e., 4-5 sessions per week) and tasks were administered in a hierarchical fashion emphasizing training of more complex sustained attention parameters, rather than focusing on simple parameters such as reaction time.

However, in contrast to recent recommendations that support the administration of metacognitive training in conjunction with direct attention training for individuals with TBI (Sohlberg et al., 2003), feedback during the training sessions was limited to naturalistic prompting, redirecting, reinforcement, and support in attending to task. While the TBI literature suggests that metacognitive training may be beneficial, it is not in fact clear whether positive results are due to training of attentional processes (i.e., through the repeated activation of attentional systems and corresponding changes in neuronal activity) or strategy use. While Cicerone claims that improvement following organized attention drills with a strategy feedback component is likely due to an improved ability to compensate for remaining deficits through the adoption of effective attention allocation strategies (2002), the pediatric ADHD literature suggests that cognitive-behavioural therapies that teach children strategies to apply to their own behaviour may 1) only be successful when both teacher and parent training is provided,

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[9] Examples of varying complexity for individuals' strengths and needs include increasing the number of sorting items for children who found the more basic level sorting tasks too simplistic or creating hierarchically more complex visual search paradigms through the addition of alternate visual search maps.

and 2) fail to generalize outside of the treatment program (see Semrud-Clikeman et al., 1999). These authors suggest that these approaches lack the ability to establish internalized self-regulatory skills that can support the generalization and maintenance of positive outcomes (Semrud-Clikeman et al., 1999). As such, it is both empirically and clinically important to isolate the effects of direct process training from the effects of alternate or augmentative strategies (e.g., metacognitive strategy training) for this population. It was deemed particularly important that treatment protocols, if effective, be able to be delivered easily and efficaciously by paraprofessionals (e.g., educational assistants) working with children with FASD in the school environment. The more demanding the requirements for meeting treatment integrity, the lower the likelihood that any treatment paradigm will in fact be utilized successfully with children who may benefit. In addition, based on successful outcomes of studies with the pediatric population that did not employ metacognitive strategy training (e.g., Cho et al., 2002; Kerns et al., 1999), it was predicted that direct attention training would be beneficial as a stand-alone treatment.

Hypotheses

Several hypotheses guided this research. First, in parallel to previous studies of attention training (e.g., Kerns et al., 1999; Cho et al., 2002) it was hypothesized that attention process training would improve performance on untrained neuropsychological and behavioural measures of attention and related cognitive functioning above and beyond the effects provided by supportive contact within an academic environment.

Second, it was expected that benefits of sustained attention training would be evident primarily on untrained process specific sustained attention measures, including basic capacities required to sustain attention such as increased focus and increased tolerance for distracters (see Sohlberg et al., 2003). Similar results were expected on behavioural measures (e.g., teacher reports) for parameters that tap sustained attention ability, but not on higher-order executive functioning parameters. Third, because sustained attention training tasks require some degree of selectivity, it was expected that beneficial effects may in fact also be evident on selective attention performance. For example, during the training sessions children were required to inhibit impulsive responses in order to reach success criteria for each activity, an ability that is also necessary during distractibility (or selective attention) tasks. However, these effects were not expected for process parameters that require greater cognitive manipulation of information and that can be considered higher order, or executive functioning processes (e.g., alternating or divided attention tasks). While the ability to sustain attention over shorter or longer intervals is a common demand across tasks regardless of task complexity (Manly et al., 1999), based on earlier work (see Parks & Ingles, 2001; Sohlberg et al., 2003), it is expected that process specific changes will be more robust. Higher order processes such as alternating and dividing attention would be expected to change only following training of such processes directly. While higher order processes do depend on the ability to sustain attention they also require much more elaborate processing, mental control, and flexibility. Fourth, similar to previously reported findings with children with ADHD (e.g., Klingberg et al., 2005) it was expected that training would generalize to measures of non-verbal reasoning. Tasks of non-verbal reasoning depend not only on higher order reasoning ability, but also on the ability to sustain attention or concentrate throughout a testing session and avoid lapses in attention. In other words, it is expected that performance deficits on these tasks are due, in part, to impaired sustained attention. Conversely, improvements in sustained attention should arguably translate to improved performance on non-verbal tasks that, while not designed to measure this ability, do in fact depend on it. In contrast, verbal reasoning (a more crystallized type of intelligence) was not expected to change following attentional training. More detailed outcome parameters and hypothesized changes are provided in Appendix B.

Power Analysis

As is usually the case with clinical-type populations, finding an adequately sized sample to ensure meaningful findings is difficult when enlisting children with FASD. Given the low number of available participants (i.e., 20 children), one of the concerns of the present study was establishing statistical power. Research with small samples will have unacceptably low power with small or medium effect sizes. However, with larger effect sizes even small samples will provide adequate statistical power (Bezeau & Graves, 2001). An a priori power analysis using GPower3 (Faul, Erdfelder, Lang, & Buchner, 2007) indicated that a very large effect size was necessary (i.e., Cohen's f = .67) for achieving adequate experimental power (i.e., .80) for the current 20-participant, 2-

group design[10]. Such a large effect would generally seem optimistic; however, research in clinical neuropsychology is known to produce much larger effect sizes than research in experimental psychology. For example, in an evaluation similar to Cohen's original review (1962), Bezeau and Graves review the adequacy of statistical power in current clinical neuropsychological research and report a mean effect size of .88 (Cohen's d) across 66 recently published articles (2001). These authors suggest that assuming a Cohen's large effect size would be appropriate for theoretically motivated clinical neuropsychological research and a very large effect size (e.g., Cohen's $d \geq 1.35$) for applied clinical neuropsychological research. Still, given the lack of prior intervention research for children with FASD that could speak to the power issue, concerns remain.

Alternatively, a compromise power analysis is a novel method for computing power in research situations where controlling certain variables is not feasible; for example, working with clinical-type populations where the available N is too small to satisfy conventional levels of alpha and beta given the available effect size (Faul et al., 2007). This type of power analysis allows for specifying the relative seriousness of both Type I and Type II error. For purposes of the current research, the overall probability of a Type I and Type II error would be equated. In particular, given the human and fiscal costs involved in providing individual treatment to children, it is important that if the current intervention is not effective it not be mistaken as such (avoiding a false positive).

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[10] The number of groups was adjusted to 3 in GPower3 in order to account for the degrees of freedom associated with the covariate, and alpha level was set at the conventional value .05.

However, given the need for evidence-based treatment options for children with FASD, it would be equally important to ensure that the current intervention is deemed effective, if in fact it genuinely is (avoiding a false negative). As such, a compromise power analysis that sets the β/α ratio to 1 may require error probabilities that may be non-standard, for example $\alpha=\beta=.19$ for a sample size of 20, with a large effect size (Cohen's $f=.50$) and adequate statistical power (.80). While these may be not be standard error probabilities, Faul and colleagues argue that in certain studies (for example those of clinical significance) it makes no better sense to insist on the standard level $\alpha=.05$ (in this case associated with $\beta=.44$), if it is associated with a risk of almost 50% of falsely accepting the null hypothesis, than to establish a more appropriate β/α ratio (in this case 1) (2007). These authors note that while it is a common convention to select $\alpha=.05$ or $\alpha=.01$ as the type-1 error probability, no specific conventions have been established for β or type-2 probabilities. While Cohen (1988, 1992; cited in Field, 2005) has suggested a .2 probability of failing to detect a genuine effect, others prefer equivalent levels of alpha and beta (Bredenkamp, 1980; cited in Erdfelder, Faul, & Buchner, 1996). As such, the current data was also examined in a more unconventional way (setting $\alpha=\beta=.19$, power .80) in order to unveil large effect sizes that may be important despite the lack of conventional statistical significance.

METHOD

Participants

A total of 20 (11 female, 9 male) school-age Labrador Inuit children (mean age = 9 years 6 months, SD = 1 year 6 months, range = 6 years, 9 months – 11 years, 11 months), with FASD participated in this study. All children participated with Nunatsiavut government, community, school board, school, and parental approval. Written consent and verbal assent was also obtained from each child participant. A sample parent and child consent form is provided in Appendix C. All participants had previously been diagnosed with a fetal alcohol spectrum disorder by one primary physician[11] and all had been screened to rule out any other developmental disorder. Eighteen children had a diagnosis of pFAS and two children had a diagnosis of FAS. Children were randomly assigned to training and control conditions. Previous research confirms common behavioural deficits and brain anomalies in children with heavy prenatal exposure, with or without FAS (e.g., pFAS, ARND; Mattson & Riley, 1998, 2000; Roebuck et al., 1999), and researchers support combining children with a diagnosis on the spectrum into one group for empirical purposes (e.g., Lee et al., 2004; Mattson & Roebuck, 2002). None of the participants were taking medication at the time of study nor had they been in the near past. Only one child in the treatment group had been diagnosed with ADHD, however many of the children had not been assessed for co-morbid conditions. Due to

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[11] Dr. Ted Rosales, one of the authors of the Canadian Guidelines for diagnosing FASD (Chudley et al., 2005).

the remote location of this community, accessible only by water or air, children did not have regular opportunities for referral to specialized health care personnel such as those in psychology, psychiatry, speech-language therapy, and occupational therapy. All children spoke English at home and school as their main language, however all were exposed to their cultural language (Inuktitut) in their community and through language classes in the school setting.

The Sustained Attention (SA) treatment group consisted of 10 children matched by age and non-verbal IQ (i.e., NIQ as measured by the CTONI-NIQ; Hammill, Pearson, & Wiederholt, 1996) to 10 children assigned to the contact-control (CC) group. Each child of a pair was randomly assigned to one of the two groups: SA treatment or CC. There were no significant differences between the treatment and contact-control groups on variables of age, gender, diagnosis, or medication status. There were also no significant differences between groups on pre-study standardized measures of cognitive processing or adaptive behaviour, results which will be discussed shortly.

The SA treatment group had a mean age of 9.54 years (range 6.8-11.9 years, SD 1.58 years) and the CC group had a mean age of 9.50 years (range 6.8-11.7 years, SD 1.62 years). The groups had an average difference between matched pairs of 2 months (range 0-5 months). The SA treatment group had a mean NIQ (CTONI) of 91.90 (range 74-107, SD=10.98) and the CC group had a mean NIQ (CTONI) of 89.80 (range 69-102, SD=11.15).

Materials

Pre- and post-treatment assessments were completed in individual 30-min sessions during the week prior to initiating the intervention and within one week following the intervention. Specific measures were selected to include direct and untrained standardized measures of attention and verbal/non-verbal intelligence, and indirect standardized scales of attention and executive functioning that were completed by children's teachers. Table 1 summarizes the specific subtests utilized with more detailed descriptions to follow.

Direct Measures of Attention (TEA-Ch & KiTAP)

The TEA-Ch is a standardized and normed clinical battery designed to differentially assess attentional subcomponents in 6-16 year old children. This battery is relevant for children with suspected or diagnosed attentional difficulties, not only for more clearly identifying the pattern of attentional difficulties but also for informing treatment and management programs (Manly et al., 1999). Two forms are available for test-retest situations. TEA-Ch subtests make increasing demands on attention and include auditory *sustained attention* (Score & Code Transmission), *selective attention/maintaining focus* (Sky Search & Map Mission), *sustained attention/behavioural inhibition* (Walk Don't Walk), *sustained attention/divided attention* (Score DT & Sky Search DT), and *attentional control/switching* (Creature Counting & Opposite Worlds), which also involves a component of maintaining and manipulating information in working memory.

Table 1. Pre- and post-treatment measures

Domain Assessed	**Measure**	**Subtest Selected**
• Attention	• Test of Everyday Attention for Children (TEA-Ch; Manly et al., 1998)	• Sustained Attention (i.e., Score & Code Transmission) • Selective Attention (Sky Search & Map Mission) • Alternating Attention/Flexibility (Creature Counting)
	• Children's Test of Attentional Processing (KITAP – the Enchanted Castle; Zimmermann et al., 2005)	• Sustained Attention (Ghosts' Ball) • Selective Attention - (The Sad & Happy Ghost) • Alternating Attention/Flexibility (The Dragon's Castle) • Divided Attention (The Owls)
• Behavioural measures of attention and executive function (clinical scales)	• Attention Deficit Disorder Evaluation Scale, 3rd Ed, School Version (ADDES-3-SV; McCarney & Arthaud, 2004)	• Teacher Checklist
	• Behavioral Rating Inventory of Executive Functioning (BRIEF; Gioia, Isquit, Guy, & Kenworthy, 2000)	• Teacher Checklist
• Verbal and non-verbal reasoning	• Comprehensive Test of Non-verbal Intelligence (CTONI; Hammill et al., 1996)	• Geometric & Pictorial Subscales
	• Kaufman Brief Intelligence Test, 2nd Ed (KBIT2; Kaufman & Kaufman, 2004)	• Verbal & Non-Verbal Subscales

The KiTAP is a child-oriented standardized computerized test battery designed to measure different aspects of attention. Currently available norms include 6-10 year-old children. All subtests were delivered on a Latitude D610 laptop with a 25-pin serial port required for the KiTAP testing key. A total of eight subtests are available to measure *alertness* (the Witch), *behavioural inhibition* (go/no-go, the Cat & the Vampire Bat), *distractibility* (the Sad & Happy Ghost), *vigilance* (the Mirror), *visual scanning* (the Witches' Parade), *alternating attention* or *flexibility* (the Dragon's Castle), *sustained attention* (the Ghosts' Ball), and *divided attention* (the Owls). All tasks assess attention across the visual domain, except for the divided attention subtest, which includes both visual and auditory task components.

While subtests of the TEA-Ch and KiTAP measure different attentional components, all require the ability to sustain attention over time and progressively more difficult task demands. Several subtests were selected for assessing the differential effects of sustained attention training. These included tests of auditory sustained attention (TEA-Ch: Score & Code Transmission) and visual sustained attention (KiTAP: Ghosts' Ball), tests of selective attention (TEA-Ch: Sky Search & Map Mission; KiTAP: distractibility – Sad/Happy Ghost subtests), tests of alternating attention (TEA-Ch: Creature Counting; KiTAP: Dragons' Castle), and tests of divided attention (KiTAP: The Owls).

Sustained Attention

The Score and Code Transmission subtests tap into the ability to sustain auditory attention over extended periods of time. The Score subtest requires children to count 10 sets of *scores* presented at varying inter-stimulus intervals, while the Code Transmission subtest requires children to listen to a long list of numbers, detect two consecutively occurring number 7s, and recall the number that occurred prior to the two 7s. The Ghosts' Ball is a test of visual sustained attention that requires the mental comparison of a stimulus with a subsequently occurring stimulus, followed by a decision of whether the two have a previously defined feature in common (e.g., similar colour, or similar colour and similar location). Target stimuli include ghosts that appear consecutively in different windows of a castle. These tests rely on working memory for good performance and involve the effortful maintenance of selectivity over a longer span of time (Zimmermann, et al., 2005), for example requiring the mental comparison of a recently presented stimulus with a currently occurring stimulus; a decision of whether the two stimuli have a previously defined feature in common; and a recollection of a target stimulus that had occurred immediately prior to the two stimuli. The number of correct responses, and the number of omissions primarily and commissions secondarily, are significant indicators of performance. Increased errors of omission indicate lapses of attention and inability to sustain attention over extended periods.

Selective Attention

Two visual search tasks, Sky Search and Map Mission, were selected to assess selective attention under self-paced and experimenter-timed task demands. The Sky Search subtest requires the discrimination of perceptually very similar pairs of objects (flying spaceships) in a busy visual array of similar objects (more flying spaceships). In order to eliminate the effect of motor speed on task performance children are also asked to circle similar object pairs, without being required to discriminate between pairs (e.g., circle all spaceship pairs on the page). The Map Mission task requires that children search and detect visually difficult to discern symbols on a map of diverse symbols, words, and locations. Indicators of performance are the number of targets correctly identified within a 60 second interval. These types of tasks examine children's efficiency in filtering information in order to detect relevant stimuli and reject or inhibit irrelevant or distracting stimuli. Targets are presented simultaneously, and children must also rely on their ability to plan and organize their search behaviour in order to optimize performance.

One of the most significant aspects of focusing attention is the ability to maintain control over the focus of attention in complex situations, under distracting conditions. During the KiTAP distractibility test (Happy-Sad Ghost), children are required to perform a centrally presented decision task (a Go/No-go type of task), with a randomly appearing distracting stimuli in the periphery of the visual field during half of the trials. The central stimulus, a sad or happy ghost, is designed such that the distinction between the two can be made only by focusing centrally. Distracters appear immediately before the target stimulus, such that only one saccade may potentially be directed to the distracter before the appearance of the discriminative stimulus. Presentation of the latter is very brief, and if focus is off-centre the target stimulus generally disappears before re-fixation is possible. Shifting attention from peripheral distracters to the target stimulus creates increases in either omissions (misses of the target) or commissions (false alarms) of the target. The number of omissions with or without distracter is the most important parameter for judging distractibility. However, children are considered distractible when the number of omissions for the distracter condition is much greater than the number of omissions for the non-distracter condition. A high number of false reactions is also indicative of distractibility, as children clearly would not be responding based on target recognition but rather, based on guesses.

Alternating Attention

The *alternating attention* subtests of the KiTAP (the Dragon's Castle) and the TEA-Ch (Creature Counting) both rely on flexibility: the ability to shift or alternate attention, change cognitive set, and keep in mind rules of behaviour. These subtests require the co-ordination of different attentional skills in completing particular tasks, and are considered tests of higher-order attentional function, involving the ability to sustain attention over time, to selectively orient attention towards relevant features or targets, and to shift or alternate attention accordingly. For example, in the Creature Counting task children are required to count "creatures" in a tunnel, and every time they reach an arrow (either pointing up or down), they have to verbally label the arrow "up" or "down" and change the direction of their counting. Arriving at an arrow pointing down would necessitate switching to counting backwards from the last count, and at the end ensuring a particular total count (determined not only by the number of creatures, but also by the number of arrows or switches required). Counting time[12] and number of correct responses are calculated as indicators of performance for this measure.

The KiTAP flexibility[13] subtest similarly involves not only the ability to direct attention toward an event, but also to redirect attentional focus. Inability to disengage and redirect attention causes perseverative behaviours (Lezak, 1995). Targets of the KiTAP subtest alternate such that children must press a key on the side of a green dragon, followed by pressing a key on the side of a blue dragon, both of which appear to the left and right of the centre gate. Task difficulty relies on the arbitrary appearance of different coloured dragons, to either the left or right side of the centre gate, thereby minimizing expectation effects for the test taker. The number of commissions and speed of response or median response time are calculated for this test. Zimmermann and colleagues (2005) point to the complimentary relationship between these two parameters, due to the speed-accuracy trade-off. Poor performance is indicated either by a significantly slowed response time or by a large number of commissions. Another

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[12] Because of significantly impaired performance on this subtest, speed of response – or overall processing efficiency could not be computed for most of the children due to a low number of correctly counted targets.

[13] Flexibility in this model is synonymous with alternating attention and indicates the ability to intentionally regulate the focus of attention, alternating between task demands. This subtest examines the ability to adjust to new task demands by measuring responses to constantly changing target stimuli.

important task parameter is the standard deviation or variability of response time, as it indicates the stability with which attention is re-oriented.

Divided Attention

Paying attention to a number of items or events at the same time requires the ability to divide attention simultaneously between different processes. The ability to divide attention was examined with a dual auditory-visual task (The Owls), in which a sequence of auditory and visual stimuli had to be observed in order to respond to the critical acoustic or visual stimulus. Specifically, in one version of this task, children are asked to press a key when they notice that one of two owls protecting a castle falls asleep or when they hear the other owl give a warning signal. Important indicators of performance are the number of omissions and commissions in one or both modalities. Reaction time is also measured in this subtest; however it is of secondary importance in interpreting results.

Behavioural Measures of Attention and Executive Function (ADDES & BRIEF)

Teachers completed the school version of the ADDES-3 (SV, McCarney & Arthaud, 2004) and the BRIEF (Gioia, et al., 2000) at pre- and post-intervention. While teachers were aware that children were involved in the study, they were blind to the condition of each child (i.e., SA treatment or CC groups). The ADDES-3-SV provides two scales of behaviour: inattention and hyperactivity/impulsivity. Because SA training was hypothesized to improve sustained attention, it was predicted that there would be a related improvement on the inattention scale, but not necessarily on the hyperactivity-impulsivity scale (these scales are moderately correlated). These scales include items such as "does not listen to all of what is said" or "does not wait his or her turn in activities or games", and are rated on a 6-point system from 0 (behaviour not developmentally applicable to the age of the child) and 1 (behaviour not observed) to 5 (behaviour occurs one to several times per hour). The ADDES is based on the DSM-IV-TR™ (APA, 2000) definition of ADHD, and utilizes criteria most widely accepted by health care and education professionals.

The BRIEF categorizes behaviours on several measures including *behavioural inhibition, shift, emotional control, initiation, working memory, planning and organization, organization of materials,* and *monitoring*. The BRIEF is designed to assess a child's self-control and problem-solving skills by measuring eight components of executive functioning. Sample skills include goal selection for specific tasks; planning and organizing in problem solving; initiating a plan of action; resisting impulses and inhibiting distractions; holding a goal in mind; flexibility in problem solving or trying new approaches; and checking to see if goals are achieved. Both of these measures show good psychometric properties and are normed for use with this age group.

Verbal and Non-verbal Reasoning Measures (CTONI & KBIT2)

The ability to sustain attention has been associated with cognitive task performance in both children and adults (e.g., Bialystok, 1992; Bialystok and Majumder, 1998; Carter and Swanson, 1995; Choudhury & Gorman, 2000; Griggs, Platt, Newstead, & Jackson, 1998) and with performance on intelligence measures, particularly nonverbal or performance tasks (e.g., Crawford, 1991; Schweizer & Moosbrugger, 2004; Schweizer, Moosbrugger, & Goldhammer, 2005; Schweizer, Zimmermann, & Koch, 2000). Nonverbal reasoning measures play an increasingly important role in psychoeducational assessment, and the CTONI (Hammill et al., 1996) is one of the most widely utilized throughout the US (Rossen, Shearer, Penfield, & Kranzler, 2005). Designed to assess "particular abilities that exist independent of language and that increase a person's capacity to function intelligently" (Hammill et al., 1996, p. 2), this measure is also regularly used as an assessment of non-verbal reasoning ability throughout the current northern population[14]. The CTONI is appropriate for use with individuals between the ages of 6-89 and can be used when other tests are inappropriate or biased, for example for deaf or marginalized individuals or those with neurological impairment (Hammill et al., 1996). Six subtests measure analogical reasoning, categorical classification, and sequential reasoning performance, in both pictorial and geometric formats, and instructions can be delivered verbally or in pantomime (a computerized version also exists). The verbal form of the test was used in the current study. Mean test-retest reliabilities for the pictorial non-verbal intelligence quotient (PNIQ), the geometric nonverbal intelligence quotient (GNIQ) and the overall nonverbal intelligence quotient (NIQ) are .93, .95, and .97 respectively. Criterion related validity indicates that the CTONI correlates well with other measures of intelligence, for

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[14] Labrador School Board, personal communication, 2006

example .81 with the WISC-III (Wechsler, 1991[15]), .74 with the PPVT (Dunn & Dunn, 1981[14]), and .82 with the TONI-2 (Brown et al., 1990[14]). In addition, Wiseley (2001, cited in Rossen et al., 2005) found that the CTONI NIQ correlated significantly with reading and math achievement in a Native American group. Because of the relationship between sustained attention and nonverbal reasoning, and given previously reported gains in nonverbal measures following working memory training (e.g., Klingberg et al., 2005) it was hypothesized that treatment effects from sustained attention training should generalize to nonverbal reasoning, and CTONI performance.

The KBIT2 (Kaufman & Kaufman, 2004), is a broadly utilized brief intelligence measure, with high reliability and validity. Two scales, verbal (measuring verbal knowledge and riddles) and nonverbal (matrices subtest), measure two aspects of intelligence; crystallized ability and fluid reasoning respectively. The KBIT2 was chosen to analyze the specificity of training effects between fluid reasoning (which is considered to be sensitive to attentional functioning) and crystallized ability (which, assuming constant motivation to task between pre- and post-test, would not be as highly sensitive to attentional change). Both the CTONI and the KBIT2 are well-standardized, however like other currently available psychometric measures, neither are standardized for use with Inuit populations. Since the scope of this study was to assess pre- and post-test changes in performance rather than to interpret performance relative to a population norm, this issue is somewhat minimized for the current purpose. However, given the

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[15] Reported in Hammill et al., 1996

cultural bias of these measures, reliable interpretations cannot be made about children's functioning within their own culture and community (as would normally be the case).

Pay Attention Materials

SA training consisted of visual and auditory sustained attention activities from the *Pay Attention!* training protocol (Thomson, et al., 2001). This training program includes hierarchically designed attention training activities for sustained, selective, alternating, and divided attention components. Tasks selected for the current research involved child-paced visual sustained attention activities such as card sorts and target searches; examiner-timed visual sustained attention tasks such as card flip activities; and examiner-timed auditory sustained attention activities. Materials were interesting, colourful, and visually engaging for children, and utilized familiar concepts such as physical features (e.g., hair colour, gender, clothing), or family relationships (e.g., parents, grandparents, siblings). For example, children could be asked to select all of the adults wearing glasses and a hat from a set of cards displaying adults and children, in an examiner-paced task. Alternatively, in a child-paced card sort task children could be asked to sort cards into piles, where the sorting criteria increased in difficulty by adding sorting features and increasing complexity, or adding cards to the task. The program used both visual and auditory stimuli, and tasks were graded in difficulty. Auditory tasks were presented on a Latitude D610 laptop and started with simple activities such as detecting simple auditory targets that progressed to more difficult tasks, such as detecting things one might see in the sky, for example. Children's performance on each task was expected to reach a pre-specified criterion prior to moving ahead to more difficult tasks. A description of activities and selected pictures have been adapted from Kerns and colleagues (1999) and included in Appendix D. While information for all attentional components is provided, only sustained attention activities were utilized in the present study.

It is important to note that the visual search tasks available with the *Pay Attention!* program were found to be too simplistic, as determined both through previous pilot work and also noted for this cohort of children who excelled at these tasks immediately. As such, four additional search tasks were included in training this visual sustained attention component, in order of complexity; Freddy in Monsterville, Detective Donald's Army Camp, Freddy at the Beach, and Freddy at the Ballpark. These search tasks were obtained from The Big Book of Search and Find (Tallarico, 2007) for ages 5-12, and children progressed through these in both child-paced searches and examiner-timed searches.

Intervention

All children were seen daily, in individual 30min sessions over a period of 12 sessions (assessment sessions also occurred in individual 30min periods during the week immediately prior to and immediately following the intervention). All children completed the required training/contact-control sessions over 2.5 – 3.5 weeks, during the school-day or after school. On average, children completed all assessment and training sessions during intervals of 5-6 weeks. All sessions were conducted in a small, quiet room in the same school. A visual clock (Time Timer, LLC; 1999-2007) was utilized throughout all assessment, training, and contact-control sessions. All children received a visual schedule, and at the end of each session each child received stickers that they could place on their visual schedule. Children chose one or more stickers depending on their own assessment of "how hard they had worked that day". Following post-assessments, visual schedules were laminated and presented to each child with a treat bag for participating in the study. Parents and teachers in both groups were informed that all sessions would involve game-like activities that would include both visual and auditory targets or typical academic activities or games. Parents and teachers were blind to the condition of each child (treatment or contact-control).

