Integrating Effective and Feasible FASD Programming in Schools: An Executive Function Intervention

by

Marnie Lenore Hutchison

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University of Alberta

Abstract

Developing appropriate and accessible services for individuals with fetal alcohol spectrum disorder (FASD) is a priority for caregivers and service providers, especially schools. For this reason, the serious game *Caribbean Quest* (CQ) was developed. CQ engages children's attention and working memory, two processes sensitive to the effects of prenatal alcohol exposure. Educational assistants have been successfully trained to deliver CQ at school and children with FASD demonstrate significant improvements on attention, working memory, and academic fluency measures following training. The current study advanced this work and used neurocognitive and neurobehavioural assessment and teacher, educational assistant, and child interviews to examine the effectiveness and feasibility of CQ under a new condition – group delivery. The most robust finding reflected improvements in basic inhibitory control, suggesting this executive function might be the most sensitive to CQ training. Teachers reported significant improvements in working memory, behaviour regulation, metacognition, and overall executive functioning following treatment, although scores remained near or in the clinically significant range. Emerging themes from educator interviews will be formative in feasibly integrating CQ as school-based intervention. Group delivery came with benefits and challenges, but the prevailing message from this study is that outcomes are similar to or better than one-on-one treatment and it offers schools a feasible means of providing intervention to many children with FASD simultaneously.

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Introduction

Children who have been exposed to alcohol *in utero* are at risk for developing a wide range of adverse cognitive, behavioural, and neurological deficits. A number of alcohol-related disabilities are associated with prenatal alcohol exposure (PAE) and the term fetal alcohol spectrum disorder (FASD) is used to collectively refer to individuals with one of several alcohol-related diagnoses. The prevalence of FASD (estimates range from 9 to 11.7 per 1000 births; Stade et al., 2009; Thanh, Jonnson, Salmon & Sebastianski, 2014), and the breadth of neurocognitive impairment caused by PAE, suggests an especially high need for educators to have opportunities to support students in meeting academic, social, emotional, and behavioural goals (Green, 2007). Early intervention has long been recognized as a protective factor for children with FASD, acting as a moderator on school disturbance, involvement with the criminal justice system, and later psychopathology (Streissguth, Barr, Kogan, & Bookstein, 1996). To date however, there are few research-based interventions available for children with FASD. Instead, caregivers