Sustained Attention (SA) Training

Participants in the SA training group were engaged in treatment sessions that targeted visual and auditory sustained attention as per the *Pay Attention!* protocol. For example, children may have been required to sort a pack of family cards as quickly as possible such that family members with blond hair were sorted in one stack while family members with brown hair were sorted in another stack. Or, children may have been required to listen to a set of stimuli and press a buzzer when they heard a specific target stimulus – for example the word *dog* in a list of unrelated words, or the words *red* or *yellow* in a list of colours. Tasks were hierarchically organized such that children were required to progress from easier to more difficult activities, for example having to sort family members in two stacks with one stack composed of the individuals with *brown* *hair or glasses* and the other stack composed of individuals with *blond hair and a hat*; or to press a buzzer whenever they heard something that they might see in the sky, or something big. Prior to progressing to more difficult activities children were required to perform to a set criterion, such as errorless performance on two consecutive sessions and increased speed of performance while maintaining over 90% accuracy on timed tasks. For a more detailed description of training materials see Kerns and colleagues (Kerns et al., 1999; Thomson et al., 1994). Children were not taught specific strategies to help them sustain their attention nor where they asked to practice outside of the training sessions. All children started with basic level tasks on sustained attention and progressed to more difficult tasks across the training sessions.

Contact-Control

Contact control sessions were devised to provide the same amount of individualized contact time for the CC children as for the SA children, but without a structured intervention program. Individualized support was provided through utilizing worksheets, games, and art activities that were tailored for academic concepts, for example vocabulary (e.g., rhyming, synonyms, antonyms), mathematics (e.g., sorting, sequencing, mapping), arts and crafts (e.g., colouring, cutting, and pasting), and reading. Materials utilized were not standardized for the group, as it was intended that children receive the type of support that would be typically available within the regular academic environment, but on an individual instead of a group basis. Tasks varied between children depending on the interest and developmental level of each child.

Activities were selected from various classroom resources available for teachers and other education professionals (e.g., Donaldson & Waldock, 2002; Family Education Network, 2000-2006; Morrow & Boyd, 1999; Reading a-z, 2002-2007; Teacher Vision, 2000-2007). In some instances, children brought classroom assignments to the sessions for support or preferred to work on special art projects that they had started in class (for example at Thanksgiving, Halloween, and during the lead-up to Christmas).

RESULTS

Data from both pre- and post-training assessments were analyzed. Both raw scores and standardized scores (where available) are provided. Standardized scores were useful in providing an estimate of children's attentional processing relative to available norms. These scores are presented with some caution, particularly since measures currently available are more (e.g., KBIT2 Verbal scale) or less (e.g., KiTAP) culturally biased. While some measures rely on basic processing efficiency rather than culturally dependent knowledge, the current sample of children (and indeed the population from which they were drawn) is not comparable to the samples from which available norms were drawn. Thus, and since the main interest in this investigation was the actual improvement made by the children, raw scores were felt to be somewhat more sensitive for providing the actual change in performance for each child as opposed to performance relative to the standardization sample.

Because SA and CC groups were matched on age and non-verbal IQ, no between-group differences were expected on these parameters. Raw scores are expressed in the format in which performance was scored (e.g., number of correct responses, number of errors, ms, etc.). Standardized scores are expressed in scaled scores (M=10, SD=3), T scores (M=50, SD=10), and IQ or Quotient scores (M=100, SD=15), as appropriate for each of the subtests discussed.

Pre-Training Results

SA vs. CC group performance was compared on several pre-test measures including direct measures of attention (i.e., TEA-Ch & KiTAP), behavioural measures of attention and executive functioning (i.e., ADDES-3-SV & BRIEF teacher checklists), and measures of verbal and non-verbal reasoning (i.e., CTONI & KBIT2). First, general descriptive information is provided based on children's pre-test performance for each measure. Second, results of performance on pre-test measures are provided based on independent samples t-tests.

Direct Measures of Attention

TEA-Ch

The TEA-Ch is a widely utilized diagnostic tool with large age-range norming categories. Pre-test (and post-test) analyses included both raw and scaled score performance. Performance means, standard deviations, and t-values are provided for raw and scaled scores for SA training and CC groups in Appendix E.1. As indicated by scaled scores, children in both groups showed impaired performance on auditory sustained attention subtests (Score & Code Transmission). Mean scaled scores ranged from 3.20 to 4.70 for correct responses on the Code Transmission and Score subtests for the SA training group and from 4.10 to 6.40 on these same subtests for the CC group. While children scored well within average norms for the number of targets identified in both child- and experimenter-paced visual selective attention tasks (Sky Search & Map Mission; i.e., mean scaled scores ranged from 7.50 to 9.70), both groups performed well below average on speed of response, as indicated by attention composite scaled scores (SA: M=5.80 and CC: M=6.50) even after simple motor speed was accounted for. Perhaps not surprisingly given results on these measures, children were also significantly impaired on a higher-order test of alternating or shifting attention (Creature Counting) with SA and CC mean accuracy scaled scores of 5.50 and 4.20 respectively.

Independent samples t-tests indicate no significant between group differences at pre-test on any of the TEA-Ch attention components (i.e., auditory sustained attention, selective attention, or the higher order alternating attention).

KiTAP

The KiTAP is a newly developed computerized battery with a narrow standardization age range. T scores could not be computed for all children because of the age range differences between the currently available norms (6-10 years of age) and the current study group (6-12 years of age). However, in order to get some idea of the whole group's attentional profile relative to available norms, T scores were analyzed (as available) for the fifteen 6-10 year olds in the sample (8 in the SA training group and 7 in the CC group). It is important to stress that firm conclusions about the performance of the 5 older children and hence a definitive estimate of the performance of the entire group would be difficult to draw based exclusively on results from the younger children. Pre-test (and post-test) performance was analyzed on several attention parameters including: correct responses, errors of commission (false alarms), errors of omission, mean and median response time, and standard deviation or variability of response time. All parameters were analyzed across subtests of visual sustained attention, selective attention (i.e., distractibility subtest), alternating attention or flexibility, and divided attention. Means, standard deviations, and t-values are provided for raw and standardized scores (T values as available for the 6-10 year old subgroup) in Appendices E.2-E.5. T value information was available for the following parameters; errors of commission, errors of omission, and median RT on the sustained, selective, and divided attention subtests, and errors of commission, median RT and standard deviation or variability of RT on the alternating attention subtest and also presented in Appendices E.2-E.5.

Descriptive information is provided based on T score performance of the younger children (6-10 year olds) in the study. This subset of children shows impairments primarily on parameters of errors of commission and errors of omission on visual sustained attention, with overall T scores ranging from 33.75 to 35.43 (Appendix E2). Median response time does not appear to be impaired, with mean T values of 48 and 45 for the SA and CC groups respectively. Paired t-tests conducted on the entire group of children suggest significant differences in performance between the 1st half of the test and the 2nd half of the test, for correct responses t(19)=2.89, p=.009; errors of omission t(19)=-2.89, p=.009; mean response time t(19)=-2.60, p=.018, and median response time t(19)=-2.13, p=.046. Overall, children experienced a performance decrement across the testing phase, exhibiting fewer correct responses (M=15.5, SD=3.99) and greater errors of omission (M=9.50, SD=3.99) during the 2nd part of the visual sustained attention subtest than during the 1st part of this test (M=17.95, SD=4.47 and M=7.05, SD=4.47 for correct responses and errors of omission respectively). Children also had significantly greater mean (M=845.25, SD=164.40 vs. M=777.70, SD=128.98) and median (M=807.45, SD=167.42 vs. M=748.85, SD=136.94) response times during the 2nd phase of this test.

Similar findings emerged on the selective attention subtest for overall performance. High errors of commission for both SA and CC groups emerged, with mean overall T values of 31.50 and 39.00 respectively (Appendix E.3). This was also the case in comparing both trials with and trials without distracters, with overall T values for errors of commission of 37.73 and 37.71 respectively for the younger group. Interestingly, this subgroup of children scored in the average range on errors of omission on this subtest, with average overall T values of 47.38 and 47.14 for SA and CC control groups, and also had comparable response times to the standardization sample (i.e., 61.38 and 50.29 for SA and CC groups respectively). In follow-up paired t-tests, significant differences emerged between performance on trials with distracters and performance on trials without distracters for all children across correct responses t(19)=-4.02, p=.001; errors of omission t(19)=4.02, p=.001; mean response time t(19)=4.32, p=.000;

and variability of response time t(19)=4.60, p=.000. Not surprisingly, children had poorer performance for trials with distracters than trials without distracters, making fewer correct responses (M=16.7, SD=2.64 vs. M=18.20, SD=2.37) and more errors of omission (M=3.30, SD=2.68 vs. M=1.80, SD=2.37), and having increased mean (M=831.40, SD=381.07 vs. M=539.25, SD=131.73) and variability (M=607.30, SD=430.97 vs. M=261.25, SD=194.98) of response time.

On the test of alternating attention or flexibility, all children showed high errors of commission with average T values for the 6-10 year olds of 38.75 and 34.86 for SA and CC groups respectively, but average median response time performance (Appendix E.4). In terms of stability of response times (i.e., SD of RT), children in the CC group showed slightly more impaired performance (M=37.86) than children in the SA group (M=45.38), however this difference was not significant. While the difference is not significant, younger children in the CC group appear to be impaired on this parameter relative to norms, whereas children in the SA group perform within the expected range. It is difficult to gauge whether this finding would also apply to the older group of children.

Last, on the divided attention subtest children exhibited a different pattern of performance for errors of commission and omission than previously noted (Appendix E.5). Specifically, all children showed greater errors of omission, with average overall T values of 38.88 and 38.14 for SA and CC groups respectively for the 6-10 year olds, but the SA group displayed performance within the acceptable average range for errors of commission, with an overall T value of 45.13. The CC children however, still scored slightly below average on this parameter, with an average overall T score of 39.14. Both groups of children scored within the average range for median response time. Paired t-tests across all children indicate significant differences between auditory and visual trials of the divided attention subtest on correct responses t(19)=-4.183, p=.001 and errors of omission t(19)=4.183, p=.001. Specifically, children had significantly more correct responses for visual (M=17.90, SD=1.79) than auditory targets (M=9.90, SD=1.68), and significantly less errors of omission for visual (M=2.10, SD=1.79) than auditory targets (M=10.1, SD=2.1).

Comparisons between the two groups, SA and CC, revealed no significant differences at pre-test on parameters of sustained attention, alternating, or divided attention subtests. However, a couple of significant differences were found between groups on a measure of selective attention. Specifically, a significant difference emerged for median response times on trials with no distracter stimuli, t(18)=-2.79, p=.012, and this represented a very large sized effect d=1.31. Specifically, children in the SA group had significantly faster median response times (M=407.10, SD=125.42) than children in the CC group (M=556.70, SD=114.28). A similar difference was only marginally significant for median response time on overall trials t(18)=-2.05, p=.055. However, this difference did represent a large sized effect, d=.97, with the SA group having a faster median response time (M=425.80, SD=134.08) than the CC group (M=572.50, SD=182.04).

Behavioural Measures of Attention and Executive Function

ADDES-3-SV and BRIEF

Appendix E.6 provides means and standard deviations for ADDES-3 and BRIEF checklists. As appropriate, results are presented as raw scores, scaled scores, T values, and Quotient scores. Interestingly, teachers rated children as having typical overall attention and hyperactivity, as measured by the ADDES-3-SV, with an overall mean ADHD Quotient of 96.33 and 92.60 for the SA and CC groups respectively (M=100, SD=15). These results seem to be in contrast with results from direct attention measures, however when examining the frequencies of scores across the two subscales, it is evident that teachers view several of the children as being fairly impaired on the attention dimension, for example 7 children scored at a scaled score of ≤ 6 (M=10, SD=3) for attention. In addition, this sample of children was not considered hyperactive, with only 1 child scoring at a scaled score of 5 for hyperactivity. Anecdotally, it is possible to confirm that children's behaviour was not hyperactive during their daily interaction with the examiner.

In contrast, analyses on the BRIEF parameters indicate that this cohort of children has significant impairments in executive functioning and higher order attention components. Mean T values for the group were greater than 65 for all subscales and considered to be of clinical significance (Gioia et al., 2000), and a large proportion of children had difficulty on all parameters (as indicated by T values of 60 and above). Overall, children had difficulty with parameters of Inhibit (65% of T scores ≥ 61), Shift (70% of T scores ≥ 62), Emotional Control (50% of T scores ≥ 69), Initiate (90% of T scores ≥ 64), Working Memory (90% of T scores ≥ 61), Planning and Organization (85% of T scores ≥ 61), Organization of Materials (55% of T scores ≥ 67), and Monitoring (75% of T scores ≥ 61), and the respective indices of Behavioural Regulation (65% of T scores ≥ 62), Metacognition (95% of T scores ≥ 62) and Global Executive Composite (85% of T scores ≥ 60). This was the case irrespective of group: Performance comparisons between the SA and CC groups at pre-test revealed no significant differences in attentional and executive functioning parameters as reported by teachers on the ADDES-3-SV or the BRIEF subscales. For example on parameters of inhibition, working memory, and monitor (components requiring some degree of sustained attention ability) teacher ratings indicate mean T values of 66.0 & 70.2, 79.33 & 78.8, and 68.33 & 77.90 for SA and CC groups respectively.

Verbal and Non-Verbal Reasoning Measures

CTONI & KBIT2

Means, standard deviations, and range for standardized pre-study measures (IQ scores) are provided along with t values for SA training and CC groups in Appendix E.7. It is important to note the wide range of nonverbal (e.g., 69-107 and 52-106 for CTONI and KBIT2 respectively) and verbal (e.g., 56-107 for KBIT2) performance of this cohort. Overall, children scored in the average range for CTONI NIQ (M=90.85, SD=10.83) and below average for KBIT2 NIQ (M=82.70, SD=14.37). Verbal, and consequently composite score performance was much more impaired at M=72.10 (SD=1.63) and M=74.10 (SE=13.21) respectively. There were no experimental group differences in IQ for SA or CC groups at pre-test.

Post-Training Results

Post-training assessments of attention and executive functioning were conducted on untrained measures directly administered to the children (i.e., TEA-Ch & KiTAP), and indirectly through behavioural checklists completed by the teachers (i.e., ADDES-3-SV & BRIEF). In addition, post-training assessments were conducted on measures of verbal and non-verbal reasoning (i.e., CTONI & KBIT2). While all measures were analyzed in similar fashion, only significant results are reported. Similarly, covariates are reported only when significant.

Within-subject changes were analyzed with the pre-treatment score serving as the control. Because groups were matched for age and non-verbal IQ, there was no concern that these variables would be linked to changes in between-group performance. Data was analyzed through multiple ANCOVAs by Training Condition (SA v CC) with pre-test performance as the covariate in each analysis. Following a query of the appropriateness of utilizing multiple ANCOVAs vs MANCOVAs, it was determined that the simple ANCOVA would be most appropriate to the research questions and hypotheses raised in this study. For example, Huberty & Morris (1989) suggest that multiple ANOVAs may be appropriate for studying the effects of treatment variable(s) on conceptually independent outcome variables, as redundant information may be obtained on conceptually dependent outcome variables. Recently, several systematic attempts have been made to develop batteries of attentional tests that work in tandem to evaluate theoretically based components of attention differentially. Some of these include the Attention Process Training Test (APT-test; Sohlberg & Mateer, 1989), the Test of Everyday Attention-Adults and -Children (TEA: Robertson, Ward, Ridgeway & Nimmo-Smith, 1994, 1996; TEA-Ch: Manly, Robertson, Anderson, & Nimmo-Smith, 1999), and the Test of Attentional Performance for Adults and Children (TAP: Zimmermann & Fimm, 1994; KiTAP: Zimmermann et al., 2005). Children's versions of these batteries were utilized in the present research, such as Robertson and colleagues' TEA-Ch battery (1999), and sustained, selective, alternating, and divided attention capacities were measured differentially.

However, because there are several variables of interest, this study has a large number of statistical tests. While the outcome measures were identified *a priori*, a large number of tests may unveil chance findings and increase the overall probability of making a Type I error on at least one comparison. The current research attempts to solve this problem with clearly outlined *a priori* hypotheses and specific statistical tests to unveil main effects for each hypothesis (Bezeau & Graves, 2001). Post hoc tests have only been utilized to determine if the degree of predicted change was significantly different from zero (e.g., comparing the two groups, experimental vs. contact control).

Any significant treatment effects (indicating that the pattern of change between pre- and post-tests was different for SA v CC groups) were subjected to individual paired t-tests, which were then used to determine how much change was noted for each group and if the change was significantly different from zero. Effect sizes were calculated using Cohen's f as a more appropriate estimate of effect size than the η^2

produced by SPSS (Field, 2005, p.384). While ANOVA procedures are quite robust when sample sizes are equal (Field, 2005, p. 324), assumption of homogeneity of variances was calculated with Levene's Test and met for the vast majority of reported results. Where the homogeneity of variance assumption was not met, a more stringent alpha level (.01) was adopted for reporting significant results (see Keppel, 1991, p.106). In effect, this kept the probability of a type-1 error close to .05. On parameters that did not show a treatment effect, paired samples t-tests were conducted to unveil any nonspecific effects of being part of the study.

Direct Measures of Attention (TEA-Ch & KiTAP)

TEA-Ch

Post-test analyses include both raw and scaled scores. Means, standard deviations and t scores for significant effects are provided in Appendices F.1-F.3.

Auditory sustained attention (TEA-Ch Score & Code Transmission subtests). ANCOVA analyses on post-training performance with pre-training performance set as the covariate revealed significant treatment effects for correct responses on both raw, F(1,17)=11.86, p=.003, f=.84, and scaled performance, F(1,17)=12.65, p=.002, f=.86 of the Score subtest (Figure 1), and for raw, F(1,17)=28.17, p=.000, f=1.29 and scaled performance, F(1,17)=34.86, p=.000, f=1.43 of the Code Transmission subtest (Figure 2). Significant covariate effects were found for the Score subtest for both raw F(1,17)=6.00, p=.025, f=.59, and scaled score F(1,17)=10.40, p=.005, f=.78 pre-test performance but only for scaled Code Transmission pre-test performance F(1,17)=20.54, p=.000, f=1.10.

Follow-up individual paired t-tests revealed that only the SA training group improved significantly in performance on auditory sustained attention parameters for both raw t(9)=-4.47, p=.002 and scaled performance t(9)=-5.95, p=.000 of the Score subtest, and raw t(9)=-13.72, p=.000 and scaled performance t(9)=-8.41, p=.000 of the Code Transmission subtest. Of particular interest, post-test performance for the SA training group fell within the average range as indicated by scaled scores (M=8.70), representing a significant improvement from pre-test scaled scores (M=3.20).

Figure 1. Pre- & Post-test Correct Response Performance on TEA-Ch Auditory Sustained Attention (Score Subtest)

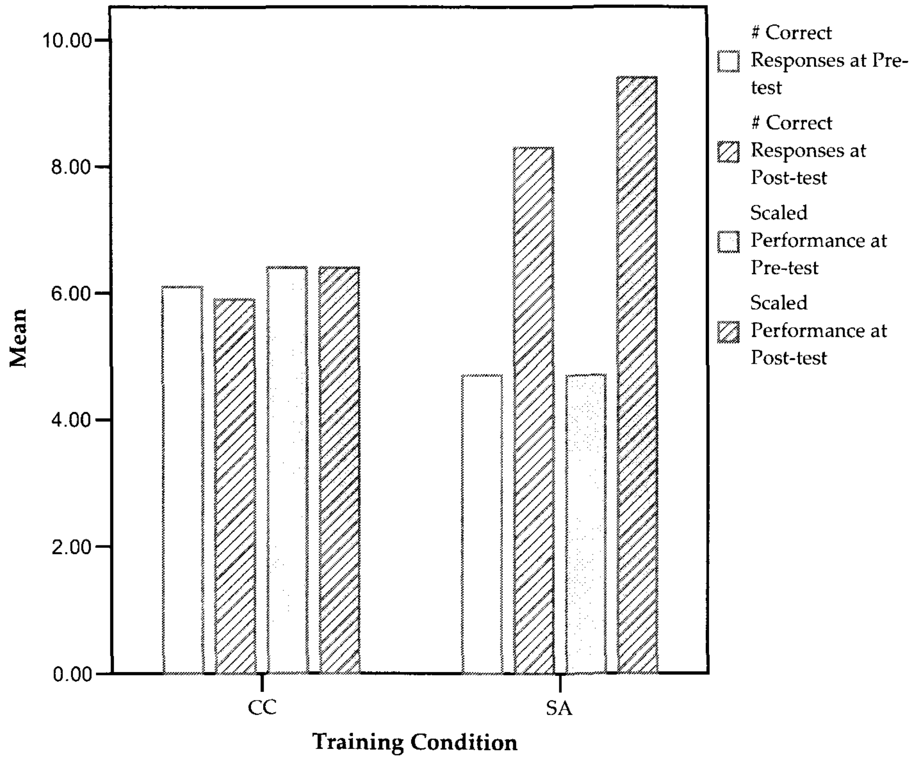
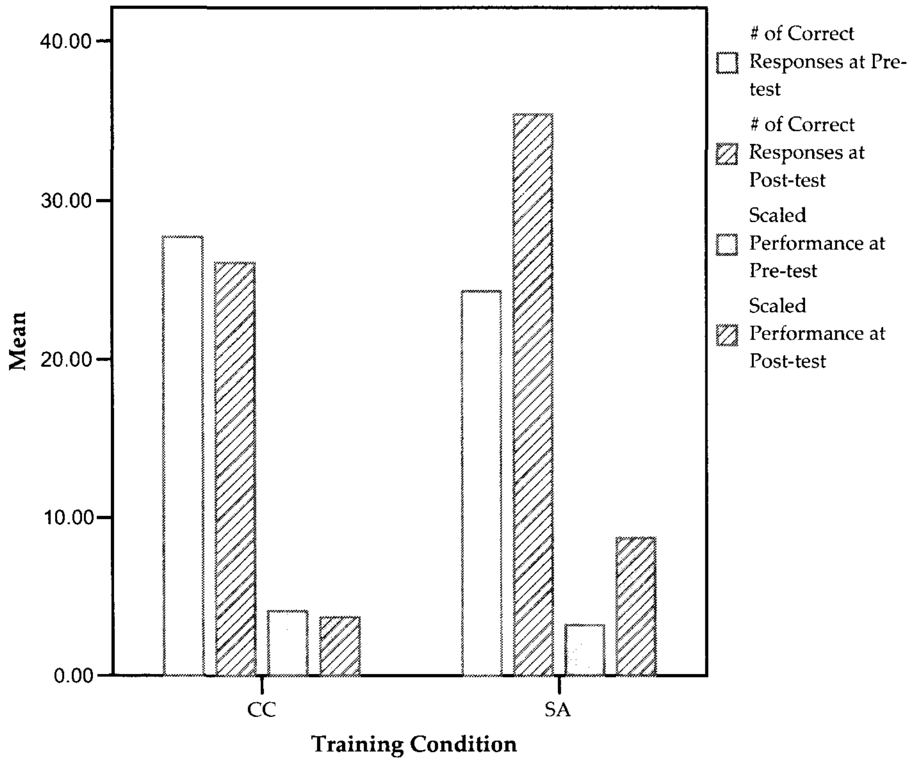


Figure 2. Pre- & Post-test Correct Response Performance on TEA-Ch Auditory Sustained Attention (Code Transmission Subtest)



Results for the Code Transmission subtest were further analyzed to see if the improvement was due specifically to changes in the 1st half of the test (0-7min) or changes in the 2nd half of the test (7-14min) or both. Main effects of training were found for both intervals F(1,17)=23.76*, p=.000, f=1.18 and F(1,17)=12.85*, p=.002, f=.87 respectively. Paired t-tests indicate that only the SA training group made significant

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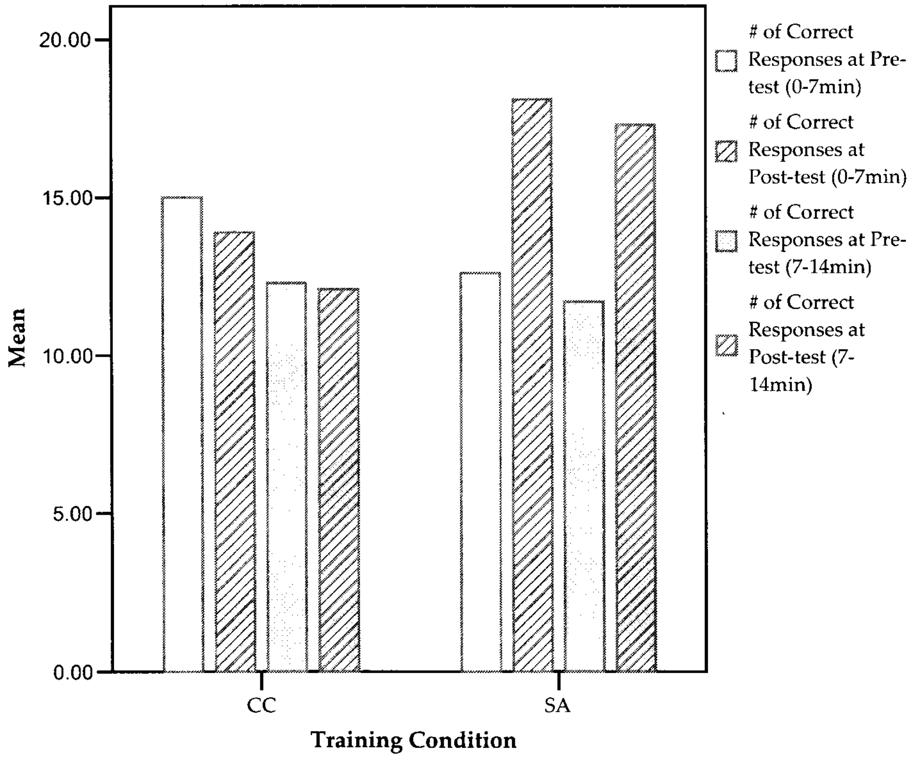
* Levene's Test is significant, thus values are reported as significant only at the more stringent p level (p<.01).

improvements during the 0-7min interval t(9)=-9.45, p=.000 and during the 7-14min interval t(9)=-8.81, p=.000 of this auditory sustained attention measure. Figure 3 represents raw performance. Standardized scores were not available to calculate scaled performance for both halves of this measure.

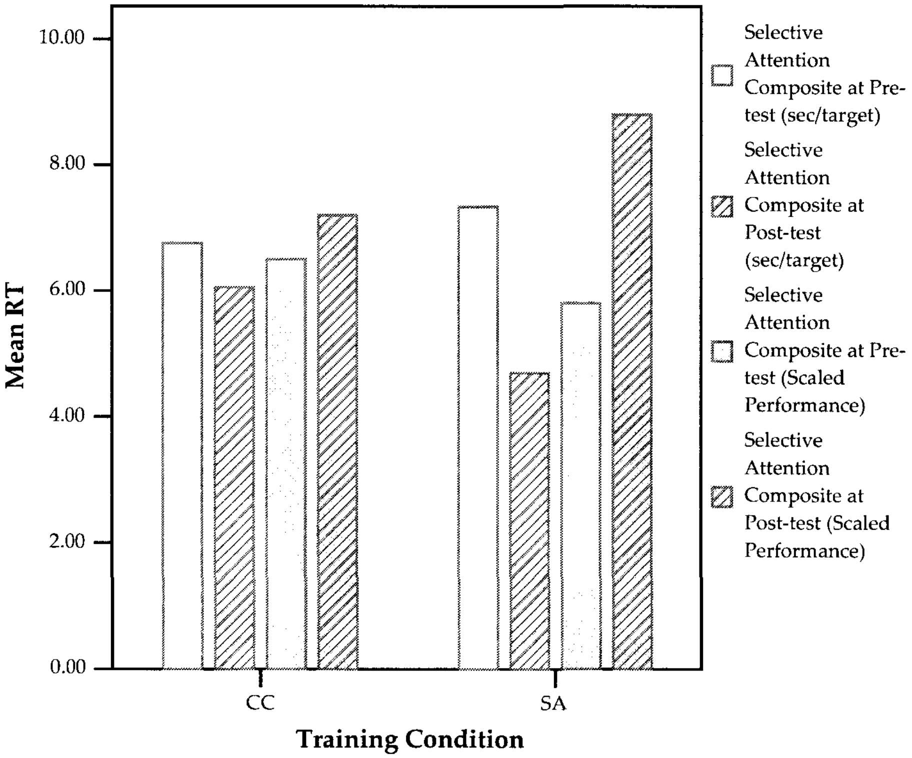
Figure 3. Pre- & Post-test Correct Response Performance across 0-7 & 7-14min Intervals of TEA-Ch Auditory Sustained Attention (Code Transmission Subtest)



Selective attention (TEA-Ch Sky Search & Map Mission subtests). A clear improvement was noted for speed of response. A main effect of treatment emerged on the selective attention composite (RT) for raw F(1,17)=4.54, p=.044, f=.53 and scaled performance F(1,17)=4.82, p=.042, f=.53 of the Sky Search subtest (Appendix F.1). Pre-test performance was significantly correlated to post-test performance for raw F(1,17)=18.64, p=.000, f=1.05 and scaled scores F(1,17)=23.47, p=.000, f=1.18.

Follow-up individual paired t-tests revealed that while both groups improved, this improvement was significant only for the SA training group, as measured by raw t(9)=2.44, p=.037 and scaled t(9)=-3.11, p=.013 performance. Importantly, these children scored within the average range at post-test (e.g., M=8.80). Changes in raw and scaled performance for RT on the self-paced Sky-Search test can be found in Figure 4.

Figure 4. Pre- & Post-test Performance on TEA-Ch Selective Attention (Sky Search Subtest)



In contrast, no main effects emerged on the examiner-timed measure of selective attention (i.e., Map mission). However, in order to examine the non-specific effects of being part of the study on this subtest, paired t-tests were conducted and results indicate that all children showed improvements in raw scores t(19)=-2.24, p=.037 pre- and post-means at 34.45 and 37.95 respectively.

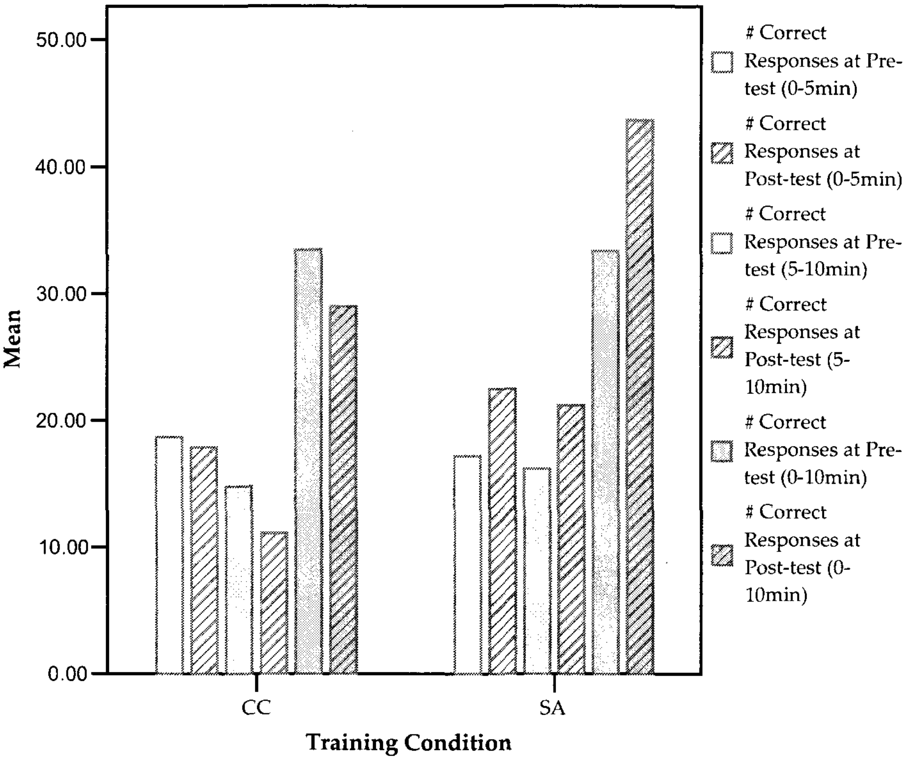
Alternating Attention (TEA-Ch Creature Counting subtest). Interestingly, a marginal main effect of treatment was found for this higher-order attentional component for correct responses F(1,17)=4.33, p=.053, f=.51 with children in the SA condition outperforming children in the CC condition at post-test for number of correct responses (Appendix F.1). While this effect was not significant at the conventional α=.05, it is significant at α=β=.19, and represents a large sized effect that can be detected with 80% statistical probability. Not surprisingly, there is a significant correlation between pre- and post-test performance, F(1,17)=11.55, p=.003, f=.83.

KiTAP

Parameters analyzed included correct responses, errors of commission (false alarms), errors of omission, mean and median reaction time, and standard deviation or variability of reaction time.

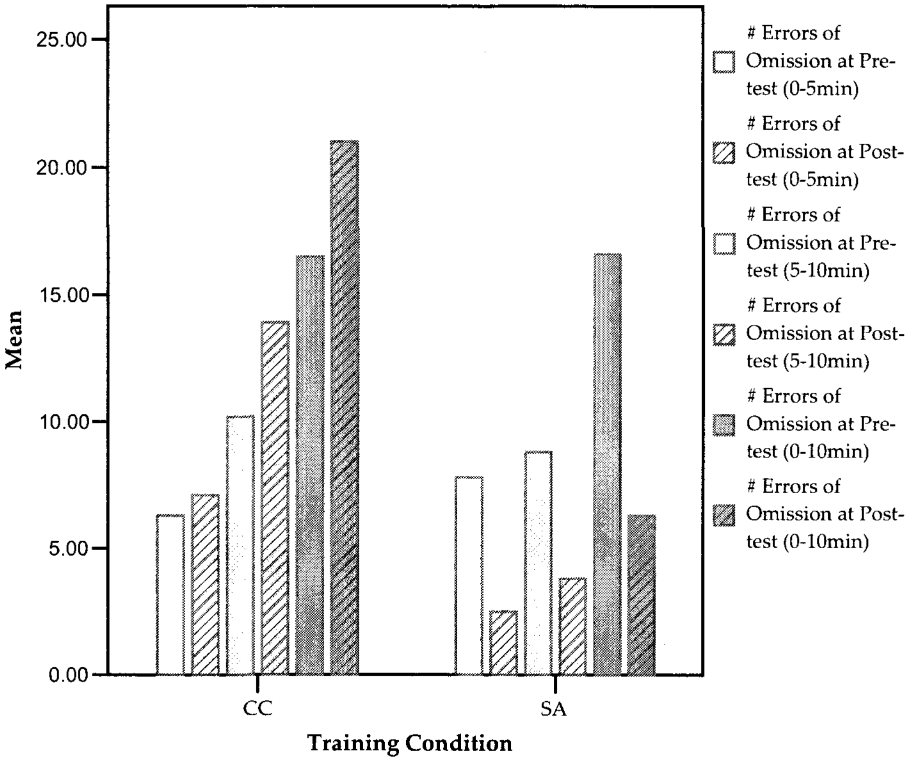
Visual sustained attention (KiTAP Ghosts' Ball). ANCOVA analyses revealed significant treatment effects on several *sustained attention* parameters. A main effect of training emerged for correct responses during the 0-5min interval F(1,17)=14.84, p=.001, f=.93, the 5-10min interval F(1,17)=40.42, p=.000, f=1.54, and overall F(1,17)=35.59, p=.000, f=1.45. Individual paired t-tests revealed that only the SA training group improved significantly on correct responses for the 0-5min interval, t(9)=-4.38, p=.002; the 5-10min interval t(9)=-4.84, p=.001; and overall trials t(9)=-6.68, p=.000 (Figure 5).

Figure 5. Pre- & Post-test Correct Response Performance for KiTAP Visual Sustained Attention (Ghosts' Ball Subtest)



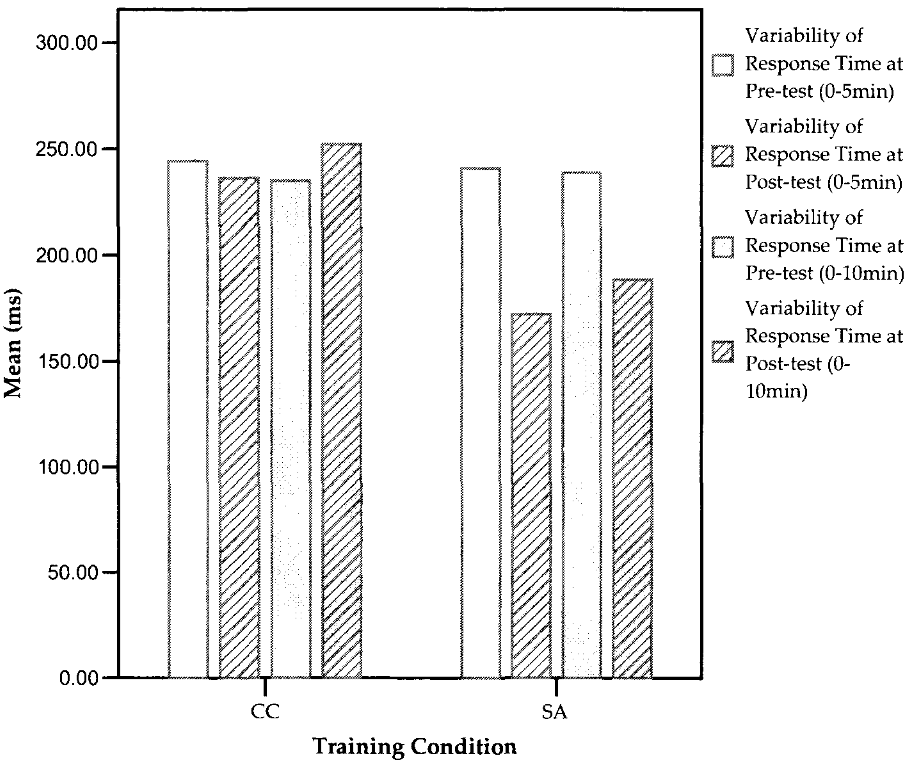
Similar effects were found for a closely related parameter, errors of omission, with identical F values to those noted above. Only children in the SA training group showed significantly reduced omission rates for the 0-5min interval t(9)=4.38, p=.002; for the 5-10min interval t(9)=4.84, p=.001; and for overall trials t(9)=6.68, p=.000 (Figure 6). Means, standard deviations, and t-scores are provided in Appendix F.2.

Figure 6. Pre- & Post-test Errors of Omission for KiTAP Visual Sustained Attention (Ghosts' Ball Subtest)



Last, a main effect of training emerged for variability of response time during the 0-5min interval F(1,17)=5.21, p=.036, f=.55 and overall F(1,17)=5.24, p=.035, f=.56. The rate of change for this parameter was marginally significant for the SA training group for the 0-5min interval t(9)=2.10, p=.065 and for overall trials t(9)=2.22, p=.054 but not for the CC group (Figure 7).

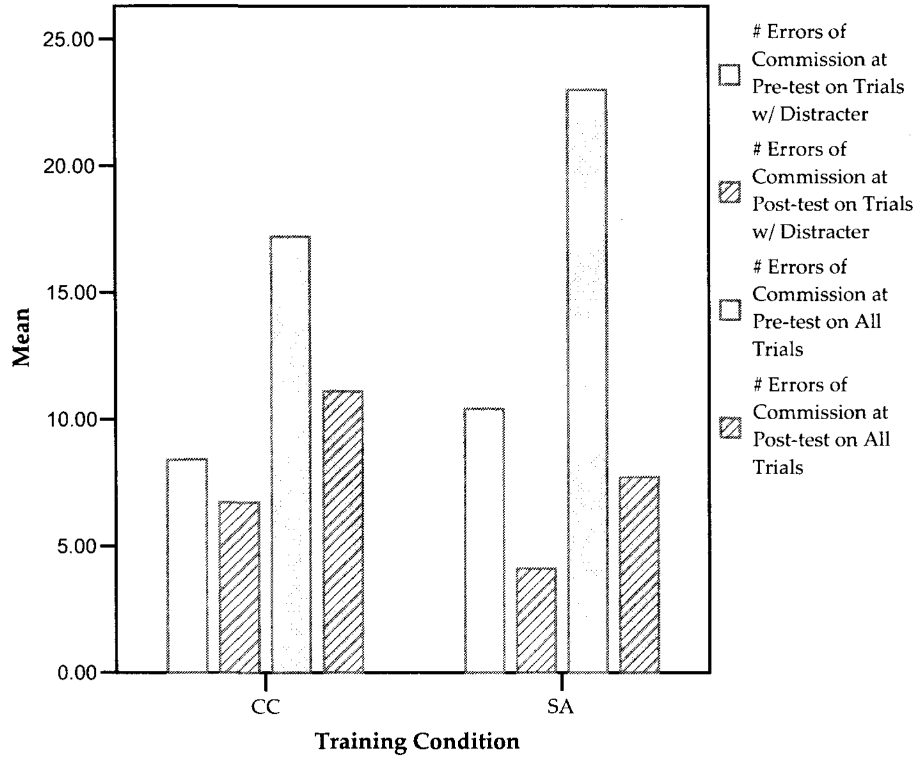
Figure 7. Pre- & Post-test Stability of RT (0-5min & 0-10min) for KiTAP Visual Sustained Attention (Ghosts' Ball Subtest)



In analyzing scaled scores for the 6-10 year olds in the sample, a main effect of treatment emerged for errors of omission F(1,12)=23.60, p=.000, f=1.40; such that the rate of improvement for the SA group positioned these children's post-test performance within the average range for similar-aged peers (M=48.63, SD=6.71 from M=35.12, SD=3.68), a change that was significant t(7)=-4.75, p=.002. In contrast, the CC group remained at pre-training performance on this parameter (M=31.57, SD=7.02 from M=35.42, SD=10.37).

Selective Attention (KiTAP Happy-Sad Ghost subtest). A main effect of treatment emerged on errors of commission for trials with distracter F(1,17)=10.00, p=.006, f=.77, and overall F(1,17)=8.27, p=.010, f=.70, and a significant correlation between errors of commission at pre- and post-test, for trials with distracter F(1,17)=9.15, p=.008, f=.73 and overall F(1,17)=10.08, p=.006, f=.77. Children in the SA training group improved significantly on trials with distracter t(9)=5.20, p=.001, and all children's changes were significantly different from zero for overall trials [SA group: t(9)=6.17, p=.000, and CC group: t(9)=4.62, p=.001], but significantly greater for the SA group (Figure 8).

Figure 8. Pre- & Post-test Errors of Commission for KiTAP Selective Attention (Happy/Sad Ghost Subtest)



Importantly, all children also made significant gains on errors of commission for trials without distracters t(19)=6.68, p=.000, however, the pattern of change is not significantly different between groups. Means, standard deviations, and t scores are provided in Appendix F.3 for errors of commission for trials with and without distracters, and for overall trials

Of note is that scaled performance for the younger children of the group parallels the above-noted findings for raw score performance. A main effect was found for scaled score performance for errors of commission on trials with distracter F(1,12)=6.01, p=.031, f=.71; specifically, children in the SA group had a greater rate of improvement (M=52.25, SD=7.98 from M=35.38, SD=11.81) at post-test than children in the CC group (M=45.71, SD=11.48 from M=40.43 SD=9.02). This improvement was significant t(7)=-4.98, p=.002.

Alternating Attention (KiTAP Dragon's Castle subtest). No main effects emerged on this hierarchically more complex subtest at the conventional α=.05. However, the change in performance for correct responses is significant in a compromise power analysis F(1,17)=2.89, p=.107, and represents a large sized effect, f=.41. Similar results emerge for errors of commission on this subtest F(1,17)=2.27, p=.150, f=.42. Not surprisingly, there is a significant correlation between pre- and post-test performance, for both correct responses F(1,17)=5.30, p=.034, f=.56 and errors of commission F(1,17)=5.46, p=.032, f=.57. It is important to note that while these findings may represent large-sized effects, the statistical probability with which they can be detected is somewhat lower than proposed at onset (i.e., 74% & 75% respectively). However, the trend for improved performance on a hierarchically more complex attentional component following lower-order sustained attention training is promising. In contrast to the performance of children in the CC group, gains exhibited by children in the SA group were significantly different from zero for both correct responses t(9)=-2.52, p=.033 (M Pre-test = 33.2, SD=10.39 vs. M Post-test = 40.1, SD=4.56) and errors of commission t(9)=2.33, p=.044 (M Pre-test = 7.40, SD=4.67 vs. M Post-test = 4.50, SD=2.27). [CC group correct responses performance at pre-test (M=34.90, SD=4.98) was similar to correct response performance at post-test (M=35.90, SD=9.06). This pattern was also observed for errors of commission at pre-test (M=6.80, SD=2.49) vs. errors of commission at post-test (M=6.30, SD=4.27)].

Divided attention (KiTAP The Owls subtest). No main effects of treatment emerged on this hierarchically more complex subtest. However, paired t-tests indicate that all children made improvements on parameters of divided attention, simply due to their participation in the study, for example, on correct responses (auditory trials) t(19)=-2.42, p=.026; omissions (auditory trials) t(19)=2.42, p=.026; errors (visual trials) t(19)=2.34, p=.030; correct responses (overall) t(19)=-2.38, p=.028; errors (overall) t(19)=2.65, p=.016; and omissions (overall) t(19)=2.38, p=.028.

Behavioural Measures of Attention & Executive Function (ADDES & BRIEF)

For the BRIEF & ADDES-3-SV analyses, one SA training group participant was removed due to the occurrence of a significant traumatic event between pre- and post-training assessments, which necessitated the use of two raters for these checklists. While inter-rater reliability is fairly good for both measures, anecdotal information suggested that the classroom behaviour of this young lady and her peers underwent significant changes during the interval between pre- and post-training sessions, which would inevitably have confounded teacher ratings of behaviour at post-test. As such, it was felt that the post-test indirect assessment would be an unreliable estimate of change, and hence is not included in the analyses. Behavioural or motivational changes were not noted in the daily individual sessions with the investigator, and as such the direct assessment data was not felt to be impacted. Results are reported based on an N of 19 for the indirect measures.

Attention Deficit Disorder Evaluation Scale (ADDES-3-SV). ANCOVAs revealed no main effects of treatment on Inattention or Hyperactivity parameters of the ADDES. Paired samples t-tests were conducted on these parameters to unveil any nonspecific effects of being part of the study. Although pre-test ratings were fairly high, all children were rated as improving significantly on Inattention raw t(18)=2.91, p=.009 and standard t(18)=-2.90, p=.010 scores and Hyperactivity raw t(18)=2.21, p=.040 and standard t(18)=-2.36, p=.030 scores, and overall Quotient t(18)=-2.79, p=.012.

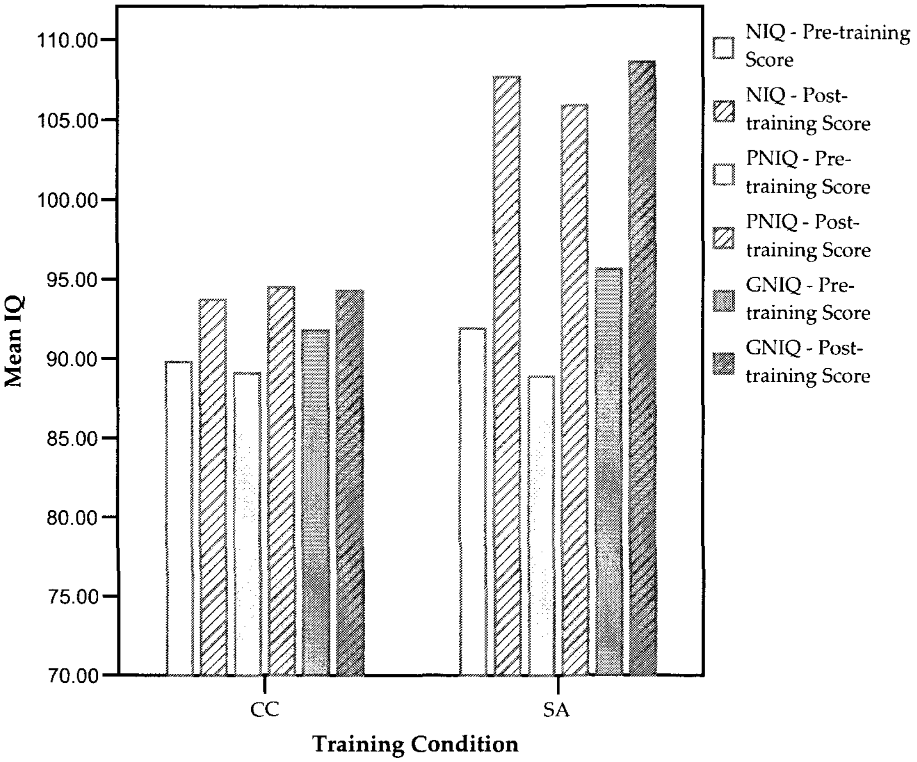
Behavioral Rating Inventory of Executive Functioning (BRIEF). Simple ANCOVAs revealed no main effects of treatment on BRIEF parameters. Paired samples t-tests were conducted on BRIEF parameters to unveil any nonspecific effects of being part of the study. Both groups showed significant improvements across multiple parameters for raw and standardized (T) scores. For example, significant improvement in classroom behaviour is reported by teachers on clinical scales for standardized scores: Shift t(18)=3.53, p=.002; Emotional Control t(18)=3.27, p=.004; Initiate t(18)=3.96, p=.001; Working Memory t(18)=4.66, p=.000; Plan/Organize t(18)=2.87; p=.010; and Monitor t(18)=2.73, p=.014..

Verbal and Non-Verbal Reasoning Measures (CTONI & KBIT2)

Comprehensive Test of Non-verbal Intelligence (CTONI). ANCOVA analyses on post-training performance with pre-training performance set as the covariate revealed a significant treatment effect on the CTONI: overall NIQ, F(1,17)=11.08, p=.004, f=.81; PNIQ, F(1,17)=12.06, p=.003, f=.84, & GNIQ F(1,17)=7.15, p=.018, f=.65 subtests (Figure 9).

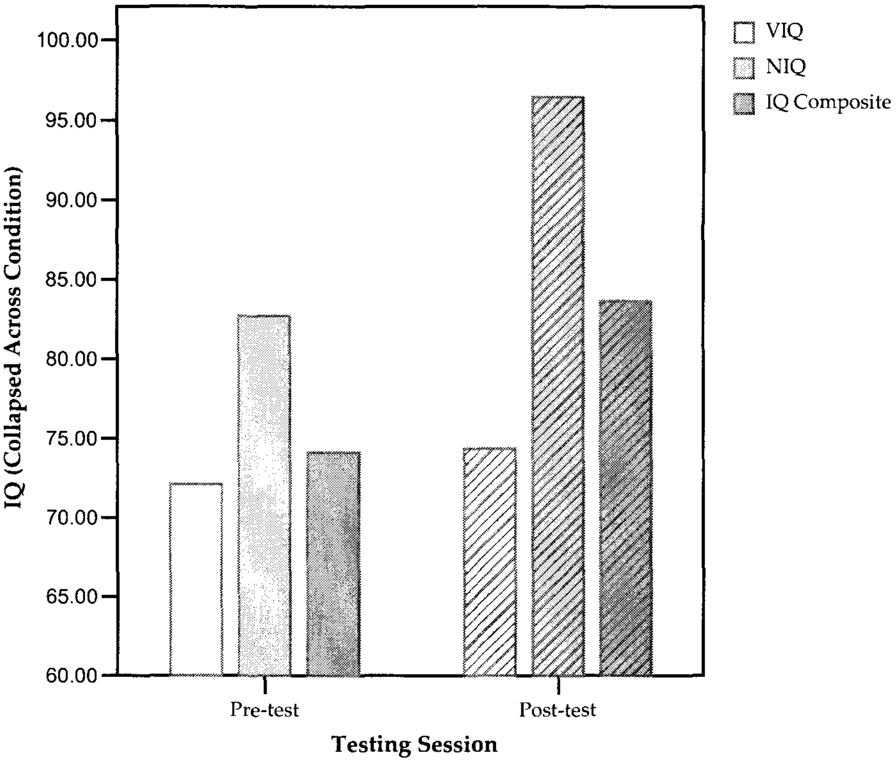
As predicted, a significant effect of pre-test performance was found on post-test performance, with overall NIQ F(1,17)=28.06, p=.000, f=1.29, PNIQ F(1,17)=29.54, p=.000, f=1.32, and GNIQ F(1,17)=25.67, p=.000, f=1.23. Paired t-tests revealed that while both groups improved on post-test performance, only in the SA training group was the improvement significant on the overall NIQ, t(9)=-7.84, p=.000, and PNIQ t(9)=-10.12, p=.000, & GNIQ t(9)=-5.41, p=.000 subtests. Means, standard deviations, and t scores are provided in Appendix F.4.

Figure 9. Pre- & Post-test Performance on Non-Verbal Reasoning Scales of the CTONI



Kaufman Brief Intelligence Test (KBIT2). ANCOVA analyses reveal no significant treatment effect on the KBIT2. Paired t-tests, however, reveal similar trends as those on the CTONI. Children made significant gains on the NIQ parameter t(19)=-4.57, p=.000 (and consequently on the overall IQ composite, t(19)=-5.32, p=.000) but showed no change on the VIQ parameter t(19)=-1.88, p=.075. Figure 10 displays performance collapsed across groups. While a training effect was not significant for the NIQ scale at the conventional alpha=.05, it was significant at the less stringent criterion, $\alpha=\beta<.191$, F(1,17)=2.08, p=.167, and represented a medium- to large-sized effect f=.35 (Table F4).

Figure 10. Pre- & Post-test Performance Collapsed across Groups on Verbal and Non-Verbal Reasoning Scales of the KBIT2



DISCUSSION

Pre-Training Analyses

Direct Measures of Attention

Sustained Attention (Auditory & Visual Modalities)

In keeping with previously reported results (e.g., Kerns et al., 1997), scaled scores on the TEA-Ch auditory sustained attention subtest revealed significant pre-training impairments in auditory sustained attention with children's performance falling 2 to 3 standard deviations below average for total correct responses. Similarly, while standard scores were not available for the older children for KiTAP subtests, T values calculated for the younger group (6-10yr olds) suggest that these children also have difficulty with visual sustained attention – as exhibited by below average performance for both errors of commission and errors of omission on the Ghosts' Ball subtest. Upon closer analysis of raw performance on this subtest, it appears that children's performance was proportional to the length of the task, deteriorating even further across the 5-10min interval, with significantly increased errors of omission, and consequently, decreased accuracy performance (as measured by the number of correct responses). In essence, it appears as though children underwent a performance decrement akin to that expected in vigilance paradigms (Zimmermann, et al., 2005). This is not surprising given the parallels between sustained attention and vigilance. In addition, children's median response times increased over the 5-10min interval of this task also indicating overall lowered vigilance in the latter trials, perhaps a loss of staying power that resulted in a decreased ability to maintain attention to task over the full 10 minute interval. These results parallel those of earlier findings (e.g., Streissguth et al., 1984; 1986; 1989; 1990). Similar to Connors and colleagues (1999), based on the available norms for the TEA-Ch and KiTAP, it appears that children in this group may have had more difficulty in the auditory modality (i.e., scoring between 2-3 SD below the mean for the TEA-Ch Code Transmission subtest) than in the visual modality (i.e., scoring between 1-2 SD below the mean for the KiTAP Ghosts' Ball subtest) for correct responses and errors of omission and commission.

Selective Attention

One of the most basic aspects of attention is the ability to intentionally maintain the focus of attention under distracting conditions. Children's selective attention was assessed under two types of task demands: 1) Scanning of concurrently presented stimuli in order to detect static targets among a sea of static distracters (under both child-paced and experimenter-timed conditions); and 2) Focusing on temporally presented stimuli in order to detect dynamic targets while ignoring temporally presented and constantly changing distracters. Under the first set of task demands (i.e., TEA-Ch subtests), children performed in the average range on their ability to detect targets for both self-paced and experimenter-timed subtests. However, they showed impaired speed of response, scoring poorly on the selective attention composite with scaled scores falling at least 2 standard deviations below average. At first glance, these results indicate impaired processing efficiency of selective attention and would be in keeping with earlier reports of impaired speed of RT (e.g., Nanson & Hiscock, 1990; Streissguth et al., 1984; 1986; 1994) and impaired selective attention for this population (e.g., Lee et al., 2004). However, when comparing self-paced and experimenter-timed performance, different profiles emerge with differential performance between these tasks that seem to have similar procedural demands: Impaired performance was noted only on the self-paced task. Several possibilities arise. The first possibility rests on an assumption that children were highly motivated to succeed on these tasks. As such, it is possible that children may have been overly cautious in searching for targets, spending more time ensuring they had "all of the *targets*" (as per instructions) on the child-paced subtest, which greatly increased their total time on task and consequently their time per target or speed of response score. In contrast, when asked to find "all of the *targets* they could see" during the 60s interval of the experimenter-timed subtest (thereby eliminating the task requirement of making a decision of when they have found "all of the *targets*" or of when to stop searching), children performed similarly to same-age peers. Alternatively, it is possible that children may have had trouble disengaging from the task, in essence showing perseverative-type behaviour on the self-paced measure. This suggestion would not be atypical of previously reported patterns of behaviour for both children with FASD (Coles et al., 2002) and animal analogues of FASD (Bell & Riley, 2006). Last, while this particular behaviour was not overt, it is possible that children had poor search strategy, such that instead of searching systematically they searched randomly, meandering through the targets and distracters, thereby increasing total time on task.

In addition, poor performance was evident under the second set of task demands (i.e., KiTAP Distractibility subtest), particularly for errors of commission on trials with and without distracters, and consequently, on overall trials. This effect was confirmed by significantly below-average T scores for the younger group of children. An increase in false alarms on overall trials would indicate that children had difficulty recognizing centrally presented targets under temporal and dynamic conditions, and instead responded according to their guess (Zimmermann, et al., 2005). Moreover, it was clear that the presentation of distracters added another layer of difficulty, such that on trials with distracters children had significantly more errors of omission, less correct responses, and increased mean and variability of response times. The higher number of misses on trials with distracters over trials without distracters indicates that this group was prone to distractibility. However, based on the scaled performance of the younger children for overall trials (i.e., impaired scores on errors of commission, yet average scores on errors of omission and median response times), it is possible that there may have been within-group differences between younger and older children. It is also possible that children's difficulty may have been due to the need to discriminate between rapidly presented targets that required a substantial degree of local processing (i.e., children were required to discriminate between a smile and a frown on the face of a ghost), an interpretation that would be consistent with some reports that children with prenatal alcohol exposure are more impaired in local than global processing of visual stimuli (Mattson, Gramling, Delis, Jones, & Riley, 1996).

Last, although significant between-group differences at pre-test were not expected, a difference emerged for median response times on this subtest. Children in the SA group had significantly faster median response times than children in the CC group. Interestingly, scaled scores from the younger subgroup indicate that the SA group scored almost 2 standard deviations below age-appropriate norms for errors of commission and over 1 standard deviation above the mean for median response times; whereas CC children scored a little over 1 standard deviation below the mean for errors of commission and right at mean for median response times. This indicates that overall, children in the SA group were somewhat more impulsive at pre-test than children assigned to the control group, and thus scored more poorly on this subtest overall.

Alternating Attention (Flexibility and Attentional Control)

A hierarchical theory of attention would predict that lower-order attentional components would have to be intact for unimpaired processing on hierarchically higher-order components (e.g., Sohlberg & Mateer, 1987). Based on children's performance on sustained and selective attention subtests, it was expected that alternating attention (and divided attention) would be impaired. This is in fact the case, with children showing significant impairments on tests of visual attentional control (TEA-Ch Creature Counting) and mental flexibility (KiTAP Dragons' Castle), results which are also consistent with previous findings (e.g., Coles et al., 1997). On the former subtest, which combines simple skills of counting up and counting down under explicit conditions to "switch" cognitive sets, children scored almost 2 standard deviations below average. Similar results were found on the mental flexibility subtest, on which children showed high errors of commission; a possible indication of impulsive responding. Interestingly, children's median RT performance was fairly typical, further supporting the possibility that in their zest to maintain quicker RTs, children's performance succumbed to a speed-accuracy trade-off. In this case, poor performance would be indicated either by slowed response times and accurate performance, or, as is evident with this group, an increase in false alarms and faster responding.

Divided Attention

Findings on the divided attention subtest are in keeping with previously reported findings (e.g., Connor et al., 1999; Kerns et al., 1997) in that children show deficits in divided attention. However, despite indication on other subtests that these children are prone to increased errors of commission (i.e., previous subtests of distractibility and flexibility), younger children showed fairly typical rates of false alarms on this subtest. Instead, children exhibit increased errors of omission, the younger subgroup falling within 2 standard deviations below the norm. In trying to differentiate performance between auditory and visual trials, it was evident that children had much more difficulty with auditory targets. All children made significantly fewer correct responses and had more errors of omission on auditory than visual targets. Interestingly, median response times appear to be in the average range (at least for the younger children). Thus it appears that children were either dedicating far more effort on the visual targets to the detriment of the auditory critical stimuli, or alternatively, they had a much easier time processing visual targets and *ignored* the auditory targets. Interestingly, these results support the earlier noted findings between TEA-Ch auditory and KiTAP visual sustained attention subtests.

In sum, pre-test results on direct measures of attention suggest that this sample of children with FASD had significant impairment across both auditory and visual sustained attention, experiencing greater difficulty across the auditory modality and with increasing task demands – both in terms of duration and complexity. While difficulties across the selective attention component were not substantial, at least as assessed within fairly short tasks (e.g., 2-3min), these children were prone to distractibility and had significant difficulty with alternating and divided attention tasks. These effects were seen through decreased rates of correct responses and increased rates of errors of commission on lower order attention tasks such as sustained and selective attention – particularly the distractibility subtest, and on alternating attention tasks. However, on a task that required simultaneous processing of information across two modalities (i.e., divided attention test), children were more prone to errors of omission. Some of the pre-test results were in keeping with previously reported findings, for example a much greater impairment across auditory than visual tasks (e.g., Connor et al., 1999; Kerns et al., 1997). Interestingly, however, in contrast to previous reports of impaired processing speed (e.g., Streissguth et al., 1994), this group of children did not exhibit greatly impaired processing speed. Aside from impaired speed of response or efficiency of selective attention on the child-paced subtest of the TEA-Ch, children had fairly typical median response times on all KiTAP subtests, including the more difficult divided attention and flexibility subtests. While these interpretations are based solely on the younger subset of children due to the availability of their norms for the KiTAP, they are somewhat confirmed by typical performance on the experimenter-timed selective attention subtest of the TEA-Ch. These findings are in direct contrast to earlier reports that have reported impaired task performance either through RT or externally imposed time restrictions for children with prenatal alcohol exposure (e.g., Jacobson, 1998; Kable & Coles, 2004). These results could be due to children's being overly cautious when required to make a self-determined assessment of performance, and could potentially indicate perseverative -type behaviour in a situation that did not support external cuing (Mattson et al., 2002).

Last, while variability of response times was calculated for all KiTAP attentional components, appropriate norms are not available to support definitive conclusions of impaired performance on this parameter. While analyses of the performance of the younger subgroup indicate some difficulty with this parameter on the flexibility subtest [i.e., T scores in the low average (M=41.87, SD=12.60) and a wide range of performance ($21 \geq T \leq 58$)], it is difficult to confirm earlier findings of high variability of RT for children and individuals with prenatal alcohol exposure (e.g., Connor et al., 1999; Kerns et al., 1997; Streissguth et al., 1994). Given the wide range of performance in the current sample, follow-up work would be needed to unveil the differences, if any, between children who scored poorly and children who scored in the high average range on this parameter. For example, children with hyperactivity (Cohen & Douglas, 1972) and children with ADHD (Seidel & Joschko, 1990) have been reported to exhibit increased variability of RT. As previously noted, attention deficits and hyperactivity are common findings in the profile of FASD (Chudley, et al., 2005). Hence, while not evident from previous studies, it may be that hyperactivity was a significant part of the profile of FASD individuals who exhibited high variability of RT (e.g., Connor et al., 1999; Kerns et al., 1997; Streissguth et al., 1994). Should this be the case, these samples would differ from the current study, in which hyperactivity was not a significant part of these children's profiles, a finding similar to that of Brown and colleagues (1991).

Behavioural Measures of Attention and Executive Function

Teacher ratings on the ADDES are somewhat contradictory to results from direct measures of attention and teacher ratings on the BRIEF. Scaled scores from the ADDES-3-SV suggest that while many individual children were rated as inattentive, overall, this group of children is not seen as particularly inattentive or hyperactive-impulsive. In fact, scaled performance indicates that only 1 child was rated by teachers as being hyperactive-impulsive. While it is possible that these values may reflect cultural differences for this population, particularly in relation to the perception of childhood appropriate behaviour, experimenter observations during training and testing sessions confirmed that most of the children had little difficulty with behavioural hyperactivity.

However, in contrast to teachers' perceptions on the ADDES, direct measures of attention and impulsivity indicate that children did show difficulty in these domains.

Contrasting the ADDES ratings, teacher ratings on the BRIEF confirm results from direct measures of attention (e.g., TEA-Ch & KiTAP), identifying, for example, deficits in working memory. While working memory and the ability to sustain attention may at times be conceptualized as distinct constructs, behavioural outcomes on these two domains are difficult to distinguish (Gioia et al., 2001). For example, in the empirically-based development of the BRIEF, the two original subscales of Sustain and Working Memory overlapped significantly (r=.96), suggesting that these two groupings of items were tapping the same behavioural function. As such, the items that comprised these two scales were unified into one: Working Memory (Gioia et al., 2001). These ratings are also in keeping with previously reported findings indicating working memory deficits in children with FASD (e.g., Carmichael Olson et al., 1998; Jacobson, Jacobson, Sokol & Ager, 1998; Streissguth, Barr, & Sampson, 1990).

Importantly, similar to wide spread reports of executive functioning deficits caused by prenatal alcohol exposure (e.g., Kodituwakku, 2007), T scores indicate ratings in the clinical range for all executive functioning parameters of the BRIEF (Gioia et al., 2001), including children's ability to inhibit or control impulses; to shift or alternate attention between situations, activities, and concepts, contributing to problem solving flexibility; to initiate a task and generate ideas; to hold information in mind in order to complete a given task; to plan and organize activities or future events; to organize their workspace; to assess their own performance or keep track of their own behaviour during a given task and ensure that a certain goal is attained.

Interestingly, children's ability to inhibit behaviours as rated by teachers on the BRIEF indicated significant impairment in this domain, while ratings on the hyperactivity/impulsivity scale of the ADDES did not. While in the cognitive developmental literature there exists a distinction between cognitive inhibition (e.g., resisting spreading activation when reading and thus sustaining attention and focus to task) and behavioural inhibition (e.g., suppressing a prepotent response such as motor inhibition and impulse control), it is unclear whether this distinction represents separate types of inhibition or a common underlying inhibitory function (Kipp, 2005). What is clear is that these constructs are related, and often times, cognitive inhibition mediates behavioural control or regulation (Mischel et al., 1989). Moreover, dysfunction in either one of these domains can result in similar observable behaviour, such that ultimately, poor observed inhibition is marked by poor impulse control. Thus, items assessing the ability to inhibit behaviour (e.g., BRIEF) and items assessing the ability to resist or control impulses (e.g., ADDES) should be measuring the same construct. Nonetheless, results on these two subscales varied.

It is important to note hat the content of the two subscales differ somewhat. The ADDES includes a high number of motoric hyperactivity markers (e.g., moves about while seated, fidgets, squirms, etc; hops, skips, and jumps, when moving from one place to another instead of walking; becomes overexcited and loses control in group activities, becomes loud, etc.) along with impulsivity markers (e.g., does not follow rules of the games; blurts out answers without being called on; does not wait his/her turn in activities or games). This subscale taps into both cognitive and behavioural inhibition and behavioural hyperactivity - hence labeled hyperactivity-impulsivity. Perhaps more appropriately, impulsive behaviours, as caused by poor cognitive or behavioural inhibition, should be differentiated from motoric hyperactivity. Indeed, in previous work, teacher ratings of inattention and impulsivity behaviours are separated from motoric hyperactivity (Kerns et al., 1999). As noted previously, the latter did not seem to be a problem for the current subset of children even during daily interactions with the experimenter, a finding similar to that of Brown and colleagues (1991). In contrast, the BRIEF inhibit subscale, taps behaviours due to poor inhibition predominantly (e.g., does not think before doing; interrupts others; is impulsive; gets out of seat at the wrong times; talks at the wrong times; does not think of consequences before acting; has trouble putting the brakes on his/her actions). While the authors describe this construct as a behavioural regulation function (i.e., they do not discriminate between cognitive and behavioural inhibition; Gioia et al., 2000), even a cursory reading of some of these markers would indicate a perception of thought mediated action on the part of the child, as opposed to simple hypermotoric activity. For example, "talks at the wrong times" would indicate a relative understanding of right vs. wrong time to talk, an ability to recognize the urge to talk, and an ability to inhibit the urge to talk, as opposed to "moves about, fidgets, and squirms", which indicates hyperactive motoric behaviour exclusively. Poor behavioural inhibition ratings on the inhibit subscale of the BRIEF are consistent with findings from the KiTAP selective and alternating attention subtests. Namely, children had significant errors of commission on these subtests, indicating poor inhibition of prepotent responses (i.e., responding to a happy vs. sad ghost, or a blue vs. a green dragon).

Additional contrasting results between the two checklists (e.g., on the inattention subscale of the ADDES and subscales of the BRIEF that encompass attentional constructs – such as working memory, monitor, inhibit) may be due to the rating requirements specific to each measure. For example, the ADDES checklist requires teachers to respond on a 6-point scale: 0) Behaviour not developmentally appropriate for age; 1) Behaviour not observed; 2) Behaviour observed one to several times per month, 3) Behaviour observed one to several times per week, 4) Behaviour observed one to several times per day, and 5) Behaviour observed one to several times per hour. Instructions are quite clear that behaviours must be observed by the raters. Given that half of these children were scored at the beginning of the school year, it is possible that many of the behaviours that were rated as not observed were simply not yet observed (instead of not an existing behaviour) because the teacher was not all that familiar with the student – and still in the "honeymoon" phase (according to one teacher's comments). While some teachers had a familiarity with the students, other teachers were first year instructors, and while some leeway was granted for filling out the checklists, all were collected within 3 weeks from the first point of contact with the student (and at post-test, within 3 weeks of the final training session). This issue relates to a tendency for teachers to give students the "benefit of the doubt" and results in loss of discriminative power for this checklist (McCarney & Arthaud, 2004).

In addition, anecdotal information suggests that teachers may have had difficulty with rating some of the behaviours as not developmentally appropriate for age instead of a more appropriate quantifier (e.g., not developmentally appropriate given an FASD diagnosis). Specifically, the school where the current intervention took place has implemented a *pod* system for all children, primarily due to the need to accommodate the learning needs of a very high number of children on the fetal alcohol spectrum in this community. Administrators and most of the teachers in this school have participated in FASD specific in-service sessions and are familiar with the challenges associated with this disorder. As such, children are assigned to grades based on individual ability or developmental level instead of age. For example children with FASD assigned to one grade 1 classroom ranged in age from 6.8 to 8.9 years of age, depending on the level and adaptive behaviour of each child. As such, questions of age-appropriateness may have sometimes been interpreted relative to the child's diagnosis or classroom placement. Thus a rating of not developmentally appropriate for an item such as "Loses place when reading" may indicate age-appropriateness for the 6-year-old first grader with (or without) FASD, but diagnosis related developmental appropriateness for the almost 9-year-old first grader with FASD. A high number of 0 and 1 responses would have decreased scaled scores on the attention and hyperactivity/impulsivity subscales, scores that are standardized according to age related data and not developmental delays due to FASD diagnosis.

In contrast, the BRIEF requires answers on a 3-point scale: N) The behaviour is never a problem; S) The behaviour is sometimes a problem; O) The behaviour is often a problem. While teachers may give children the "benefit of the doubt", they are forced to choose within a much more narrow range of options. Additionally, in contrast to the ADDES, BRIEF questions do not ask teachers to rate behaviours observed directly in the educational environment. Given that this was a very small and close knit community many of the teachers had ongoing daily contact and interactions with children outside of the school environment and would have likely received feedback from other teachers and community members about the behaviour of particular children. A case in point is the example of one young girl whose classroom teacher was also her temporary foster caregiver. As such, ratings on the BRIEF teacher scale may have been more influenced by overall knowledge of the child's behaviour.

Verbal and Nonverbal Reasoning

This sample of children varied greatly in intelligence on both the CTONI and the KBIT2. As expected in this culturally unique population, children performed better on non-verbal reasoning measures than verbal reasoning subtests, with performance on the CTONI NIQ in the average range. Verbal and composite score performance on the KBIT2 fell well below average. While between-group differences in verbal and non-verbal reasoning performance were insignificant, within-group variation was fairly large. These results are in keeping with previously reported data that indicates the mean IQ for children with FASD to be around 70, with a broad range between 20 and 120 (e.g., Mattson & Riley, 1998). While the current range is not quite as broad as previously reported (i.e., 50-107 depending on the measure utilized, CTONI or KBIT2), the mean falls on par with that reported in the literature for the KBIT2 (74.5) but higher for the CTONI (94). While earlier research indicates that verbal and nonverbal abilities in children with FASD may be discrepant (Mattson & Riley, 1998), it is possible that issues with cultural sensitivity for the KBIT2 in this population, particularly with regard to Verbal Reasoning, may be a confounding factor in these results. If so, a low mean on the KBIT2 Composite may in fact represent cultural differences between the current sample and standardization groups rather than true differences related to FASD. This is not an issue specific to the KBIT2, but, as previously noted, rather an intrinsic difficulty of currently available intelligence measures and any measures other than those that target basic processing across various cognitive dimensions.

IQ is generally a variable of interest particularly when working with children with FASD who often exhibit normal IQs and impaired adaptive behaviour, executive functioning, and social skills. While it is evident that the impairments of children with FASD go beyond what can be explained by low IQ (e.g., Thomas, Kelly, Mattson, & Riley, 1998), intelligence seems to be a moderating variable. For example, greater impairments have been reported in nonverbal fluency for individuals of low-IQ (Kerns et al., 1997) and executive functioning impairments seem to be mediated by decrements in intelligence (Connor, Sampson, Bookstein, Barr, & Streissguth, 2000). While planning for IQ as an additional independent variable was not plausible within the current design given the size of this sample, exploratory analyses will be undertaken in future work to assess the effects of this variable, on both pre- and post-test performance of average- and below-average-IQ children. It would be interesting to note whether current findings will be in keeping with previously reported results, for example on parameters of variability of RT. It would also be particularly interesting to assess whether or not low-average-IQ children with FASD benefit to the same degree from intervention as average-IQ children with FASD, presuming that both groups are equally impaired on attentional processing.

Post-Training Analyses

Direct Measures of Attention

Performance Changes in Sustained Attention (Auditory and Visual Modalities)

Significant improvements in auditory sustained performance were observed for children who underwent SA training. Scaled score performance on the Score and Code Transmission subtests of the TEA-Ch indicates that these children scored in the average range for overall correct responses at post-test, similar to typically developing peers. In fact, on the Code Transmission subtest, scaled changes for the SA group reached clinical significance (Manly et al., 1999). While scaled score performance is not available for the two phases of this subtest, raw performance indicates that these improvements were significant during both the 0-7min and 7-14min intervals of this task. In contrast, performance of children in the CC condition did not change between pre- and post-test for auditory sustained attention.

Similar findings emerged on the visual sustained attention subtest of the KiTAP. Improved performance was noted differentially for the SA training group on parameters of correct responses and errors of omission (overall and across the 0-5 and 5-10 min intervals of the Ghosts' ball subtest) and for variability of response time during the 0-5min interval and overall. Subsequent to SA training, children were able to make more correct responses, less errors of omission, and have more stable RTs. In analyzing the scaled results of the younger subgroup of children, results are consistent with those on the auditory sustained attention task: SA children's scaled performance at post-test fell in the average range compared to similar-aged peers (6-10 year olds) for errors of omission; and although a main effect of training did not emerge for this parameter, this was also the case for errors of commission. These results indicate significant gains, given pre-test performance of almost 2 SD below average norms. In contrast, following CC sessions, children's performance on correct responses and errors of omission remained at pre-test levels.

Performance Changes in Selective Attention

Improvements in performance related to training were observed on the self-paced visual selective attention subtest of the TEA-Ch. An analysis of scaled performance of the younger subgroup indicates that SA children's post-test performance fell in the typical range for their age group for speed of response or the selective attention composite. It is noteworthy that while training selective attention was not the aim of the current intervention, some of the visual sustained attention training tasks of *Pay Attention!* (i.e., the house search) and the more difficult tasks from the Big Book of Search and Find, did in fact utilize similar processing demands as the sky search and map mission subtests of the TEA-Ch subtest. For example visual search activities are considered as training activities for visually sustaining attention and a similar (albeit hierarchically more demanding) task for selective attention would include a similar search task with added distracter stimuli (e.g., distracter sheets in the form of visual overlays). Thus, while these specific TEA-Ch subtests were not trained directly, there was an expectation that skills learned while sustaining attention to visual search tasks would transfer to these TEA-Ch activities. Improvements on the experimenter-timed task were not significant, likely due to the fact that children's performance was within the average norms at pre-test. Interestingly, however, previous attention training work with the *Pay Attention!* materials demonstrates that children with dyslexia improved in attentional parameters following attention process training, even when not showing impairments across attentional components at pre-test (e.g., Chenault, et al., 2006). Most likely, the current finding is related to task demands of this TEA-Ch subtest; perhaps impacted by fine-motor capacity.

More importantly, improvements in selective attention following SA training were noted on the KiTAP distractibility subtest, which employs significantly different task demands than those of the training activities. Children are required to respond to rapidly presented central targets while ignoring distracter stimuli. The central stimulus, a sad or happy ghost, was designed such that the distinction between the two can be made only by focusing centrally. Distracters appear immediately before the target stimulus, such that only one saccade may potentially be directed to the distracter before the appearance of the discriminative stimulus. Presentation of the latter is very brief, and if focus is off-centre, the target stimulus generally disappears before re-fixation is possible. Shifting attention from peripheral distracters to the target stimulus creates increases in either omissions (misses of the target) or commissions (false alarms) of the target. While at pre-test children had greater difficulty on trials with distracters, a significant effect of training was found for errors of commission on these trials at post-test. While overall all children improved on this subtest, children in the SA training group made significantly less errors of commission on trials with distracters, an effect that was also evident for scaled score performance. This change caused the SA training group (at least the younger children) to reach average performance in relation to similar-aged peers. In addition, SA children's RT increased at post-test whereas the RT of the CC group remained the same. While generally this may not be viewed as a positive finding, recall that at pre-test SA children (as interpreted from the younger group's T scores) had scored well above average on scaled speed of response (M=61.38) whereas children in the CC group had scored right on target (M=50.29). In essence, it appears that at pre-test children in the training condition were responding very quickly, either unaware of the impact of speed on performance or perhaps somewhat impulsively. A slowed RT at post-test would indicate either improved impulse control or a change in strategy, whereby children realized that by slowing down their response times they would improve their test performance. This in fact was the case as evidenced by decreased errors of commission and decreased distractibility.

Importantly, children were not directly taught explicit strategies during the SA training sessions. However, many of the examiner-paced sustained attention training tasks that required a rapid response depended on the ability to withhold a response until ensuring that the appropriate target had been presented. Repetition of these tasks and ensuring that children reached a criterion of performance before moving on to more difficult tasks, perhaps indirectly encouraged children to internalize particular strategies – such as slowing their response times – in order to respond successfully. Thus, it appears that training effects occurred simply through repeated practice of training tasks, or repeatedly stimulating the attentional function. Similar beneficial effects of stimulation without explicit instructions for strategy use were found in other populations such as adults with TBI (e.g., Robertson, Tegner, Tham, Nimmo-Smith, 1995; Sturm et al., 1997), and children with ADHD (Kerns et al., 1997).

Performance Changes on Higher-Order Attentional Components (Alternating and Divided Attention)

There was no significant change in performance for either the SA or CC group for higher order divided attention subtests. However, a notable finding was a large sized effect of training for accuracy performance (i.e., total number of correct responses) on the attentional control subtest of the TEA-Ch. While this effect was only marginally significant at the conventional α (.053), it was significant at the more unconventional level (α=β=.19), and represents a large sized effect that can be detected with significant statistical probability (80%). That is, children in the SA training condition had greater gains in the number of correct responses at post-test than children in the CC condition, on the Creature Counting subtest. In parallel, large sized effects of training were also observed on the alternating attention subtest of the computerized KiTAP (the Dragon's Castle), namely for gains on number of correct responses and decreases in errors of commission. These effects were only significant at the less stringent α level and the statistical probability with which they can be detected is somewhat lower than ideal (i.e., 74% & 75% respectively).

However, the trend for improved performance on this hierarchically more complex attentional component following lower-order sustained attention training is promising. These tests tap into the ability to sustain attention to task while holding and manipulating information (working memory) and shifting cognitive set as necessary. This effect should not be entirely surprising given that the ability to sustain attention is a necessary component of higher-order attentional processing (Manly et al., 1999) and that from a behavioural outcome perspective, sustained attention has been equated with working memory (e.g., Gioia et al., 2001). Importantly, congruent findings on the TEA-Ch and KiTAP subtests suggest that while these subtests are both purported to tap into a similar underlying construct (i.e., alternating attention), there seems to be generalizability of training effects to two different task demands (i.e., switching the direction of counting vs. flexibility in responding to colour and position targets; working within an examiner delivered task vs. a self-administered computerized task).

Behavioural Measures of Attention and Executive Function

Given fairly average ratings by teachers on the ADDES at pre-test, the absence of training effects on this measure were not surprising at post-test. However, training effects were expected for teacher ratings on the BRIEF, especially for parameters that depended heavily on sustained attention (e.g., working memory). Surprisingly, teachers rated children in both SA and CC groups as having made significant gains at post-test on both attention and hyperactivity/impulsivity scales of the ADDES and on several parameters of the BRIEF (e.g., Shift, Working Memory). While teachers knew that children were participating in an intervention study, they were blind to status of each child (SA or CC). They knew that some children should have improved on attention behaviours and some may not have. As such, these findings cannot be explained by a possible halo effect where teachers expected children to improve regardless of specific or non-specific training.

It is possible, given the uniqueness of this sample and of this community that these findings indicate actual improvement in classroom behaviour. As a natural consequence of this type of work, simple behavioural management techniques (such as redirecting children to task, reinforcing appropriate behaviour, etc) had to be utilized on a consistent and individual basis with all children. Throughout the course of sessions all children received consistent positive reinforcement for their behaviour and for "working hard". Children received both verbal praise (such as "you did a great job today") and tangible rewards (stickers) on a daily basis, and at the end of the study all children received a treat bag. All personal observations and anecdotal information from teachers, parents, other professionals, and children's peers (who all wanted to "do work too") indicates that children enjoyed the sessions and thrived on the personal attention. Somewhat unexpectedly (based on prior experience with taking children out of the classroom for one-on-one work), children could not wait for their daily session (for example, it was common for children to ask the examiner if they could come out again in the afternoon, following a morning session). Instead of feeling like they were different from the rest of their classmates for having to engage in these sessions, children felt *special.* It is possible that these daily activities, consistent and individualized attention, and consistent behavioural feedback, may have overshadowed any specialized training effects on behaviour and resulted in nonspecific behavioural improvements simply through their interaction with the researcher.

While these results are not particularly helpful for the current purpose of identifying whether the effects of training generalized to the classroom environment, they do have some ecological significance. Specifically, if teachers perceive children as behaving better, they are more likely to note or reward the improved behaviour and hence strengthen a reciprocal relationship that is based on positive reinforcement. In turn, establishing a positive classroom climate is widely advocated for developing a supportive learning environment for students with FASD (e.g., Alberta Learning, 2004).

Verbal and Nonverbal Reasoning

Perhaps the most noteworthy findings were those of improved performance on a measure of non-verbal reasoning for the SA training children. These findings were confirmed on a measure that is widely utilized in this Northern population, but a similar trend was also observed on a commonly used intelligence screening instrument. Similar improvements were noted following attention training in a group of patients with diffuse traumatic lesions (Sturm, Dahmen, Hartje, & Willmes, 1983; cited in Sturm et al., 1997), for both verbal and nonverbal intelligence tests. In addition, effects are consistent with findings of improvement on non-verbal reasoning ability following working memory training in children with ADHD (Klingberg et al., 2005), and following attention process training in typically developing children (Rueda et al., 2004), results that support the hypothesis that sustained attention and working memory is necessary for reasoning ability (e.g., Engle et al., 1999). It could be argued that these effects may not have ecological validity, in that they do not signify improvements within the child's environment or day-to-day adaptive behaviour. However, many educational decisions are based on psycho-educational assessments of children utilizing standardized measures (unfortunately, even those not standardized with the population in question). In general, this sample of children was neither hyperactive nor oppositional defiant. Testing sessions relied on standardization instructions and appropriate assessment guidelines were followed (e.g., Sattler, 2001), without the added difficulty of dealing with temperamental factors such as non-compliancy or hyperactivity or other physical factors. Overall, it was felt that aside from issues of cultural sensitivity (which would have remained constant between pre- and post-test) IQ performance would have depended heavily on neuropsychological factors, such as limited attention span, limited reasoning ability, limited ability to grasp concepts needed for solutions, poor memory, and other cognitive or neuropsychological deficits (Sattler, 2001). While comprehensive neuropsychological assessments should tease apart attentional deficits from an impaired ability to grasp concepts needed for solutions (for example), what is preached is not always practiced for a variety of reasons, including limited time, fiscal, and human resources. Such a significant improvement in non-verbal reasoning performance following attention training would suggest that we may need to dig a little deeper behind the observed non-verbal reasoning performance for children with FASD. It may be that observed deficits may be explained in part by attentional deficits, which can be targeted for intervention.

Conclusions

Improved performance was noted following attention process training on untrained neuropsychological measures of attention and related cognitive functioning above and beyond the effects provided by supportive contact within an academic environment. As such, core hypotheses that guided this research were supported. Specifically, benefits of sustained attention training were evident on untrained sustained attention measures, including basic capacities required to sustain attention such as increased focus and increased tolerance for distracters. For example, significant training effects were evident across direct measures of attention that included both sustained and selective attention. A surprising effect was that sustained attention training also influenced tasks that required greater cognitive manipulation of information and that can be considered higher order, or executive functioning (e.g., alternating attention). Based on findings in previous work with individuals with TBI (see Sohlberg et al., 2003), these effects were not expected. Rather, it was predicted that for alternating attention tasks to change, alternating attention itself would have had to be trained, given the greater cognitive manipulation required for those tasks. While it is clear that sustained attention would be required to complete tasks that placed a great demand on shifting attention and flexibility, it was felt that the higher order demands would far outweigh any benefits gained from sustained attention. However, this finding is in keeping with a hierarchical theory of attention which posits that higher order processing is dependent on intact lower-order processing.

Based on previous work with individuals with TBI (see Sturm et al., 1997), children with ADHD (e.g., Klingberg et al., 2005) and typically developing children (e.g., Rueda et al., 2004), it was expected that sustained attention training would influence relevant non-verbal reasoning behaviour. These measures depend not only on higher order reasoning ability, but also on the ability to sustain attention throughout a testing session and avoid lapses in attention. As predicted, these effects did not generalize to verbal processing measures, or more crystallized types of intelligence.

While it appears that direct attention training may be beneficial for children with FASD, the reason behind these changes is not explicit. It is possible that these changes may be due to improved attentional capacity, or alternatively, to internalizing strategies for regulating attention and arousal (Kerns et al., 1999). That attention could be voluntarily controlled through self-instructional procedures has been suggested previously, with work with impulsive children (Reid & Borkowski, 1987). In fact, an effect observed in the current work that would support this notion is the significant increase in RT (to average levels) concurrent with improved performance on correct responses for children in the SA training group. While children were not explicitly taught a strategy to slow-down their responses in order to better process critical targets, it appears that they may have spontaneously adopted this practice over repeated training sessions. This effect was only evident on one of the subtests, but interestingly, it was the subtest where children had initially shown impairments in RT, responding too quickly to targets and hence having increased errors. The alternative of training self-instructional strategies should be explored in future research, particularly in conjunction with attention training.

While the effects observed in the current study were fairly large, it is difficult to generalize these results too widely for a number of reasons. First, as previously discussed, this sample of children with FASD was selected from a unique community, from a unique northern population, with unique strengths and challenges. As such, these children will have adopted a unique learning and adaptive behavioural style particular to their culture that would likely not be evident elsewhere. Also, given that these children and this community so keenly involved themselves in this particular effort suggests a level of motivation – particularly on the part of the participants – that may be unparalleled in main stream, urban communities. Motivation, or lack thereof, is a significant factor that is known to affect assessment, learning and training, and therapeutic efforts, and ultimately, successful performance (Kable & Coles, 2004). It is often the case that if interest and motivation are not combined with appropriate task content, learning does not take place (Cordopa & Lepper, 1996). While the effects of training in the current paradigm are theorized to be due to the systematic activation of the attentional system (and not a requirement to learn specific content), the necessity of intrinsic motivation in repeatedly engaging in the training tasks is quite clear.

Second, while the use of the current measures was deemed appropriate, it is particularly important to be mindful regarding issues of cultural sensitivity, especially for the teacher checklists and verbal and non-verbal reasoning measures. For example, many of the children in the current sample were not familiar with certain items (for example, cherries - an item utilized on one of the nonverbal scales), and many children drew on valid personal experience in answering some of the questions (for example answering "Ice" to the KBIT2 question "What can be walked or driven across, is above water, and usually connects two pieces of land?" - a very appropriate answer for a community who spends 7-8 months of the year living, hunting, and traveling on the frozen north Atlantic). While for the current purposes these issues are minimized in that they remain constant between pre- and post-test and hence should not affect change or gain scores, it would be difficult to compare the ratings and results of this sample with those of children from main-stream, urban communities, or children of other ethnic backgrounds. To date, Inuit appropriate measures have not been developed and Inuit norms are not available. Very much related, is the issue of scaled and standardized scores that have been reported throughout this research. These scores were reported and should be interpreted with a degree of caution given the available standardization data, none of which included Inuit children from remote communities. It is possible that where children were perceived impaired based on some scaled scores, they may not have been had more appropriate norms been available.

Third, sample sizes were small and a large number of statistical tests were utilized in this study. While outcome parameters were identified *a priori*, a large number of tests may generate chance findings and increase the overall probability of making a Type I error on at least one comparison. The current research attempted to solve this problem with clearly outlined *a priori* hypotheses and specific statistical tests to probe main effects for each hypothesis (Bezeau & Graves, 2001). Post hoc tests were only utilized to determine if the degree of predicted change was significantly different from zero. In addition, as determined through a power analysis, the effect sizes achieved for most reported results were significant at α=.05 and greater than Cohen's f=.67, achieving statistical power > .80. This would indicate that while the results should be interpreted conservatively, the current study had adequate power for detecting group differences for tasks in which performance was anticipated to improve, such as auditory and visual sustained attention tasks.

Fourth, while rating scales were utilized as part of a broader overall assessment, it is important to note possible sources of error in utilizing questionnaire-based assessments. Specifically, Gimpel and Holland (2003) review four possible sources of error variance including: *temporal variance* (the tendency of behavioural ratings to be only moderately consistent over time); *setting variance* (the situational specificity of behaviour); *source variance* (referring to the lack of objectivity of the rater); and *instrument variance* (variations among rating scales purported to measure similar constructs), and four common response sets or biases including: *error of central tendency* (the tendency to avoid extreme responses); *error from the halo effect* (rating positive or negative across all items due to a positive or negative trait of the individual being rated that is unrelated to the behaviour being rated) and *error of leniency* (overly lenient) or *severity* (overly severe rating tendencies). These sources of *error variance* and *response bias* can reduce accuracy of ratings.

Fifth, although these results seem quite robust, this study was conducted by one researcher who administered both training and assessment sessions. In noting this limitation, it is important to also note that many checks and balances were adhered to in order to ensure objective measurement and overall procedures. For example, in discussing the study with school personnel and parents it was ensured that these individuals were blind to the condition of each child. This was also the case when distributing and collecting ADDES & BRIEF checklists, such that teachers were not informed of the progress that children were making during either SA or CC sessions. The remaining assessments utilized were all standardized and all provided specific administration and scoring guidelines. Great care was taken to adhere to these guidelines across all children. In addition, the KiTAP is a fully computerized battery and aside from upfront instructions, children completed each subtest independently, without experimenter feedback or on-line knowledge of performance. In order to achieve the greatest level of objectivity all but one of the pre-test measures remained un-scored until after the completion of the study. The exception was the CTONI NIQ and this was done in order to determine pairs of similar-aged children with matching scores, who were then randomly assigned to either CC or SA condition. The CTONI assessments were completed first and last in the study (approximately 5 weeks apart) and scores were not reviewed at any point in between, hence information was impossible to keep track of for specific children. In addition, separate testing forms were utilized for pre- and post-test assessments for both the CTONI and all remaining non-computerized measures, even when one form would have sufficed for both sets of records.

While every care was taken to ensure that any knowledge of pre-test performance was not linked to post-test performance, it is possible that unintentional bias may have entered into the findings of this study. It is encouraging however, that results from the "pencil-and-paper" standardized measures are consistent with results from the computerized measures; results on closely related measures (KBIT2 & CTONI) are consistent with each other; and in a sense, results of direct assessment tools are consistent with teacher impressions, who report that all children improved on indirect behavioural measures of attention and executive functioning instead of observing no change in behaviour.

Last, it is interesting that some improvements were not related to the training tasks. It is possible that these effects are due to practice effects or familiarity with the assessment tools. Because there was no additional no-contact group it is difficult to ascertain how many of these non-specific effects are due to practice effects or to the effect of the individualized contact that children in the CC group had. Activities for the CC group were designed based on each child's needs and preferences. This group was intended to receive a similar type of contact to that normally be offered by a parent, resource teacher, teacher, peer-tutor, or sibling during a typical day. However, as discussed previously, it is possible that the added consistency and intensity of contact coupled with the motivation that children seemed to develop over the course of the study, may have contributed to nonspecific gains on both direct and indirect measures of attention. A long-term follow-up would be important to see whether the specific and non-specific effects noted represent an enduring change in attentional processing or behaviour.

Future Directions

Several limitations have been outlined that should be considered in planning follow-up work including: assessing the utility of sustained attention training in a sample of children with FASD from the mainstream population; increasing the sample size; adding a no-treatment control group; utilizing an objective observational method for assessing change in classroom behaviour instead of using rating scales; using blind raters in the collection of data pre- and post-training; and designing a long-term follow-up study to determine any enduring changes in relevant behaviour.

While children in this study were matched for non-verbal IQ and age and between-group effects were not expected on these variables, developmental effects and the effects of IQ on performance are important variables to consider in future designs. Whether low or average IQ children with FASD respond similarly to intervention or whether younger and older children with FASD have a similar pattern of change in performance are questions that merit future investigations. Similarly, based on studies that report the usefulness of intact vigilance on attention process training for individuals with TBI (e.g., Sohlberg et al., 2000), it would be important to examine this parameter in children with FASD. Moreover, the current sample of children was unique in that children were not deemed hyperactive and none of the children were taking stimulant medication, which is often prescribed to many children with FASD. As such, it would be important to assess whether this type of intervention would be equally beneficial for hyperactive children with FASD, children with FASD and co-morbid ADHD, and children on stimulant medication or other adjunct therapies.

Given widespread difficulties across executive functioning domains, future directions should also include more intense and comprehensive efforts that include a focus on working memory and higher level sustained attention, selective, divided, and alternating attention; in other words, an emphasis on executive functions. For example, based on clinical practice guidelines (Sohlberg et al., 2003), it would be important to examine the effect of training metacognitive strategies in conjunction with attention process training, particularly given the varied effects across different literatures. While effect sizes in the current study were fairly large, the lasting nature of these effects is unknown. Including a metacognitive component to the training may in fact allow children to tap into the skills gained and potentially augment any effects of process training.

Last, Posner and colleagues suggest that attention process training may in fact enhance attention and executive control networks if delivered early in development (i.e., between the ages of 3 and 5 which are associated with development in brain structure and function and consequently show extensive development of attention and executive control (Tamm et al., in press). These authors suggest that early attention intervention may have a long term impact on the functional development of these systems (Tamm et al., in press). In fact, recent work with typically developing 4-5 year olds, suggests that attention process training can improve attention and influence performance in preschoolers in just 5 sessions, with results of the same magnitude as those of typically developing school-aged children[16] (Rueda et al., 2004; Tamm et al., in press).

In closing, the results of this study parallel recent findings of improved performance in children with attentional deficits due to developmental deficits (e.g., Chenault, et al., 2006; Kerns et al., 1999) and provide specific evidence that children with FASD can benefit from direct attention training intervention. Indeed, a stimulating postnatal environment may mitigate some of the serious consequences of prenatal alcohol exposure (see Phelps, 1995). The animal literature describes several successful environmental accommodations and remedial attempts including: improvement in short-term memory impairment following an increase in encoding time in rats trained on the Morris water maze task (Clements et al., 2005); improved motor performance in the form of balance and fine motor coordination on parallel bars following intensive early motor training (Klintsova et al., 1998); and improved learning ability in reversing a previously learned response in a T-maze, subsequent to stimulation and early handling for the 1st 3 weeks postnatally (Lee & Rabe, 1999). Corresponding to behavioural changes, intensive training was found to alter brain structure, showing an increase in synaptic connections per cerebellar Purkinje cells in ethanol-exposed rats (Klintsova et al., 1998). These findings are significant in that they support the notion that the brain is amenable to behavioural intervention, and specifically, that some of the effects of

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[16] These results were reflected in improved performance for the non-verbal reasoning score of the KBIT.

prenatal alcohol may be successfully targeted through behavioural intervention (Riley, 1998). Similarly, while the neurological basis of the effect of attention process training is not yet clear, evidence from evoked potential and fMRI studies also suggests that process training in fact impacts brain function (reported in Tamm et al., in press). In turn, training can influence relevant behaviour and generalize beyond the training tasks (Tamm et al., in press).

REFERENCES

Abel, E.L. (1998). *Fetal Alcohol Abuse Syndrome.* Plenum Press: New York, NY.

Abramowitz, A.J., & O'Leary, S.G. (1991). Behavioral interventions for the classroom: Implications for students with ADHD. *School Psychology Review, 20,* 220-234.

Alberta Learning (2004). *Teaching students with fetal alcohol spectrum disorder: Building strengths, creating hope.* Edmonton, Alberta: Alberta Learning, Special Programs Branch. Last retrieved from the World Wide Web http://www.education.gov.ab.ca/k_12/specialneeds/fasd.asp, October 16, 2007

American Psychiatric Association (2000). *Diagnostic and statistical manual of mental disorders,* 4th edition, Text Revision (DSM-IV-TR). Washington, DC: American Psychiatric Association.

Archibald, S.L., Fennema-Notestine, C., Gamst, A., Riley, E.P., Mattson, S.N., & Jernigan, T.L. (2001). Brain dysmorphology in individuals with severe prenatal alcohol exposure. *Developmental Medicine & Child Neurology, 43,* 148–154.

Aronson, M., & Olegard, R. (1987). Children of alcoholic mothers. *Pediatrician, 14*(1-2), 57-61.

Astley, S. J., & Clarren, S. K. (2000). Diagnosing the full spectrum of fetal alcohol exposed individuals: Introducing the 4-digit diagnostic code. *Alcohol & Alcoholism, 35*(4), 400-410.

Baddeley, A. (1981). The cognitive psychology of everyday life. *British Journal of Psychology, 72,* 257-269.

Baddeley, A. (1986). *Working memory.* New York, NY: Clarendon Press/Oxford University Press.

Baddeley, A. (1993). Working memory or working attention? In A.D. Baddeley & L. Weiskrantz (Eds.). *Attention, selection, awareness, and control: A tribute to Donald Broadbent* (pp. 152-170). New York, NY: Clarendon Press/Oxford University Press.

Barkley, R.A. (1990). *Attention-deficit/hyperactivity disorder: A handbook for diagnosis and treatment* (pp. 36-93). New York, NY: Guilford Press

Barr, H.M., Streissguth, A.P., Darby, B.L., & Sampson, P.D. (1990). Prenatal exposure to alcohol, caffeine, tobacco, and aspirin: Effects of fine and gross motor performance in 4-year old children. *Developmental Psychology, 26,* 339-348.

Bell, M.C. & Riley, E.P. (2006). Memory and perseveration on a win-stay, lose-shift task in rats exposed neonatally to alcohol. *Journal of Studies on Alcohol, 67,* 851-860.

Belmont, J., & Butterfield, E. (1971). What the development of short-term memory is. *Human Development, 14,* 236–248.

Ben-Yishay, Y., Piasetsky, E.B., & Rattock, J. (1987). A systematic method for ameliorating disorders in basic attention. In M. J. Meyer, A. L. Benton, & L. Diller (Eds.), *Neuropsychological rehabilitation* (pp. 165–181). Edinburgh, Scotland: Churchill.

Bezeau, S., & Graves, R. (2001). Statistical power and effect sizes of clinical neuropsychological research. *Journal of Clinical & Experimental Neuropsychology, 23* (3), 399-406.

Bhatara, V., Loudenberg, R., & Ellis, R. (2006). Association of attention deficit hyperactivity disorder and gestational alcohol exposure. *Journal of Attention Disorders, 9*(3), 515-522.

Bialystok, E. (1992) Selective attention in cognitive processing: The bilingual edge. In R. J. Harris (ed.) *Cognitive Processing in Bilinguals* (pp. 501–513). Amsterdam: Elsevier Science.

Bialystok, E., & Majumder, S. (1998). The relationship between bilingualism and the development of cognitive process in problem solving. *Applied Psycholinguistics, 19*(1), 69-85.

Bingol, N., Schuster, C., Fuchs, M., Iosub, S., Turner, G., Stone, R.K., & Gromisch, D.S. (1987). The influence of socioeconomic factors on the occurrence of fetal alcohol syndrome. *Advances in Alcohol and Substance Abuse 6,* 105–118.

Boyd, T.A., Ernhart, C.B., Greene, T.H., Sokol, R.J., & Martier, S. (1991). Prenatal alcohol exposure and sustained attention in the preschool years. *Neurotoxicology and Teratology, 13*(1), 49-55.

Brett, A.W., & Laatsch, L. (1998). Cognitive rehabilitation therapy of brain-injured students in a public high school setting. *Pediatric Rehabilitation, 2,* 27–31.

Brown, R.T., Coles, C.D., Smith, I.E., Platzman, K.A., Silverstein, J., Erickson, S., & Falek, A. (1991). Effects of prenatal alcohol exposure at preschool age. II. Attention and behavior. *Neurotoxicology and Teratology, 13,* 369-376.

Burden, M.J., Burden, S.W., Jacobson, J.L. (2005). Relation of prenatal alcohol exposure cognitive processing speed and efficiency in childhood. *Alcoholism: Clinical and Experimental Research 29,* 1473–1483.

Butler, R.W. (1998). Attentional processes and their remediation in childhood cancer. *Medical and Pediatric Oncology Supplement, 1,* 75–78.

Butler, R.W., & Copeland, D.R. (2002). Attentional processes and their remediation in children treated for cancer: A literature review and the development of a therapeutic approach. *Journal of the International Neuropsychological Society, 8,* 115–124.

Canadian Perinatal Surveillance System (1998). Alcohol and Pregnancy. *Public Health Agency of Canada.* Last retrieved from the World Wide Web http://www.phac-aspc.gc.ca/rhs ssg/factshts/alcprg e.html, October 24, 2005.

Carmichael Olson, H. (Jan, 2006). The families moving forward project: Promising research helps families raising children with FASD. *Iceberg newsletter* (U Washington), Last retrieved from the World Wide Web http://www.fasiceberg.org/newsletters/Vol16Num1 Jan2006.htm, May 8, 2006.

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.

Carmichael Olson, H., Sampson, P.D., Barr, H., Streissguth, A.P., & Bookstein, F.L. (1992). Prenatal exposure to alcohol and school problems in late childhood: A longitudinal prospective study. *Developmental Psychopathology 4,* 341–359

Carney, N., Chestnut, R.M., Maynard, H., Mann, N.C., & Hefland, M. (1999). Effect of cognitive rehabilitation on outcomes for persons with traumatic brain injury: A systematic review. *Journal of Head Trauma Rehabilitation, 14,* 277-307.

Carter, J.D., & Swanson, H.L. (1995). The relationship between intelligence and vigilance in children at risk. *Journal of Abnormal Child Psychology, 23,* 201-220.

Chenault, B., Thomson, J., Abbott, R.D., & Berninger, V.W. (2006). Effects of prior attention training on child dyslexics' response to composition instruction. *Developmental Neuropsychology, 29(1),* 243-260.

Chevalier, N., Poissant, H., Bergeron, H., & Girard-Lajoie, A. (2003). The effect of visual-motor imagery training on CPT performance in children with Attention Deficit Hyperactivity Disorder. *Journal of Cognitive Education and Psychology, 3,* 120-136.

Cho, B-H., Ku, J., Jang, D.P., Kim, S., Lee, Y.H., Kim I.Y., Lee, J. H., & Kim, S. I. (2002). The effect of virtual reality cognitive training for attention enhancement. *CyberPsychology & Behavior, 5(2),* 129-137.

Choudhury, N., & Gorman, K. (2000). The relationship between sustained attention and cognitive performance in 17-24-month old toddlers. *Infant & Child Development, 9,* 127-146.

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 (Suppl),* pp. s1-s21

Cicerone, K.D., Dahlberg, C., Kalmar, K., Langenbahn, D.M., Malec, J.F., Bergquist, T.F. et al. (2000). Evidence-based cognitive rehabilitation: Recommendations for clinical practice. *Archives of Physical & Medical Rehabilitation, 81,* 1596-1615.

Cicerone, K. D. (2002). Remediation of working attention' in mild traumatic brain injury. *Brain Injury, 16,* 185-195.

Clark, E., Lutke, J., Minnes, P., & Ouellette-Kunts, H. (2004). Secondary disabilities among adults with fetal alcohol spectrum disorders in British Columbia. *Journal of FAS International,* 2(13), 1-12. Last retrieved from the World Wide Web http://www.motherisk.org/JFAS_documents/Secondary_Disabilities_Adults.pdf October 10, 2007

Clarke, A.S., & Schneider, M.L. (1997). Effects of prenatal stress on behavior in adolescent rhesus monkeys. *Annals of New York Academic Science, 807,* 490-491.

Clarren, S.K., Sampson, P.D., Larsen, J., Donnell, D.J., Barr, H.M., Bookstein, F.L., Martin, D.C., & Streissguth, A.P. (1987). Facial effects of fetal alcohol exposure: Assessment by photographs and morphometric analysis. *American Journal of Medical Genetics, 26,* 651-666.

Clements, K. M., Girard, T. A., Ellard, C. G., & Wainwright, P. E. (2005). Short-term memory impairment and reduced hippocampal c-fos expression in an animal model of fetal alcohol syndrome. Alcoholism: Clinical and Experimental Research, 29(6), 1049-1059

Cohen, N.J., & Douglas, V.I. (1972). Characteristics of the orienting response in hyperactive and normal children. *Psychophysiology, 9,* 238-245.

Coles, C.D. (2001). Fetal alcohol exposure and attention: Moving beyond ADHD. *Alcohol Research & Health, 25(3),* 199-203.

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.

Coles, C.D., Platzman, K.A., Raskind-Hood, C.L., Brown, R.T., Falek, A., & Smith, I.E. (1997). A comparison of children affected by prenatal alcohol exposure and attention deficit, hyperactivity disorder. *Alcoholism: Clinical and Experimental Research 21,* 150–161

Connor, P.D., Streissguth, A.P., Sampson, P.D., Bookstein, F.L., & Barr, H.M. (1999). Individual differences in auditory and visual attention among fetal alcohol-affected adults. *Alcoholism: Clinical and Experimental Research, 23*(8), 1395-1402.

Connor, P.D., & Streissguth, A.P. (1996). Effects of prenatal exposure to alcohol across the life span. *Alcohol Health & Research World, 20(3),* 170-174.

Connor, P.D., Sampson, P.D., Bookstein, F.L., Barr, H.M., & Streissguth, A.P. (2000). Direct and indirect effects of prenatal alcohol damage on executive function. *Developmental Neuropsychology, 18*(3), 331-354.

Cordova, D., & Lepper, M.R. (1996). Intrinsic motivation and the process of learning: Beneficial effects of contextualization, personalization, and choice. *Journal of Educational Psychology,* 88, 715-730.

Coull, J.T., Frith, C.D., & Frackowiak, R.S.J., (1996). A fronto-parietal network for rapid visual information processing: A PET study of sustained attention and working memory. *Neuropsychologia, 34*(11), 1085-1095.

Crawford, J.D. (1991). The relationship between tests of sustained attention and fluid intelligence. *Personality and Individual Differences, 12,* 599–611.

Donaldson, C., & Waldock, C. (1997). *Language power: Book B*. Toronto, Ontario: Gage Learning Corporation.

Donaldson, C., & Waldock, C. (1997). *Language power: Book C*. Toronto, Ontario: Gage Learning Corporation.

Donaldson, C., & Waldock, C. (2002). *Language power: Introductory*. Toronto, Ontario: Gage Learning Corporation.

Erdfelder, E., Faul, F., & Buchner, A. (1996). GPOWER: A general power analysis program. *Behavior Research Methods, Instruments, & Computers, 28*(1), 1-11.

Evans, J.H., Ferre, L., Ford, L.A., & Green, J.L. (1995). Decreasing attention-deficit/hyperactivity disorder symptoms utilizing an automated classroom reinforcement device. *Psychology in the Schools, 32*, 210-219.

Family Education Network (Printable Centre) (2000-2006 Pearson Education Inc). Last retrieved from the World Wide Web http://printables.familyeducation.com/ October 16, 2007.

Fan, J., McCandliss, B.D., Fossella, J., Flombaum, J.I., & Posner, M.I. (2005). The activation of attentional networks. *NeuroImage, 26*, 471-479.

Fan, J., McCandliss, B.D., Sommer, T., Raz, A., & Posner, M.I. (2002). Testing the efficiency and independence of attentional networks. *Journal of Cognitive Neuroscience, 14*(3), 340-347.

Field, A.P. (2005). *Discovering statistics using SPSS* (2nd ed). London: Sage Publications

Flavell, J., Miller, P., & Miller, S. (1993). *Cognitive development – 3rd Edition*. Englewood Cliffs, New Jersey: Prentice Hall.

Faul, F., Erdfelder, E. Lang, A.G., & Buchner, A. (2007). G*Power3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*(2), 175-191.

Fried, P.A., Watkinson, B., & Gray, R. (1992). A follow-up study of attentional behavior in 6-year-old children exposed prenatally to marihuana, cigarettes, and alcohol. *Neurotoxicology and Teratology, 14*, 299-311.

Gauthier, T.W., Drews-Botsch, C., & Falek, A. (2005). Maternal alcohol abuse and neonatal infection. *Alcoholism: Clinical and Experimental Research, 29*(6), 1035-1043.

Gimpel, G.A., & Holland, M.L. (2003). Emotional and behavioral problems of young children: Effective interventions in the preschool and kindergarten years. New York: Guilford.

Gioia, G.A., Isquith, P.K., Guy, S.C., & Kenworthy, L. (2000). *Behavior rating inventory of executive function.* Odessa, FL: Psychological Assessment Resources.

Girard, T.A., Xing, H.C., Ward, G.R., & Wainwright, P.E. (2000). Early postnatal ethanol exposure has long-term effects on the performance of male rats in a delayed matching-to-place task in the Morris water maze. *Alcoholism: Clinical & Experimental Research, 24,* 300-306.

Goodlett, C.R., Bonthius, D.J., Wasserman, E.A., & West, W.R. (1992). An animal model of CNS dysfunction associated with fetal alcohol exposure: Behavioral and neuroanatomical correlates. In L. Gormenza & E.A. Wasserman (Eds.), *Learning and memory: The behavioral and biological substrates,* (pp. 183-208), Englewood, NJ: Erlbaum.

Goodlett, C.R., Kelly, S.J., & West, J.R. (1987). Early postnatal alcohol exposure that produces high blood-alcohol levels impairs development of spatial navigation learning. *Psychobiology, 15,* 64-74.

Gray, J.M., Robertson, I., Pentland, B., &Anderson, S. (1992). Microcomputer-based attentional retraining after brain damage: A randomized group controlled trial. *Neuropsychological Rehabilitation, 2,* 97–115.

Griggs, R.A., Platt, R.D., Newstead, S.E., & Jackson, S.L. (1998). Attentional factors in a disjunctive reasoning task. *Thinking & Reasoning, 4*(1), 1-14.

Halperin, J. M. (1996). Conceptualizing, describing and measuring components of attention: A summary. In R. G. Lyon & N. A. Krasnegor (Eds.). *Attention, memory & executive function* (pp. 119-136). Baltimore, MD, US: Paul H. Brookes Publishing Co.

Hammill, D.D., Pearson, N.A., & Wiederholt, J.L. (1996). Comprehensive Test of Nonverbal Intelligence (CTONI). Austin, TX: Pro-Ed.

Harley, J.P., Allen, C., Braciszeski, T.L., Cicerone, K.D., Dahlberg, C., Evans, S., et al. (1991). Guidelines for cognitive rehabilitation. *NeuroRehabilitation, 2*(3), 62-67.

Hausknecht, K.A., Acheson, A., Farrar, A.M., Kieres, A.K., Shen, R.Y., Richards, R.B, & Sabol, K.E. (2005). Prenatal alcohol exposure causes attention deficits in male rats. *Behavioral Neuroscience, 119*(1), 302-310.

Health Canada (2003). Fetal Alcohol Spectrum Disorder: A Framework for Action. Last retrieved from the World Wide Web http://www.phac-aspc.gc.ca/dca-dea/publications/pdf/fasd-etcaf_e.pdf, October 24, 2005.

Heinrich, H., Gevensleben, H., Freisleder, F.J., Moll, G.H., & Rothenberger, A. (2004). Training of slow cortical potentials in Attention-Deficit/Hyperactivity Disorder: Positive behavioral and neurophysiologic effects. *Biological Psychiatry, 55,* 772-775.

Huberty, C.J., & Morris, J.D. (1989). Multivariate analysis versus multiple univariate analyses. *Psychological Bulletin, 105*(2), 302-308.

Hulme, C., & Mackenzie, S. (1992). *Working memory and severe learning difficulties.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Jacobson, S.W. (1998). Specificity of neurobehavioral outcomes associated with prenatal alcohol exposure. *Alcoholism: Clinical and Experimental Research, 22,* 313–324.

Jacobson, S.W., Jacobson, J.L., O'Neill, J.M., Padgett, R.J., Frankowski, J.J., & Bihun, J.T. (1992). Visual expectation and dimensions of infant information processing. *Child Development, 63,* 711-724.

Jacobson, S.W., Jacobson, J.L., & Sokol, R.J. (1994). Effects of fetal alcohol exposure on infant reaction time. *Alcoholism: Clinical and Experimental Research, 18*(5), 1125-1132.

Jacobson, J.L., Jacobson, S.W., Sokol, R.J., & Ager, J.W. (1998). Relation of maternal age and pattern of pregnancy drinking to functionally significant cognitive deficit in infancy. *Alcoholism: Clinical and Experimental Research, 22,* 345–351.

Jacobson, J.L., Jacobson, S.W., Sokol, R.J., Martier, S.S., & Ager, J.W. (1993). Prenatal alcohol exposure and infant information processing ability. *Child Development, 66,* 1706-1721.

Jones, K.L., & Smith, D.W. (1973). Recognition of the fetal alcohol syndrome in early infancy. *Lancet, 302* (7836), 999-1001.

Kable, J.A., & Coles, C.D. (2004). The impact of prenatal alcohol exposure on neurophysiological encoding of environmental events at six months. *Alcoholism: Clinical and Experimental Research, 28*(3), 489-496.

Kalberg, W.O., & Buckley, D. (2007). FASD: What types of intervention and rehabilitation are useful? *Neuroscience and Biobehavioral Reviews, 31,* 278-285.

Kaufman, M. H. (1997). The teratogenic effects of alcohol following exposure during pregnancy, and its influence on the chromosome constitution of the pre-ovulatory egg. *Alcohol and Alcoholism, 32*(2), 113-128.

Kaufman, A.S., & Kaufman, N.L. (2004). Kaufman Brief Intelligence Test manual. Circle Pines, MN: American Guidance Service.

Keppel, G. (1991). *Design and analysis: A researcher's handbook.* (3rd ed.). Englewood Cliffs, NJ: Prentice Hall.

Kerns, K.A., Eso, K., & Thompson, J. (1999). Investigation of a direct intervention for improving attention in young children with ADHD. *Developmental Neuropsychology, 16,* 273-295.

Kerns, K., Don, A., Mateer, C.A., & Streissguth, A.P. (1997). Cognitive deficits in nonretarded adults with fetal alcohol syndrome. *Journal of learning disabilities, 30(6),* 685-693.

Kerns, K.A., & Mateer, C.A. (1996). Walking and chewing gum: The impact of attentional capacity on everyday activities. In R.J. Sbordone & C.L. Long (Eds.), *Ecological validity of neuropsycholgical testing* (pp. 147–170). Delray Beach, FL: St. Lucie Press.

Kipp, K. (2005). A developmental perspective on the measurement of cognitive deficits in attention-deficit/hyperactivity disorder. *Biological Psychiatry, 57,* 1256-1260.

Klingberg, T., Fernell, E., Olesen, P. J., Johnson, M., Gustafsson, P., Dahlstrom, K., et al., (2005). Computerized training of working memory in children with ADHD – A randomized, controlled trial. *Journal of the American Academy of Child & Adolescent Psychiatry, 44(2),* 177-186.

Klintsova, A.Y., Cowell, R.M., Swain, R.A., Napper, R.M., Goodlett, C.R., & Greenough, W.T. (1998), Therapeutic effects of complex motor training on motor performance deficits induced by neonatal binge-like alcohol exposure in rats. Brain Research, 800(1), 48-61.

Kopera-Frye, K., Carmichael Olson, H., & Streissguth, A.P. (1997). Teratogenic effects of alcohol on attention. In J. Burack & E. James (Eds). *Attention, Development, and Psychopathology* (pp 171-204). New York, NY, US: Guilford Press.

Kodituwakku, P.W. (2007). Defining the behavioral phenotype in children with fetal alcohol spectrum disorders: A review. *Neuroscience and Biobehavioral Reviews, 31,* 192-201.

Kodituwakku, P.W., Kalberg, W., & May, P.A. (2001). The effects of prenatal alcohol exposure on executive functioning. *Alcohol Research & Health, 25(3),* 192-198.

Kurtz, M.M., Moberg, P.J., Gur, R.C., & Gur, R.E. (2001). Approaches to cognitive remediation of neuropsychological deficits in schizophrenia: A review and meta-analysis. *Neuropsychology Review, 11*(4), 197-210.

Larkby, C., & Day, N. (1997) The effects of prenatal alcohol exposure. *Alcohol Health & Research World, 21,* 192-197.

Larroque, B., & Kaminsky, M. (1998). Prenatal alcohol exposure and development at preschool age: Main results of a French study. *Alcoholism: Clinical & Experimental Research, 22*(2), 295-303.

Laws, G., MacDonald, J., & Buckley, S. (1996). The effects of a short training in the use of a rehearsal strategy on memory for words and pictures in children with Down syndrome. *Down Syndrome: Research & Practice, 4,* 70–78.

Lee, K.T., Mattson, S.N., & Riley, E.P. (2004). Classifying children with heavy prenatal alcohol exposure using measures of attention. *Journal of the International Neuropsychological Society 10,* 271–277.

Lee, M. H., & Rabe, A. (1999). Infantile handling eliminates reversal learning deficit in rats prenatally exposed to alcohol. Alcohol, 18(1), 49-53.

Lemoine, P., Harousseau, H., et al., (1968). Children of alcoholic parents: Abnormalities observed in 127 cases. *Quest Medical, 21,* 476-482

Lentz, F.E. (1988). Reductive procedures. In J.C. Witt, S.N. Elliott, & F.M. Gresham (Eds.), *Handbook of behavior therapy in education* (pp. 439-468). New York, NY: Plenum Press.

Leslie, M., & Roberts, G. (2001). *Enhancing Fetal Alcohol Syndrome: FAS-related Interventions at the Prenatal and Early Childhood Stages in Canada.* Ottawa, ON: Canadian Centre on Substance Abuse.

Leth-Steensen, C., Elbaz, Z.K., & Douglas, V.I. (2000). Mean response times, variability, and skew in the responding of ADHD children: A response time distributional approach. *Acta Psychologica, 104,* 167-190.

Lezak, M.D. (1995). *Neuropsychological assessment (3rd Ed).* London: Oxford University Press.

Linnet, K. M., Dalsgaard, S., Obel, C.,Wisborg, K., Henrikson, T. B., Rodriguez, A., et al. (2003). Maternal lifestyle factors in pregnancy risk of attention deficit hyperactivity disorder and associated behaviors: Review of the current evidence. *American Journal of Psychiatry, 160,* 1028-1040.

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

Lovaas, O.I. (1987). Behavioral treatment and normal intellectual and educational functioning in autistic children. *Journal of Consulting and Clinical Psychology, 55,* 3-9.

Ma, X., Coles, C.D., Lynch, M.E., LaConte, S.M., & Hu, X. (2003). Evaluation of corpus callosum anisotropy in young adults with fetal alcohol syndrome using diffusion tensor imaging. *Alcoholism: Clinical and Experimental Research, 27,* A41.

Manly, T., Anderson, V., Nimmo-Smith, I., Turner, A., Watson, P., & Robertson, I. (2001). The differential assessment of children's attention: The test of everyday attention for children (TEA-Ch), normative sample and ADHD performance. *Journal of Child Psychology and Psychiatry, 42*(8), 1065-1081.

Manly, T., Robertson, I.H., Anderson, V.A., & Nimmo-Smith, I. (1999). *TEA-CH: The test of everyday attention for children.* Bury St. Edmunds: Thames Valley Test Co.

Mapou, R. (1995). A cognitive framework for neuropsychological assessment. In R. Mapou & J. Spector (Eds.), *Clinical neuropsychological assessment: A cognitive approach* (pp.295-337). New York, NY: Plenum Press.

Mateer, C.A. (1992). Systems of care for post-concussive syndrome. In L.J. Horn & ND. Zasler (Eds.), *Rehabilitation of post-concussive disorders* (pp.143-160). Philadelphia, PA: Henley & Belfus.

Mateer, C.A., & Sohlberg, M.M. (1988). A paradigm shift in memory rehabilitation. In H. Whitaker (Ed.), *Neuropsychological studies of nonfocal brain injury: Dementia and closed head injury* (pp.202-225), New York, NY: Springer-Verlag.

Mateer, C.A., Sohlberg, M.M., & Youngman, P. (1990). The management of acquired attention and memory disorders following closed head injury. In R. Wood (Ed.) *Cognitive Rehabilitation in Perspective* (pp.68-95), London: Taylor & Francis

Matthews, D.B., & Simson, P.E. (1998). Prenatal exposure to ethanol disrupts spatial memory: effect of the training-testing delay period. *Physiology & Behavior, 64,* 63-67.

Mattson, S.N., Calarco, K.E., & Lang, A.R. (2006). Focused and shifting attention in children with heavy prenatal alcohol exposure. *Neuropsychology, 20*(3), 361-369.

Mattson, S.N., Gramling, L., Delis, D.C., Jones, K.L., & Riley, E.P. (1996). Global-local processing in children prenatally exposed to alcohol. *Child Neuropsychology, 2,* 165–175.

Mattson, S.N., Lang, A.R., & Calarco, K.E. (2002). Attentional focus and attentional shift in children with heavy prenatal alcohol exposure. *Journal of the International Neuropsychological Society, 8,* 295.

Mattson, S.N., & Riley, E.P. (1998). A review of the neurobehavioral deficits in children with fetal alcohol syndrome or prenatal exposure to alcohol. *Alcoholism: Clinical and Experimental Research, 22*(2), 279-294.

Mattson, S.N., & Riley, E.P. (2000). Parent ratings of behavior in children with heavy prenatal alcohol exposure and IQ-matched controls. *Alcoholism: Clinical and Experimental Research* 24(2), 226-231

Mattson, S.N., & Roebuck, T.M. (2002). Acquisition and retention of verbal and nonverbal information in children with heavy prenatal alcohol exposure. *Alcoholism: Clinical and Experimental Research, 26* (6), 875-882.

Mattson, S.N., Schoenfeld, A.M., & Riley, E.P. (2001). Teratogenic effects of alcohol on brain and behavior. *Alcohol Research & Health, 25*(3), 185-191.

McCarney, S.B., & Arthaud, T.J. (2004). *The attention deficit disorders evaluation scale.* (School Version, 3rd ed). Columbia, MO: Hawthorne Educational Services

McEachin, J.J., Smith, T., & Lovaas, O.I. (1993). Long-term outcome for children with autism who received early intensive behavioral treatment. *American Journal on Mental Retardation, 97,* 359-372.

Middleton, D.K., Lambert, M.J., & Seggar, L.B. (1991). Neuropsychological rehabilitation: Microcomputer-assisted treatment of brain-injured adults. *Perceptual and Motor Skills,* 72, 527-530.

Mischel, W., Shoda, Y., & Rodriguez, M.L. (1989). Delay of gratification in children. *Science, 244,* 933-938.

Mirsky, A.F. (1996). Disorders of attention: A neuropsychological perspective. In G.R. Lyon & N.A. Krasnegor (Eds.). *Attention, memory, and executive function* (pp. 71-95). Baltimore, MD: Paul H Brookes Publishing.

Mirsky, A.F., Anthony, B.J., Duncan, C.C., Ahearn, M.B., & Kellam, S.G. (1991). Analysis of the elements of attention: A neuropsychological approach. *Neuropsychology Review,* 2(2), 109-145.

Nanson, J.L., & Hiscock, M. (1990). Attention deficits in children exposed to alcohol prenatally. *Alcoholism: Clinical and Experimental Research,* 14(5), 656-661.

Niemann, H., Ruff, R.M., & Baser, C.A. (1990). Computer assisted attention retraining in head injured individuals: A controlled efficacy study of an out-patient program. *Journal of Consulting & Clinical Psychology, 58,* 811-817.

Morrow, P., & Boyd, A. (1999). Quest 2000: Exploring Mathematics (Practice and Homework Book, Gr. 2). Toronto, Ontario: Pearson Education Canada, Inc.

Morrow, P., & Boyd, A. (1999). Quest 2000: Exploring Mathematics (Practice and Homework Book, Gr. 3). Toronto, Ontario: Pearson Education Canada, Inc.

Novack, T.A., Caldwell, S.G., Duke, L.W., & Berquist, T. (1996). Focused versus unstructured intervention for attention deficits after traumatic brain injury. *Journal of Head Trauma Rehabilitation, 11*(3), 52-60.

O'Connor, M.J., Frankel, F., Paley, B., Schonfeld, A.M., Carpenter, E., Laugeson, E.A., & Marquardt, R. (2006). A controlled social skills training for children with fetal alcohol spectrum disorders. *Journal of Consulting and Clinical Psychology, 74*(4), 639-648.

O'Leary, M.E. (2002). Inhibition of HERG potassium channels by cocaethylene: A metabolite of cocaine and ethanol. *Cardiovascular Research, 53*, 59-67.

Oesterheld, J.R., &Wilson, A. (1997). ADHD and FAS [Letter to the editor]. *Journal of American Academy of Child and Adolescent Psychiatry, 36*, 1163

O'Malley, K.D., & Nanson, J.D. (2002). Clinical implications of a link between fetal alcohol spectrum disorder and attention-deficit hyperactivity disorder. *Canadian Journal of Psychiatry, 47*, 349-354.

Overholser, J.C. (1990). Fetal alcohol syndrome: A review of the disorder. *Journal of Contemporary Psychotherapy, 20*(3), 163-176.

Park, N. W., & Ingles, J. L. (2001). Effectiveness of attention rehabilitation after acquired brain injury: A meta-analysis. *Neuropsychology*, 15, 199-210.

Park, N. W., Proulx, G., & Towers, W. M. (1999). Evaluation of the attention process training programme. *Neuropsychological Rehabilitation, 9*, 135-154.

Penkman, L. (2004). Remediation of attention deficits in children: A focus on childhood cancer, traumatic brain injury and attention deficit disorder, *Pediatric Rehabilitation, 7 (2)*, 111-123.

Pfiffner, L.J., & Barkley, R.A. (1990) Educational placement and classroom management. In R.A. Barkley (Ed.) *Attention-deficit/hyperactivity disorder: A handbook for diagnosis and treatment* (pp. 498-539). New York, NY: Guilford Press.

Phelps, L. (1995). Psychoeducational outcomes of fetal alcohol syndrome. School Psychology Review, 24(2), 200-212.

Ponsford, J.L., & Kinsella, G.J. (1988). Evaluation of a remedial programme for attentional deficits following closed head injury. *Journal of Clinical and Experimental Neuropsychology, 14,* 822-838.

Posner, M., & Petersen, S.E. (1990). The attention system of the human brain. *Annual Review of Neuroscience, 13,* 25-42.

Powell, J.M., Hunt, E., & Pepping, M. (2004). Collaboration between cognitive science and cognitive rehabilitation: A call for action. *Journal of Head Trauma Rehabilitation, 19,* 266-276.

Reading a-z (2000-2007). The online reading program. Last retrieved from the World Wide Web http://www.readinga-z.com/, October 16, 2007.

Rasmussen, C. (2005). Executive functioning and working memory in fetal alcohol spectrum disorder. *Alcoholism: Clinical and Experimental Research, 29,* 1359–1367.

Reid, M.K., & Borkowski, J.G. (1987). Causal attributions of hyperactive children: Implications for teaching strategies and self-control. *Journal of Educational Psychology, 79*(3), 296-307.

Reid, R., & Harris, K.R. (1993). Self-monitoring of attention versus self-monitoring of performance: Effects on attention and academic performance. *Exceptional Children, 59,* 1-13.

Richards, J.E., & Casey, B.J. (1992). Development of sustained visual attention in the human infant. In B.A. Campbell, H. Hayne, & R. Richardson (Eds.). *Attention and Information Processing in Infants and Adults: Perspectives from Human and Animal Research* (pp. 30-60), Hillsdale, NJ: Lawrence Erlbaum Associates.

Riley, E. P. (1998). Fetal Alcohol Syndrome. Created April 10, 1998. Last retrieved from the World Wide Web www.rsoa.org/lectures/07/07.ppt January 23, 2006

Robertson, I.H., Tegner, R., Tham, K., & Nimmo-Smith, I. (1995). Sustained attention training for unilateral neglect: Theoretical and rehabilitation implications. *Journal of Clinical and Experimental Neuropsychology, 17,* 416-430.

Robertson, J.H., Ward, T., Ridgeway, V., & Nimmo-Smith, I. (1994). The test of everyday attention, Bury St. Edmunds, UK: Thames Valley Test Co.

Robertson, J.H., Ward, T., Ridgeway, V., & Nimmo-Smith, I. (1996). The structure of normal human attention: The test of everyday attention. *Journal of the International Neuropsychological Society, 2,* 525-534.

Roebuck, T.M., Mattson, S.N., & Riley, E.P. (1999). Behavioral and psychosocial profiles of alcohol-exposed children. *Alcoholism: Clinical & Experimental Research, 23*(6), 1070.

Rolland, M, and Guay, M.-C. (2001). Cognitive training for children diagnosed with attention deficit/hyperactivity disorder. *Brain and Cognition, 47,* 213-216.

Rossen, E.A., Shearer, D.K., Penfield, R.D., & Kranzler, J.H. (2005). Validity of the comprehensive test of nonverbal intelligence (CTONI). *Journal of Psychoeducational Assessment, 23,* 161-172.

Rueda, M. R., Fan, J., McCandliss, B. D., Halparin, J. D., Gruber, D. B., Lercari, L. P., et al. (2004). Development of attentional networks in childhood. *Neuropsychologia, 42*(8), 1029-1040.

Ruff, R.M., Baser, C.A., Johnston, J.W., & Marshall, L.F. (1989). Neuropsychological rehabilitation: An experimental study with head-injured patients. *Journal of Head Trauma Rehabilitation, 4*(3), 20-36.

Ruff, R.M., Mahaffety, R., Engel, J., Farrow, C.E., Cox, D., & Karzmark, P. (1994). Efficacy of THINKable in the attention and memory retraining of traumatically head-injured patients. *Brain Injury, 8,* 3-14.

Sack, S.A., & Rice, C.E. (1974). Selectivity, resistance to distraction and shifting as three attentional factors. *Psychological Reports, 34,* 1003-1012.

Sampson, P.D., Streissguth, A.P., Barr, H.M., & Bookstein, F.L. (1989). Neurobehavioral effects of prenatal alcohol: Part II. Partial least squares analysis. *Neurotoxicology and Teratology, 11,* 477–491.

Sattler, J.M. (2001). *Assessment of children: Cognitive applications* (4th ed.). San Diego, CA: Jerome M. Sattler Publisher, Inc.

Schweizer, K., & Moosbrugger, H. (2004). Attention and working memory as predictors of intelligence. *Intelligence, 32*(4), 329-347.

Schweizer, K., Moosbrugger, H., & Goldhammer, F. (2005). The structure of the relationship between attention and intelligence. *Intelligence, 33*(6). 589-611.

Schweizer, K., Zimmermann, P., & Koch, W. (2000). Sustained attention, intelligence, and the crucial role of perceptual processes. *Learning and Individual Differences, 12,* 271-286.

Seidel, W.T., & Joschko, M. (1990). Evidence of difficulties in sustained attention in children with ADDH. *Journal of Abnormal Child Psychology, 18,* 217–229.

Semrud-Clikeman, M., Nielsen, K.H., Clinton, A., Sylvester, L., Parle, N., & Connor, R.T. (1999). An intervention approach for children with teacher- and parent-identified attentional difficulties. *Journal of Learning Disabilities, 32,* 581–590.

Sivak, M., Hill, C.S., & Olson, P.L. (1984a). Computerized video tasks as training techniques for driving-related perceptual deficits of persons with brain damage: A pilot evaluation. *International Journal of Rehabilitation Research, 7,* 389-98.

Sivak, M., Hill, C.S., Henson, D.L., Butler, B.P., Silber, S.M., & Olson, P. (1984b). Improved driving performance following perceptual retraining in persons with brain damage. *Archives of Physical Medicine and Rehabilitation, 65,* 163–167.

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.

Sohlberg, M.M., & Mateer, C.A. (1986). *Attention process training.* Puyallup, WA: Centre for Cognitive Rehabilitation.

Sohlberg, M.M., & Mateer, C.A. (1987). Effectiveness of an attention training program. *Journal of Clinical and Experimental Neuropsychology, 19,* 117-130.

Sohlberg, M.M., & Mateer, C.A. (1998). *Cognitive rehabilitation: Introduction to theory and practice.* New York, NY: Guilford Press.

Sohlberg, M.M., & Mateer, C.A. (2001). *Cognitive rehabilitation: An integrative neuropsychological approach.* New York, NY: The Guilford Press

Sohlberg, M.M., Mateer, C.A., & Stuss, D.T. (1993). Contemporary approaches to the management of executive control dysfunction. *Journal of Head Trauma Rehabilitation, 8,* 45-58.

Sohlberg, M.M., McLaughlin, K.A., Pavese, A., Heidrich, A., & Posner, M.I. (2000). Evaluation of attention process training and brain injury education in persons with acquired brain injury. *Journal of Clinical and Experimental Neuropsychology, 22*(5), 656-676.

Sood, B., Delaney-Black, V., Covington, C., Nordstrom-Klee, B., Ager, J., Templin, T., Janisse, J., Martier, S., & Sokol, R.J. (2001). Prenatal alcohol exposure and childhood behavior at age 6 to 7 years: A dose-response effect. *Pediatrics* 108:E34

Spohr, H.L., Willms, J., & Steinhausen, H.C. (1993). Prenatal alcohol exposure and long-term developmental consequences. *Lancet, 341,* 907.

Strache, W. (1987). Effectiveness of two modes of training to overcome deficits of concentration. *International Journal of Rehabilitation Research, 10,* 141S–145S.

Stratton, K.R., Howe, C.J., & Battaglia, F.C. (1996). *Fetal alcohol syndrome: diagnosis, epidemiology, prevention, and treatment.* Washington, D.C: National Academy Press.

Sroufe, L.A., Sonies, D.C., West, W.D., & Wright, F.S. (1973) Anticipatory heart rate deceleration with and without referral for learning disabilities. *Child Development, 44,* 267-273.

Streissguth, A.P., Aase, J.M., Clarren, S.K., Randels, S.P., LaDue, R.A., & Smith, D.F. (1991a). Fetal alcohol syndrome in adolescents and adults. *Journal of the American Medical Association, 265*(15), 1961-1967.

Streissguth, A.P., Barr, H.M., & Martin, D.C. (1983). Maternal alcohol exposure and neonatal habituation assessed with Brazelton scale. *Child Development, 54,* 1109–1118.

Streissguth, A.P., Barr, H.M., & Martin, D.C. (1984). Alcohol exposure in utero and functional deficits in children during the first four years of life. *CIBA Foundation Symposium, 105,* 176–196.

Streissguth, A.P., Barr, H.M., & Sampson, P.D. (1990). Moderate prenatal alcohol exposure: Effects on child IQ and learning problems at age 7-12 years. *Alcoholism: Clinical and Experimental Research, 14*(5), 662-669.

Streissguth, A.P., Barr, H.M., Sampson, P.D., & Bookstein, F.L. (1994). Prenatal alcohol and offspring development: The first fourteen years. *Drug & Alcohol Dependency, 36,* 89–99.

Streissguth, A.P., Barr, H.M., Sampson, P.D., Darby, B.L., & Martin, D.C. (1989). IQ at age 4 in relation to maternal alcohol use and smoking during pregnancy. *Developmental Psychology, 25,* 3–11.

Streissguth, A.P., Barr, H.M., Sampson, P.D., Parrish-Johnson, J.C., Kirchner, G.L., & Martin, D.C. (1986). Attention, distraction and reaction time at age 7 years and prenatal alcohol exposure. *Neurobehavioural Toxicology & Teratology, 8,* 717–725.

Streissguth, A.P., Bookstein, F.L., & Barr, H.M. (1996). A dose-response study of the enduring effects of prenatal alcohol exposure: Birth to 14 years. In H.L. Spohr & H.C. Steinhausen (Eds.) *Alcohol, pregnancy and the developing child.* (pp.141-168), New York, NY: Cambridge University Press.

Streissguth, A.P., Bookstein, F.L., Sampson, P.D., & Barr, H.M. (1989). Neurobehavioral effects of prenatal alcohol: III PLS analyses of neuropsychologic tests. *Neurotoxicology & Teratology, 11*(5), 493-507.

Streissguth, A. P., Clarren, S. K., & Jones, K. L. (1985). Natural history of the fetal alcohol syndrome: A 10-year follow-up of eleven patients. *Lancet, 13,* 85-91.

Streissguth, A.P, Herman, C.S., & Smith, D.W. (1978). Stability of intelligence in the fetal alcohol syndrome: A preliminary report. *Alcoholism: Clinical and Experimental Research 2*(2), 165-170.

Streissguth, A.P., Martin, D.C., Barr, H.M., Sandman, B.M., Krichner, G.L., & Darby, B.L. (1984). Intrauterine alcohol and nicotine exposure: Attention and reaction time in 4-yearold children. *Developmental Psychology, 20,* 533–541.

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. *Alcoholism: Clinical & Experimental Research, 18,* 202–218.

Streissguth, A.P., Randels, S.P., & Smith, D.F. (1991b). A test-retest study of intelligence in patients with fetal alcohol syndrome: Implications for care. *Journal of the American Academy of Child & Adolescent Psychiatry, 30*(4), 584-587.

Sturm, W., Fimm, B., Cantagallo, A., Cremel, N., North, P., et al., (2003). Specific computerized attention training in stroke and traumatic brain-injured patients: A European multicentre efficacy study. *Zeitschrift für Neuropsychologie, 14*(4), 283-292.

Sturm, W., Longoni, F., Weis, S., Specht, K., Herzog, H., Vohn, R., Thimm, M., & Willmes, K. (2004). Functional reorganization in patients with right hemisphere stroke after training alertness: a longitudinal PET and fMRI study in eight cases. *Neuropsychologia, 42*, 434-450.

Sturm, W., & Willmes, K. (1991). Efficacy of reaction training on various attentional and cognitive functions in stroke patients. *Neuropsychological Rehabilitation, 1*, 259-80.

Sturm, W., Willmes, K., & Orgass, B. (1997). Do specific attention deficits need specific training? *Neuropsychoogical Rehabilitation, 7*, 81-103.

Stuss, D.T., Stethem, L.L., Hugenholtz, H., Picton, T., Pivik, J., & Richard, M.T. (1989). Reaction time after head injury: Fatigue, divided and focused attention, and consistency of performance. *Journal of Neurology, Neurosurgery, and Psychiatry, 52*, 742-748.

Tallarico, T. (2007). *The big book of search and find*. Big book series. Kids Books, Inc.

Tamm, L., McCandliss, B.D., Liang, B.A., Wigal, T.L., Posner, M.I., & Swanson, J.M. (in press). Can attention itself be trained? Attention training for children at-risk for ADHD. In K. McBurnett (Ed.), Attention Deficit/Hyperactivity Disorder: A 21st Century Perspective. New York: Marcel Dekker.

Teacher Vision: Lesson plans, printables, and more (2000-2007 Pearson Education Inc). Last retrieved from the World Wide Web http://www.teachervision.fen.com/ 2006.

Thomas, S.E., Kelly, S.J., Mattson, S.N., & Riley, E.P. (1998). Comparison of social abilities of children with fetal alcohol syndrome to those of children with similar IQ scores and normal controls. *Alcoholism: Clinical and Experimental Research, 22*(2), 528-533.

Thomson, J. (1995). Rehabilitation of high school-ed individuals with traumatic brain injury through utilization of an attention training program. *Journal of the International Neuropsychological Society, 1:* 149.

Thomson, J.B., & Kerns, K.A. (2000). Mild traumatic brain injury in children. In S.A. Raskin, (Ed). *Neuropsychological Management of Mild Traumatic Brain Injury* (pp. 232-251) New York, NY: Oxford University Press.

Thomson, J., Kerns, K.A., Seidenstrang, L., Sohlberg, M.M., & Mateer, C.A. (2001). *Pay Attention!: A children's attention process training program.* Wake Forest, NC: Lash & Associates

van der Meere, J., Gunning, W.B., & Stemerdink, N. (1996). Changing a response set in normal development and in ADHD children with and without tics. *Journal of Abnormal Child Psychology, 24,* 767–786.

van Zomeren, A.H., & Brouwer, W.H. (1994). *Clinical neuropsychology of attention.* Oxford: Oxford University Press.

Webster, J.S., & Scott, R.R. (1983). The effects of self-instructional training of attentional deficits following head injury. *Clinical Neuropsychology, 5,* 69-74.

Wechsler, D. (1991). *Wechsler Intelligence Scale for Children, Third Edition.* San Antonio, TX: The Psychological Corporation.

Weiner, L. & Morse, B.A. (1994). Intervention and the child with FAS. *Alcohol Health & Research World, 18*(1), 67-73.

Wilson, B., & Robertson, I.H. (1992). A home based intervention for attentional slips during reading following head injury: A single case study. *Neuropsychological Rehabilitation, 2,* 193-205.

Wood, R.L., & Fussey, I. (1987). Computer assisted cognitive retraining: A controlled study. *International Disability Studies, 9,* 149-153.

Zevenbergen, A.A., & Ferraro, F.R. (2001). Assessment and treatment of fetal alcohol syndrome in children and adolescents. *Journal of Developmental and Physical Disabilities, 13(2),* 123-136.

Zimmermann, P., Gondand, M., & Fimm, B. (2005). *KITAP: Test of Attentional Performance for Children,* Freiburg, Germany: Psytest

Zimmermann, P. & Fimm, B. (1993). *Testbatterie zur Erfassung von Aufmerksamkeitsstörungen. Version 1.02.* Freiburg: Psytest.

Appendix A.1
Institute of Medicine Diagnostic Criteria for FAS and Alcohol Related Effects

Fetal alcohol syndrome (FAS)

1. *FAS with confirmed maternal alcohol exposure**
   - A. Confirmed maternal alcohol exposure*
   - B. Evidence of a characteristic pattern of facial anomalies that includes features such as short palpebral fissures and abnormalities in the premaxillary zone (e.g., flat upper lip, flattened philtrum and flat midface)
   - C. Evidence of growth retardation, as in at least one of the following:
     - low birth weight for gestational age
     - decelerating weight over time not due to nutrition
     - disproportional low weight-to-height ratio
   - D. Evidence of central nervous system neurodevelopmental abnormalities, as in at least one of the following:
     - decreased cranial size at birth
     - structural brain abnormalities (e.g., microcephaly, partial or complete agenesis of the corpus callosum, cerebellar hypoplasia)
     - neurologic hard or soft signs (as age appropriate), such as impaired fine motor skills, neurosensory hearing loss, poor tandem gait, poor eye-hand coordination
2. *FAS without confirmed maternal alcohol exposure*

   B, C, and D as above
3. *Partial FAS with confirmed maternal alcohol exposure*
   - A. Confirmed maternal alcohol exposure*
   - B. Evidence of some components of the pattern of characteristic facial anomalies

   Either C or D or E
   - C. Evidence of growth retardation, as in at least one of the following:
     - low birth weight for gestational age
     - decelerating weight over time not due to nutrition
     - disproportionally low weight-to-height ratio
   - D. Evidence of CNS neurodevelopmental abnormalities, e.g.,
     - decreased cranial size at birth
     - structural brain abnormalities (e.g., microcephaly, partial or complete agenesis of the corpus callosum, cerebellar hypoplasia)
     - neurologic hard or soft signs (as age appropriate) such as impaired fine motor skills, neurosensory hearing loss, poor tandem gait, poor eye-hand coordination
   - E. Evidence of a complex pattern of behaviour or cognitive abnormalities that are inconsistent with developmental level and cannot be explained by familial background or environment alone; e.g., learning difficulties; deficits in school performance; poor impulse control; problems in social perception; deficits in higher level receptive and expressive language; poor capacity for abstraction or metacognition; specific deficits in mathematical skills; or problems in memory, attention or judgment.

Alcohol-related effects

Clinical conditions in which there is a history of maternal alcohol exposure,*† and where clinical or animal research has linked maternal alcohol ingestion to an observed outcome. There are 2 categories, which may co-occur. If both diagnoses are present, then both diagnoses should be rendered.

4. *Alcohol-related birth defects (ARBD)*

   Congenital anomalies, including malformations and dysplasias

   Cardiac
   Atrial septal defects
   Ventricular septal defects
   Aberrant great vessels
   Tetralogy of Fallot

   Skeletal
   Hypoplastic nails
   Shortened fifth digits
   Radioulnar synostosis
   Flexion contractures
   Camptodactyly
   Clinodactyly
   Pectus excavatum and carinatum
   Klippel-Feil syndrome
   Hemivertebrae
   Scoliosis

   Renal
   Aplastic, dysplastic, hypoplastic kidneys
   Horseshoe kidneys
   Ureteral duplications
   Hydronephrosis

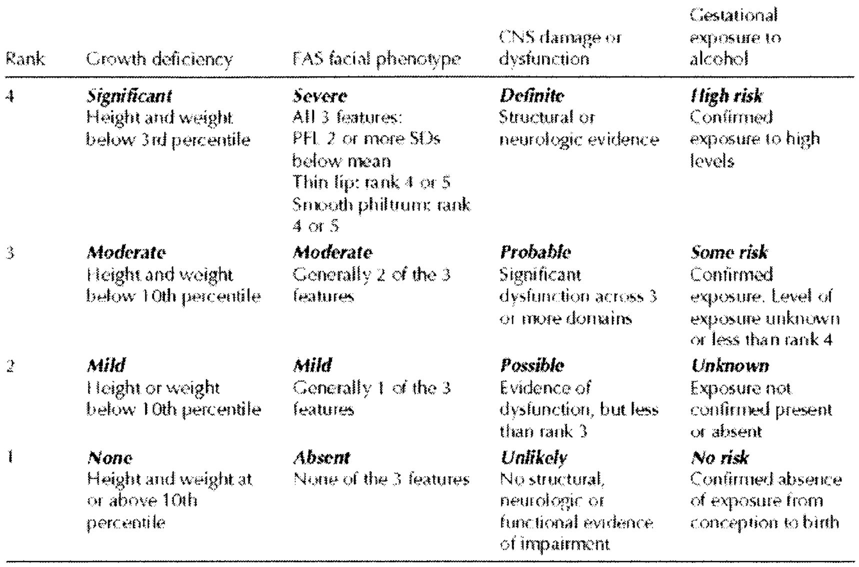
   Ocular
   Strabismus
   Retinal vascular anomalies
   Refractive problems secondary to small globes

   Auditory
   Conductive hearing loss
   Neurosensory hearing loss

   Other
   Virtually every malformation has been described in some patient with FAS. The etiologic specificity of most of these anomalies to alcohol teratogenesis remains uncertain.
5. *Alcohol-related neurodevelopmental disorder (ARND)*

   Presence of A or B or both.
   - A. Evidence of CNS neurodevelopmental abnormalities, as in any one of the following:
     - decreased cranial size at birth
     - structural brain abnormalities (e.g., microcephaly, partial or complete agenesis of the corpus callosum, cerebellar hypoplasia)
     - neurologic hard or soft signs (as age appropriate), such as impaired fine motor skills, neurosensory hearing loss, poor tandem gait, poor eye-hand coordination
   - B. Evidence of a complex pattern of behaviour or cognitive abnormalities that are inconsistent with developmental level and cannot be explained by familial background or environment alone: e.g., learning difficulties: deficits in school performance; poor impulse control; problems in social perception; deficits in higher level receptive and expressive language; poor capacity for abstraction or metacognition; specific deficits in mathematical skills; or problems in memory, attention or judgment.

Appendix A.2
4-Digit Diagnostic Code Criteria for FASD



Rank	Growth deficiency	FAS facial phenotype	CNS damage or dysfunction	Gestational exposure to alcohol
4	***Significant*** Height and weight below 3rd percentile	***Severe*** All 3 features: PFL 2 or more SDs below mean Thin lip: rank 4 or 5 Smooth philtrum: rank 4 or 5	***Definite*** Structural or neurologic evidence	***High risk*** Confirmed exposure to high levels
3	***Moderate*** Height and weight below 10th percentile	***Moderate*** Generally 2 of the 3 features	***Probable*** Significant dysfunction across 3 or more domains	***Some risk*** Confirmed exposure. Level of exposure unknown or less than rank 4
2	***Mild*** Height or weight below 10th percentile	***Mild*** Generally 1 of the 3 features	***Possible*** Evidence of dysfunction, but less than rank 3	***Unknown*** Exposure not confirmed present or absent
1	***None*** Height and weight at or above 10th percentile	***Absent*** None of the 3 features	***Unlikely*** No structural, neurologic or functional evidence of impairment	***No risk*** Confirmed absence of exposure from conception to birth

Borrowed from Chudley et al., 2005

Appendix A.3
Canadian Recommendations for Diagnostic Criteria for FAS, partial FAS, and ARND

1. Fetal Alcohol Syndrome (FAS)	A. Evidence of prenatal or postnatal growth impairment in at least 1 of: - Birth weight or length < 10th percentile - Height or weight < 10th percentile - Disproportionately low weight-to-height ratio (= 10th percentile). B. Simultaneous presentation of all 3 of the following facial anomalies: - Short palpebral fissures (> 2SD below mean) - Smooth or flattened philtrum (rank 4 or 5 on the lip-philtrum guide) - Thin upper lip (rank 4 or 5 on the lip-philtrum guide). C. Evidence of impairment in 3 or more of the following CNS domains: - hard and soft neurologic signs; brain structure; cognition; communication; academic achievement; memory; executive functioning and abstract reasoning; attention deficit/hyperactivity; adaptive behaviour, social skills, social communication. D. Confirmed (or unconfirmed) maternal alcohol exposure
2. Partial Fetal Alcohol Syndrome (pFAS)	B. Simultaneous presentation of 2 of the following facial anomalies: - Short palpebral fissures (> 2SD below mean) - Smooth or flattened philtrum (rank 4 or 5 on the lip-philtrum guide) - Thin upper lip (rank 4 or 5 on the lip-philtrum guide). C. Evidence of impairment in 3 or more of the following CNS domains: - hard and soft neurologic signs; brain structure; cognition; communication; academic achievement; memory; executive functioning and abstract reasoning; attention deficit/hyperactivity; adaptive behaviour, social skills, social communication. D. Confirmed maternal alcohol exposure
3. Alcohol-Related Neurodevelopmental Disorder (ARND)	C. Evidence of a complex pattern of behaviour or cognitive abnormalities that are inconsistent with developmental level and cannot be explained by familial background or environment alone – e.g., learning difficulties, deficits in school performance, poor impulse control, problems in social perception, deficits in higher level receptive and expressive language, poor capacity for abstraction or metacognition, specific deficits in math skills, problems in memory, attention, or judgment D. Confirmed maternal alcohol exposure
4. Alcohol-related birth defects (ARBD)	It is recommended that the term alcohol-related birth defects (ARBD) should not be used as an umbrella or diagnostic term, for the spectrum of alcohol effects. ARBD constitutes a list of congenital anomalies, including malformations and dysplasias and should be used with caution

Adapted from Chudley et al., 2005

Appendix B
Outcome Parameters Hypothesized to Change with Training

Direct Measures of Attention

I. Sustained Attention

a. Auditory Sustained Attention (TEA-Ch Score & Code Transmission subtests). Parameters recorded include the number of correct responses. It was hypothesized that children receiving SA training would increase in the number of correct responses (accuracy) at post-test.

b. Visual Sustained Attention (KiTAP Ghosts' Ball subtest). Parameters recorded included correct responses, errors of commission and omission, mean, median, and variability of response time. It was hypothesized that children receiving SA training would increase in number of correct responses, and consequently decrease in errors of omission and commission at post-test. In addition, it was expected that RT and variability of response time would decrease (i.e., mean, median, and standard deviation of RT).

II. Selective Attention

a. Self-paced and experimenter-timed visual search tasks (TEA-Ch Sky Search & Map Mission subtests). Parameters recorded include correct responses and processing efficiency or selective attention composite (time/target for targets with distracters). It was hypothesized that children would show some improvement across both subtests, given that the sustained attention visual search tasks of the Pay Attention are somewhat similar to these outcome measures.

b. Distractibility Tasks (KiTAP Happy/Sad Ghost). Parameters recorded included correct responses, errors of commission and omission, mean, median, and variability of response time for trials with and without distracter, and overall trials. It was hypothesized that children receiving SA training would show an increase in number of correct responses, and consequently a decrease in errors of omission and commission at post-test. In addition, it was expected that RT and variability of response time would decrease. Moreover, it was predicted that this effect would be stronger for trials without distracters than trials with distracters, as children were not directly trained to ignore distracters.

III. Alternating Attention
   a. Attentional Control/Switch (TEA-Ch Creature Counting). Parameters recorded include total correct responses and time per target or speed of response. While sustained attention is a necessary component of this higher-order attentional component and sustained attention training should improve performance on some level, it was not clear that these effects would be strong enough to change post-test performance scores. This is particularly the case given the requirement for higher level manipulation of information in working memory and attentional flexibility that are important in this type of task.
   b. Flexibility (KiTAP Dragons' Castle). Parameters recorded included correct responses, errors of omission, mean, median, and variability of response time. Predicted results are as described above in III a.

IV. Divided Attention
   a. Divided Attention (KiTAP The Owls subtest). Parameters recorded included correct responses, errors of omission and commission, mean, median, and variability of response time for both visual and auditory trials. Similar to the alternating attention task, sustained attention training should have some effect on overall attentional ability. However, it was not expected that this effect would transfer to a higher-order measure of divided attention that include processing of simultaneous auditory and visual targets.

Indirect Measures of Attention and Executive Functioning

I. ADDES
   a. Attention subscale. While difficult to know whether the effects of training would be strong enough to generalize to classroom behaviour, improved ratings were expected on items assessing attention following sustained attention training.
   b. Hyperactivity/Impulsivity subscale. While it was expected that sustained attention training may improve impulsive behaviours, but not those behaviours due to hyperactivity, this subscale includes a high degree of hyperactivity markers along with impulsivity markers. As such, an improved score following sustained attention training was not expected on this subscale. It was felt that any hyperactive markers noted for children would outweigh any effects of training on impulsive behaviour.

II. BRIEF

a. Inhibit. Because this parameter deals with the ability to control impulses and control cognitive or behavioural impulses, some change was expected following sustained attention training sessions. Many of the training activities in which children were engaged involved the ability to stop behaviour (for example not pressing a buzzer for a non-target, in order to avoid errors of commission). The behaviours assessed with the BRIEF inhibit parameter are not confounded by hyperactivity markers (as is the case for the hyperactivity/impulsivity scale of the ADDES), hence effects of training may be expected to generalize to this subscale.
b. Shift. This higher order alternating attention component includes behaviours that enhance smooth transitions between situations, activities, aspects of a problem and includes problem solving flexibility. These types of behaviour were not directly targeted through sustained attention training, and while sustained attention is an important ability in higher-order processing, differential changes were not expected at post-test.
c. Emotional Control. The ability to modulate emotional responses appropriately hinges on many parameters that not only include self-regulatory abilities (which would incidentally be practiced through attention training by learning to not impulsively press the buzzer at inappropriate times), but also more complex mental health considerations, such as infant attachment relationships. As such, a differential change in performance following sustained attention training was not expected on this parameter.
d. Initiate. Children's ability to begin a task or generate ideas is not expected to change differentially with sustained attention training.
e. Working Memory. Sustained attention incorporates the notion of working memory (Sohlberg & Mateer, 1989). It involves holding information in mind for the purpose of completing a task, or staying power. In addition previously identified Sustained and Working Memory subscales were unified into one scale because they were highly correlated (Gioia et al., 2000). As such, it was expected that positive changes may be noted on this parameter following sustained attention training, albeit perhaps not very large-sized effects.
f. Plan/Organize. This parameter refers to the ability to anticipate future events, set goals, develop a plan of action, carry out a plan, and clearly communicate ideas or key concepts. Ratings on this higher order executive functioning component were not expected to change differentially following sustained attention training.
g. Organization of materials. The ability of children to keep their workspace, play areas, and materials orderly depends on much more than attentional

ability. As such this parameter was not expected to change with attention training.

h. Monitor. The ability of children to check their work or assess their performance during a task and keep track of their own behaviour in order to ensure attainment of a particular goal is indirectly targeted during sustained attention training. For example, based on the number of correct or incorrect responses children make on repeated practice trials they would have to adopt internal strategies for ensuring that errors decreased and correct responses increased on subsequent trials. These strategies would entail a degree of self-monitoring and behavioural correction on their part in order to progress through the practice sessions. While these types of strategies were not directly trained, it was expected that children would engage in this self-monitoring, which might then transfer to classroom behaviour.

Verbal and Non-verbal Reasoning

I. CTONI. The CTONI is composed of three non-verbal subscales that include geometric and pictorial stimuli. Because non-verbal reasoning is dependent on attentional function and the ability to visually sustain attention to the testing stimuli, and because even simple sustained attention is closely related to higher order attentional functions such as working memory, some change in performance would be expected for the geometric, pictorial, and non-verbal IQ composite following sustained attention training.

II. KBIT2. The KBIT2 is composed of a verbal and non-verbal scale. It is hypothesized that as with the CTONI, changes in performance may be evident following sustained attention training on the non-verbal scale. In contrast, the verbal attention subscale that assesses more crystallized intelligence is not expected to change at post-test.

Appendix C
Parent Consent & Child Assent Form

Faculty of Medicine, Schools of Nursing and Pharmacy of Memorial University of Newfoundland; Health Care Corporation, St. John's; Newfoundland Cancer Treatment and Research Foundation

Consent to Take Part in Health Research

TITLE: **Attention Process Training for Young Children with Fetal Alcohol Spectrum Disorders**

INVESTIGATOR(S): **R. Vernescu, M.Sc., Dr. M. Courage, Dr. P. Canning, Dr. T. Rosales**

You have been asked to take part in a research study. It is up to you to decide whether to be in the study or not. Before you decide, you need to understand what the study is for, what risks you might take and what benefits you might receive. This consent form explains the study.

The researchers will:

- **discuss the study with you**
- **answer your questions**
- **keep confidential any information which could identify you personally**
- **be available during the study to deal with problems and answer questions**

You should feel free to decline our request for your child's participation in this intervention study. If you decide not to take part or to leave the study this will not affect you or your child's status or access to health or educational services

1. Introduction/Background:

Children with Fetal Alcohol Disorders have difficulty with attention. These difficulties influence performance at home and at school. Studies have shown that intervention programs that target specific attention components are helpful in improving attention in general. These improvements sometimes generalize to other activities (for example, reading ability, academic, and work performance). Improvement has been seen in children with ADHD. To date, there has not been any similar study completed with children with Fetal Alcohol Disorders.

2. Purpose of study:

We are conducting this study because we hope to reduce the attentional problems of children with Fetal Alcohol Disorders. Individualized attention training programs may be used to see if children with attention difficulties can improve on measures of attention and school related tasks. This study will be completed as a part of a PhD Dissertation.

3. Description of the study procedures and tests:

The primary investigator (Roxana Vernescu) or a research assistant associated with the study will work with your child. Your child will be assigned a study code and information will be kept under lock and key, such that identifying details about your child will be available only to the primary researchers. No personally identifiable information about you or your family will be retained following the completion of the study.

Your child will be assessed on measures of attention and school related activities and either undergo an attention training program or receive one-on-one support in areas of identified academic difficulty such as reading or math. This training or support will be provided over a period of 2-3 weeks. Your child will meet with a researcher 4-5 times per week, for 30 minutes each time. Anyone meeting with your child will have a clear record of conduct and will have obtained a certificate of conduct from the RNC. Your child will work on tasks that are structured to improve attention or reading and math activities.

These tasks may be computer games, pencil-and-paper games, or listening games. We will ask you and your child's teachers to answer questions about his/her behaviour and daily activities. This will help us understand the effects of our intervention on your child's school-related behaviour. We will measure your child's progress at the beginning and end of the study. Each assessment will take approximately 2.5-3 hours to complete. At your request, we will provide you with information about your child's results, as well as the results of the study, at the completion of the study.

4. Length of time:

The study will take approximately 2-3 weeks. Training and assessment sessions will be conducted in your child's school. When in school, your child will be excused from class and meet with a researcher one-on-one during these sessions. We may request to work with your child after school or on weekends during the assessment phases of the study.

5. Possible risks and discomforts:

All tasks will be fun and appealing. Children are expected to enjoy these game-like tasks. If at any point you or your child is not comfortable or requests a break, we will stop the sessions without delay. Your child will not be asked to answer any questions with which he/she feels uncomfortable. Assessment or training will only resume if your child is freely willing to continue. Your child will not be at any anticipated risk at any point during our study.

6. Benefits:

While it is hoped that your child will improve from this intervention, it is not known whether this study will benefit you or your child.

7. Liability statement:

Signing this form gives us your consent to be in this study. It tells us that you understand the information about the research study. When you sign this form, you do not give up your legal rights. Researchers or agencies involved in this research study still have their legal and professional responsibilities.

8. Questions:

If you have any questions about taking part in this study, you can meet with the investigator who is in charge of the study at this institution. That person is:

Roxana Vernescu – 754-0425; Email rox@play.psych.mun.ca

or Mary Courage – 737-8027; Email mcourage@mun.ca

Or you can talk to someone who is not involved with the study at all, but can advise you on your rights as a participant in a research study. This person can be reached through

Office of the Human Investigation Committee (HIC) at 709-777-6974
Email: hic@mun.ca

Signature Page

Study title: Attention Process Training for Young Children with Fetal Alcohol Spectrum Disorders
Name of principal investigator: Roxana Vernescu

<u>To be filled out and signed by the participant:</u>

Please check as appropriate:

I have read the consent [and information sheet]. Yes { } No { }
I have had the opportunity to ask questions/to discuss this study. Yes { } No { }
I have received satisfactory answers to all of my questions. Yes { } No { }
I have received enough information about the study. Yes { } No { }
I have spoken to Roxana Vernescu and she has answered my questions Yes { } No { }
I understand that I am free to withdraw from the study Yes { } No { }

- at any time
- without having to give a reason
- without affecting my child's health care or educational status

I understand that my child and I will not have to answer any questions with which we are not comfortable Yes { } No { }
I understand that it is my choice to be in the study and that I may not benefit. Yes { } No { }
I agree that the study investigator may be granted access to parts of my child's record which are relevant to the study. Yes { } No { }
I agree that the study doctor or investigator may contact my child's teacher to obtain information regarding my child's behaviour in school. Yes { } No { }
I understand that a signed "Release of Information" form will be needed for the researcher to obtain this information from my child's school (form attached). Yes { } No { }
I agree to take part in this study. Yes { } No { }

__________________________ ____________________
Signature of participant Date

__________________________ ____________________
Signature of witness Date

To be signed by the investigator:

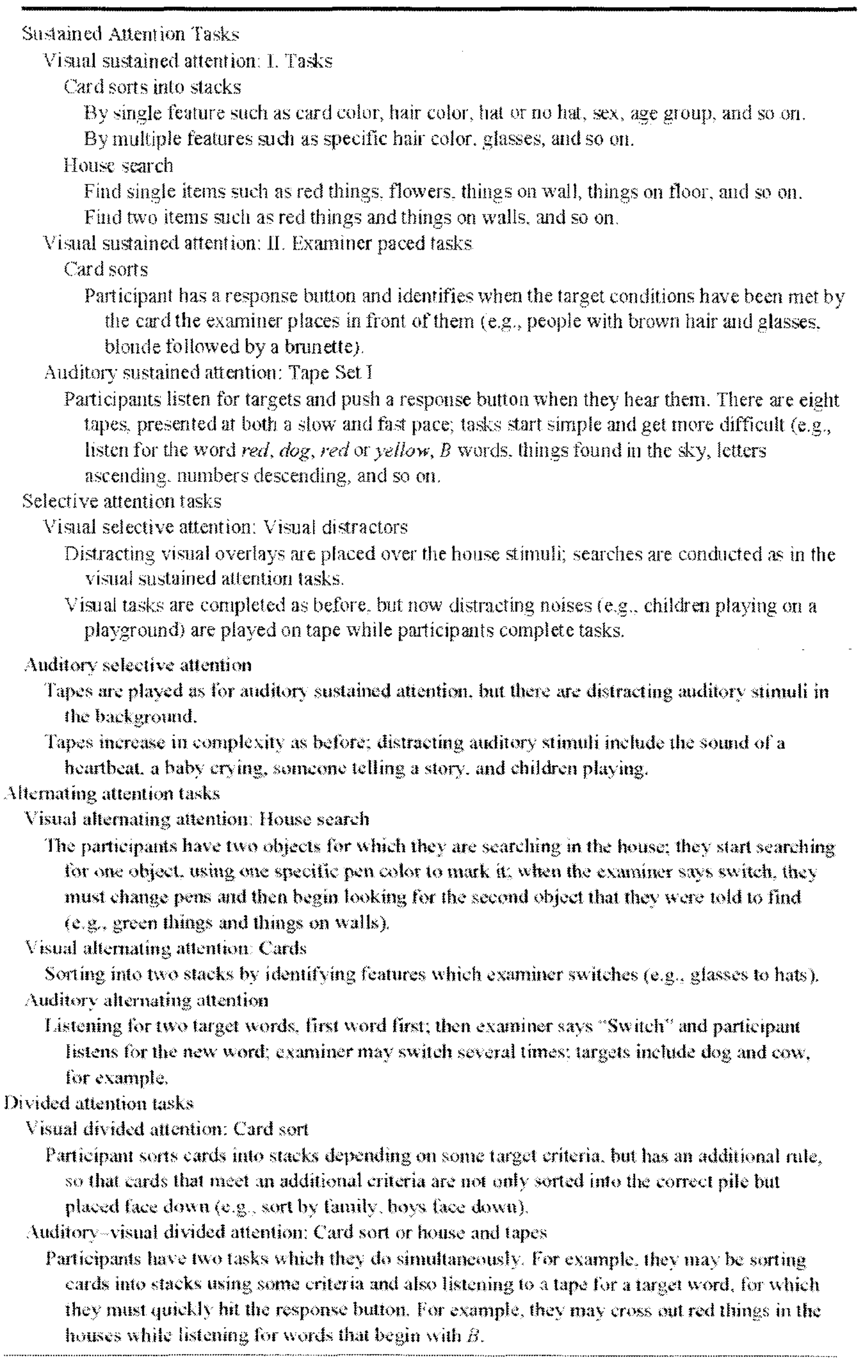
I have explained this study to the best of my ability. I invited questions and gave answers. I believe that the participant fully understands what is involved in being in the study, any potential risks of the study and that he or she has freely chosen to be in the study.

Signature of investigator	Date	Telephone Number:

Assent of minor participant (if appropriate):

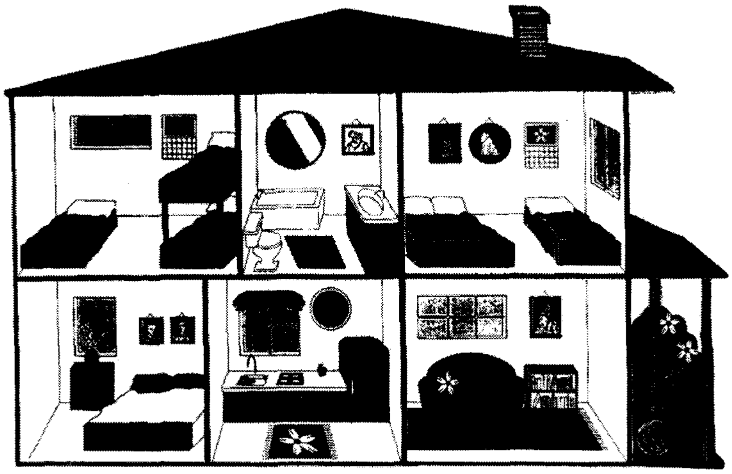
Signature of minor participant	Date	Relationship to participant

Appendix D
Pay Attention Training Materials



- Sustained Attention Tasks
  - Visual sustained attention: I. Tasks
    - Card sorts into stacks
      - By single feature such as card color, hair color, hat or no hat, sex, age group, and so on.
      - By multiple features such as specific hair color, glasses, and so on.
    - House search
      - Find single items such as red things, flowers, things on wall, things on floor, and so on.
      - Find two items such as red things and things on walls, and so on.
  - Visual sustained attention: II. Examiner paced tasks
    - Card sorts
      - Participant has a response button and identifies when the target conditions have been met by the card the examiner places in front of them (e.g., people with brown hair and glasses, blonde followed by a brunette).
  - Auditory sustained attention: Tape Set I
    - Participants listen for targets and push a response button when they hear them. There are eight tapes, presented at both a slow and fast pace; tasks start simple and get more difficult (e.g., listen for the word *red, dog, red* or *yellow, B* words, things found in the sky, letters ascending, numbers descending, and so on.
- Selective attention tasks
  - Visual selective attention: Visual distractors
    - Distracting visual overlays are placed over the house stimuli; searches are conducted as in the visual sustained attention tasks.
    - Visual tasks are completed as before, but now distracting noises (e.g., children playing on a playground) are played on tape while participants complete tasks.
  - Auditory selective attention
    - Tapes are played as for auditory sustained attention, but there are distracting auditory stimuli in the background.
    - Tapes increase in complexity as before; distracting auditory stimuli include the sound of a heartbeat, a baby crying, someone telling a story, and children playing.
- Alternating attention tasks
  - Visual alternating attention: House search
    - The participants have two objects for which they are searching in the house; they start searching for one object, using one specific pen color to mark it; when the examiner says switch, they must change pens and then begin looking for the second object that they were told to find (e.g., green things and things on walls).
  - Visual alternating attention: Cards
    - Sorting into two stacks by identifying features which examiner switches (e.g., glasses to hats).
  - Auditory alternating attention
    - Listening for two target words, first word first; then examiner says "Switch" and participant listens for the new word; examiner may switch several times; targets include dog and cow, for example.
- Divided attention tasks
  - Visual divided attention: Card sort
    - Participant sorts cards into stacks depending on some target criteria, but has an additional rule, so that cards that meet an additional criteria are not only sorted into the correct pile but placed face down (e.g., sort by family, boys face down).
  - Auditory–visual divided attention: Card sort or house and tapes
    - Participants have two tasks which they do simultaneously. For example, they may be sorting cards into stacks using some criteria and also listening to a tape for a target word, for which they must quickly hit the response button. For example, they may cross out red things in the houses while listening for words that begin with *B*.

Adapted from Kerns et al., 1999



Adapted from Kerns et al., 1999

Appendix E
Performance on Pre-Training Measures

Appendix E.1
Pre-Training Performance on TEA-Ch Subtests.

Measure	Sustained Attention Group M	Sustained Attention Group SD	Contact Control Group M	Contact Control Group SD	t score (sig. 2-tailed)
Sustained Attention (Auditory)					
Score: Correct Responses (raw)	4.70	2.31	6.10	2.60	-1.27
Correct Responses (scaled)	4.70	2.00	6.40	3.89	-1.23
Code Transmission:					
Correct Responses (raw)	24.30	3.33	27.70	4.42	-1.94
Correct Responses (scaled)	3.20	2.30	4.10	2.56	-.83
Selective Attention					
Sky Search:					
Correct Responses (raw)	16.50	2.68	17.00	2.54	-.43
Correct Responses (scaled)	8.50	3.27	9.00	3.16	-.35
Attention Composite – RT (raw)	7.34	4.15	6.76	3.42	.34
Attention Composite – RT (scaled)	5.80	3.85	6.50	3.98	-.40
Map mission:					
Correct Responses (raw)	36.40	12.65	32.50	10.76	.74
Correct Responses (scaled)	9.70	4.08	7.50	3.72	1.26
Alternating Attention					
Creature Counting:					
Correct Responses (raw)	2.10	2.23	1.80	1.14	.38
Correct Responses (scaled)	5.50	2.55	4.20	1.81	1.31

Notes: The Map Mission subtest is a 1-minute experimenter-timed subtest; The Sky Search subtest is a self-paced subtest; t values represent the differences between groups on pre-training measures; Significance values reported only when significant at $p<.05$; Standardized performance is expressed in scaled scores (M=10, SD=3).

Appendix E.2
Pre-Training Performance on KiTAP Visual Sustained Attention (the Ghosts' Ball).

Measure	Sustained Attention Group M	Sustained Attention Group SD	Contact Control Group M	Contact Control Group SD	t score (sig. 2-tailed)
Visual Sustained Attention (1st half: 0-5min)					
Correct Responses	17.20	4.64	18.70	4.42	-.74
Errors of Commission	14.60	12.85	11.50	11.55	.57
Errors of Omission	7.80	4.64	6.30	4.42	.74
Mean Response Time	751.50	106.06	803.90	149.45	-.90
Median Response Time	707.40	86.46	790.30	168.22	-1.39
Variability of Response Time	241.00	130.50	244.40	114.89	-.06
Visual Sustained Attention (2nd half: 5-10min)					
Correct Responses	16.20	1.93	14.80	5.37	.78
Errors of Commission	13.60	18.37	8.20	6.41	.88
Errors of Omission	8.80	1.93	10.20	5.37	-.78
Mean Response Time	809.20	134.13	881.30	190.18	-.98
Median Response Time	769.60	129.22	845.30	198.25	-1.01
Variability of Response Time	268.70	76.44	255.20	128.66	.29
Visual Sustained Attention (Overall: 0-10min)					
Correct Responses	33.40	5.36	33.50	9.64	-.03
Errors of Commission	28.50	29.71	19.80	17.49	.80
Errors of Omission	16.60	5.36	16.50	9.64	.03
Mean Response Time	773.60	112.37	818.40	150.65	-.75
Median Response Time	751.80	99.53	804.10	168.55	-.85
Variability of Response Time	239.00	86.61	234.90	80.69	.11
Errors of Commission (T)	33.75	7.57	34.14	10.09	Nc
Errors of Omission (T)	35.13	3.68	35.43	10.37	Nc
Median Response Time (T)	48.00	8.12	45.00	9.94	Nc

Notes: t values represent the differences between groups on pre-training measures; Significance values reported only when significant at $p<.05$; Standardized scores are presented as T values (M=50, SD=10); Nc = values not calculated due to incomplete Ss numbers for these scaled parameters (15, 6-10 year old Ss).

Appendix E.3
Pre-Training Performance on KiTAP Selective Attention (Happy-Sad Ghost).

Measure	Sustained Attention Group M	Sustained Attention Group SD	Contact Control Group M	Contact Control Group SD	t score (sig. 2-tailed)
Selective Attention (trials with distracter stimuli)					
Correct Responses	17.10	1.37	16.30	3.53	.67
Errors of Commission	10.40	4.60	8.40	3.81	1.06
Errors of Omission	2.90	1.37	3.70	3.53	-.67
Mean Response Time	865.50	435.00	797.30	338.75	.39
Median Response Time	585.40	375.67	650.40	406.93	-.37
Variability of Response Time	681.10	494.83	533.50	367.63	.76
Errors of Commission (T)	35.38	11.81	40.43	9.02	Nc
Errors of Omission (T)	45.75	3.37	48.43	11.14	Nc
Median Response Time (T)	53.00	14.35	50.29	12.09	Nc
Selective Attention (trials with no distracter stimuli)					
Correct Responses	18.70	1.34	17.70	3.09	.94
Errors of Commission	12.60	4.65	8.80	3.91	1.98
Errors of Omission	1.30	1.34	2.30	3.09	-.94
Mean Response Time	504.70	130.90	573.80	129.80	-1.19
Median Response Time	407.10	125.41	556.70	114.29	-2.79 (.012)
Variability of Response Time	307.60	235.15	214.90	142.09	1.07
Errors of Commission (T)	34.00	6.04	40.71	8.83	Nc
Errors of Omission (T)	48.38	7.96	46.00	10.39	Nc
Median Response Time (T)	63.00	10.60	49.86	8.34	Nc

Appendix E.3 continued

Selective Attention (all trials)					
Correct Responses	35.80	2.15	34.00	6.39	.84
Errors of Commission	23.00	8.37	17.20	7.46	.1.64
Errors of Omission	4.20	2.15	6.00	6.39	-.84
Mean Response Time	628.80	258.54	638.90	194.54	-.10
Median Response Time	425.80	134.09	572.50	182.04	-2.05
Variability of Response Time	461.00	366.46	320.20	213.55	1.05
Errors of Commission (T)	31.50	9.84	39.00	11.34	Nc
Errors of Omission (T)	47.38	4.60	47.14	11.20	Nc
Median Response Time (T)	61.38	11.26	50.29	10.99	Nc

Notes: t values represent the differences between groups on pre-training measures; Significance values reported only when significant p<.05; Standardized scores are presented as T values (M=50, SD=10). Nc = t values not calculated due to incomplete Ss numbers for these parameters (15, 6-10 year old Ss).

Appendix E.4
Pre-Training Performance on KiTAP Alternating Attention (Dragons' Castle).

Measure	Sustained Attention Group M	Sustained Attention Group SD	Contact Control Group M	Contact Control Group SD	t score (sig. 2-tailed)
Alternating Attention					
Correct Responses	33.20	10.39	34.90	4.98	.65
Errors of Commission	7.40	4.67	6.80	2.49	.73
Mean Response Time	1417.10	429.44	1420.40	532.25	.99
Median Response Time	1262.20	317.92	1296.60	389.20	.83
Variability of Response Time	597.00	392.42	704.10	570.65	.63
Errors of Commission (T)	38.75	14.12	34.86	5.93	Nc
Median Response Time (T)	48.75	13.73	43.43	10.56	Nc
Variability of Response Time (T)	45.38	12.58	37.86	12.27	Nc

Notes: t values represent the differences between groups on pre-training measures; Significance values reported only when significant p<.05; Standardized scores are presented as T values (M=50, SD=10). Nc = t values not calculated due to incomplete Ss numbers for these parameters (15, 6-10 year old Ss).

Appendix E.5
Pre-training Performance on KiTAP Divided Attention (the Owls)

Measure	Sustained Attention Group M	Sustained Attention Group SD	Contact Control Group M	Contact Control Group SD	t score (sig. 2-tailed)
Divided Attention (auditory trials)					
Correct Responses	8.60	8.86	11.20	6.11	-.76
Errors of Commission	4.10	2.92	8.60	8.51	-1.58
Errors of Omission	11.40	8.86	8.80	6.11	.76
Mean Response Time	841.10	450.19	776.70	301.46	.38
Median Response Time	877.40	119.08	836.22	160.39	.50
Variability of Response Time	229.50	248.66	222.50	135.62	.08
Divided Attention (visual trials)					
Correct Responses	18.50	1.84	17.30	1.64	1.54
Errors of Commission	5.50	5.25	9.60	6.17	-1.60
Errors of Omission	1.50	1.84	2.70	1.64	-1.54
Mean Response Time	748.30	136.00	810.90	91.67	-1.21
Median Response Time	716.40	138.85	759.60	78.92	-.86
Variability of Response Time	204.80	57.92	260.70	92.05	-1.63
Divided Attention (all trials)					
Correct Responses	27.10	8.27	28.50	5.38	-.45
Errors of Commission	9.60	7.83	18.20	13.57	-1.74
Errors of Omission	12.90	8.27	11.50	5.38	.45
Mean Response Time	773.30	126.23	819.80	90.11	-.95
Median Response Time	723.50	130.18	782.20	68.94	-1.26
Variability of Response Time	240.80	62.45	252.30	71.22	-.38
Errors of Commission (T)	45.13	4.76	39.14	8.49	Nc
Errors of Omission (T)	38.88	10.22	38.14	4.38	Nc
Median Response Time (T)	54.38	13.29	48.57	7.11	Nc

Notes: t values represent the differences between groups on pre-training measures; Significance values reported only when significant, $p<.05$; Standardized scores are presented as T values (M=50, SD=10). nc = t values not calculated due to incomplete Ss numbers for these parameters (15, 6-10 year old Ss).

Appendix E.6
Pre-Training Performance on ADDES-3-SV & BRIEF Scales

	Sustained Attention Group		Contact Control Group		t score (sig. 2-
Measure	**M**	**SD**	**M**	**SD**	**tailed)**
ADDES-3					
Inattention (raw)	75.67	16.60	79.30	24.94	-.37
Inattention (scaled)	8.44	2.24	7.60	2.37	.80
Hyperactivity (raw)	49.22	20.67	57.50	23.18	-.82
Hyperactivity (scaled)	10.67	2.45	10.10	1.73	.59
Attention/Hyperactivity Quotient	96.33	10.62	92.60	8.58	.85
BRIEF					
Inhibit (raw)	18.00	6.54	18.50	5.25	-.19
Shift (raw)	17.22	3.56	16.90	3.78	.19
Emotional Control (raw)	15.33	6.40	14.80	4.73	.21
Behavioural Regulation (raw)	50.22	14.58	50.20	12.85	.00
Initiate (raw)	17.00	1.32	16.40	3.57	.48
Working Memory (raw)	23.44	3.81	22.90	5.17	.26
Plan/Organize (raw)	20.56	3.00	21.80	4.13	-.74
Organization of Materials (raw)	12.89	3.82	11.70	3.95	.67
Monitor (raw)	19.89	5.13	22.50	4.01	-1.24
Metacognition (raw)	93.78	13.85	95.30	17.46	-.21
Global Executive Composite (raw)	144.00	27.69	145.50	29.94	-.11
Inhibit (T)	66.00	22.54	70.20	17.04	-.46
Shift (T)	68.22	15.36	67.30	15.11	.13
Emotional Control (T)	65.11	21.65	66.20	18.03	-.12
Behavioural Regulation (T)	68.22	21.70	70.10	17.01	-.21
Initiate (T)	75.56	8.59	73.60	12.19	.40
Working Memory (T)	79.33	16.45	78.80	16.60	.07
Plan/Organize (T)	69.33	10.43	73.40	12.13	-.78
Organization of Materials (T)	66.89	15.74	64.40	14.53	.36
Monitor (T)	68.33	17.33	77.90	14.67	-1.30
Metacognition (T)	74.89	13.83	77.40	13.62	-.40
Global Executive Composite (T)	74.00	17.67	76.70	15.83	-.35

Notes: t values represent the differences between groups on pre-training measures; Significance values reported only when significant, p<.05; Standardized scores are presented as scaled scores (M=10, SD=3), T values (M=50, SD=10) and Quotient (M=100, SD=15)

Appendix E.7
Pre-Training Performance on Verbal & Non-Verbal Reasoning (CTONI & KBIT2)

	Sustained Attention Group			Contact Control Group			t* score (sig. 2-tailed)
Measure	**M**	**SD**	**Range**	**M**	**SD**	**Range**	
CTONI - NIQ	91.90	10.98	74-107	89.80	11.15	69-102	-.42
CTNOI - PNIQ	88.90	12.14	68-104	89.10	9.64	72-102	.04
CTONI - GNIQ	95.60	8.78	83-109	91.80	12.79	70-106	-.78
KBIT2 - COMP	77.40	16.25	50-105	70.80	8.94	57-82	-1.13
KBIT2 - VIQ	75.00	14.12	56-107	69.20	8.20	58-84	-1.12
KBIT2 - NIQ	85.50	17.21	52-106	79.90	11.06	63-97	-.87

Notes: t values represent the differences between groups on pre-training measures; Significance values reported only when significant, p <.05; Standardized scores are expressed in IQ scores (M=100, SD=15); CTONI = Comprehensive Test of Non-Verbal Intelligence; NIQ = Non-Verbal IQ; PNIQ = Pictorial Non-Verbal IQ; GNIQ = Geometric Non-Verbal IQ; KBIT2 = Kaufman Brief Intelligence Test (2nd Edition); COMP = IQ Composite; VIQ = Verbal IQ.

Appendix F
Performance on Post-Training Measures: Significant Training Effects

Appendix F.1
Changes in Performance on TEA-Ch Subtests

	Sustained Attention Group		t score (sig. 2-tailed)	Contact Control Group		t score (sig. 2-tailed)
Measure	**Pre-test M(sd)**	**Post-test M(sd)**		**Pre-test M(sd)**	**Post-test M(sd)**	
Auditory Sustained Attention						
Score:	4.70	8.30	-4.47	6.10	5.90	.32
Correct Responses (raw)	(2.31)	(1.16)	(.002)	(2.60)	(2.77)	(.758)
Correct Responses (scaled)	4.70	9.40	-5.95	6.40	6.40	.00
	(2.00)	(2.59)	(.000)	(3.89)	(3.34)	(1.00)
Code Transmission:						
Correct Responses (raw	12.60	18.10	-9.45	15.00	13.90	1.13
0-7min)	(1.89)	(1.52)	(.000)	(2.91)	(2.77)	(.287)
Correct Responses (raw	11.70	17.30	-8.81	12.30	12.10	.11
7-14min)	(2.63)	(1.89)	(.000)	(3.09)	(3.98)	(.915)
Correct Responses (raw	24.30	35.40	-13.72	27.70	26.10	.86
0-14min)	(3.33)	(3.13)	(.000)	(4.42)	(5.59)	(.413)
Correct Responses (scaled	3.20	8.70	-8.41	4.10	3.70	.58
0-14min)	(2.30)	(2.83)	(.000)	(2.56)	(3.43)	(.574)
Selective Attention						
Sky Search:	7.34	4.70	2.44	6.76	6.06	1.42
Attention composite – RT (raw)	(4.15)	(1.61)	(.037)	(3.41)	(2.89)	(.188)
Attention composite – RT	5.80	8.80	-3.11	6.50	7.20	-1.17
(scaled)	(3.85)	(1.87)	(.013)	(3.98)	(3.91)	(.271)
Alternating Attention (Attentional Control/Switch)						
Creature Counting:	2.10	5.00	-4.80	1.80	3.30	-3.74
Correct Responses (raw)	(2.23)	(2.05)	(.001)	(1.14)	(1.94)	(.005)
Correct Responses	5.50	9.70	-4.85	4.20	6.70	-3.16
(scaled)	(2.55)	(2.91)	(.001)	(1.81)	(2.79)	(.012)

Notes: The Map Mission subtest is a 1-minute experimenter-timed subtest; The Sky Search subtest is a self-paced subtest; t values represent the differences between pre- and post-training performance; Standardized performance is expressed in scaled scores (M=10, SD=3).

Appendix F.2

Changes in Performance on KiTAP Visual Sustained Attention (the Ghosts' Ball)

Measure	Sustained Attention Group Pre-test M(sd)	Sustained Attention Group Post-test M(sd)	t score (sig. 2-tailed)	Contact Control Group Pre-test M(sd)	Contact Control Group Post-test M(sd)	t score (sig. 2-tailed)
Visual Sustained Attention (1st half: 0-5min)						
Correct Responses	17.20	22.50	-4.38	18.70	17.90	.41
	(4.64)	(1.72)	(.002)	(4.42)	(3.21)	(.691)
Errors of Omission	7.80	2.50	4.38	6.30	7.10	-.41
	(4.64)	(1.72)	(.002)	(4.42)	(3.21)	(.691)
Variability of Response Time	241.00	172.20	2.10	244.40	236.30	.22
	(130.50)	(48.00)	(.065)	(114.89)	(82.00)	(.833)
Visual Sustained Attention (2nd half: 5-10min)						
Correct Responses	16.20	21.20	-4.84	14.80	11.10	1.69
	(1.93)	(2.30)	(.001)	(5.37)	(4.25)	(.126)
Errors of Omission	8.80	3.80	4.84	10.20	13.90	-1.69
	(1.93)	(2.30)	(.001)	(5.37)	(4.25)	(.126)
Visual Sustained Attention (Overall: 0-10min)						
Correct Responses	33.40	43.70	-6.68	35.50	29.00	1.13
	(5.36)	(3.09)	(.000)	(9.64)	(6.91)	(.286)
Errors of Omission	16.60	6.30	6.68	16.50	21.00	-1.13
	(5.36)	(3.09)	(.000)	(9.64)	(6.91)	(.286)
Variability of Response Time	239.00	188.70	2.22	234.90	252.10	-.59
	(86.61)	(40.75)	(.054)	(80.69)	(86.50)	(.572)

Note: t scores represent differences between pre- & post-training performance.

Appendix F.3

Changes in Performance on KiTAP Selective Attention (Happy-Sad Ghost)

	Sustained Attention Group		t score	Contact Control Group		t score
Measure	**Pre-test M(sd)**	**Post-test M(sd)**	**(sig. 2-tailed)**	**Pre-test M(sd)**	**Post-test M(sd)**	**(sig. 2-tailed)**
Selective Attention - Errors of Commission						
Trials with distracter	10.40	4.10	5.20	8.40	6.70	1.83
	(4.60)	(2.33)	(.001)	(3.81)	(3.20)	(.101)
Trials without distracter	12.60	3.60	5.84	8.80	4.40	5.28
	(4.65)	(1.65)	(.000)	(3.91)	(3.20)	(.001)
Overall	23.00	7.70	6.17	17.20	11.10	4.62
	(8.37)	(3.65)	(.000)	(7.47)	(6.08)	(.001)
Selective Attention - Median Response Time						
Trials without distracter	407.10	613.10	-10.03	556.70	591.40	-.74
	(125.41)	(119.31)	(.000)	(114.29)	(137.59)	(.480)
Overall	425.80	607.30	-6.34	572.50	571.80	.01
	(134.09)	(107.59)	(.000)	(182.04)	(130.99)	(.991)

Note: t scores represent differences between pre- & post-training performance.

Appendix F.4

Changes in Performance on Verbal and Nonverbal Reasoning

	Sustained Attention Group		t score (sig. 2-tailed)	Contact Control Group		t score (sig. 2-tailed)
Measure	**Pre-test M(sd)**	**Post-test M(sd)**		**Pre-test M(sd)**	**Post-test M(sd)**	
CTONI						
Geometric IQ	95.60	108.60	-5.41	91.80	94.30	-.84
	(8.78)	(11.92)	(.000)	(12.79)	(14.94)	(.422)
Pictorial IQ	88.90	105.90	-10.12	89.10	94.50	-1.90
	(12.14)	(11.60)	(.000)	(9.64)	(12.36)	(.090)
Non-verbal IQ Composite	91.90	107.70	-7.84	89.80	93.70	-1.34
	(10.98)	(12.17)	(.000)	(11.15)	(13.37)	(.213)
KBIT2						
Verbal IQ	75.00	77.80	-1.75	69.20	70.90	-.92
	(14.12)	(13.16)	(.113)	(8.20)	(7.28)	(.381)
Performance (Non-verbal) IQ	85.50	102.30	-3.71	79.90	90.60	-2.71
	(17.21)	(11.11)	(.005)	(11.06)	(18.19)	(.024)
IQ Composite	77.40	88.50	-3.68	70.80	78.80	-4.01
	(16.25)	(12.87)	(.005)	(8.94)	(12.00)	(.003)

Note: t scores represent differences between pre- & post-training performance.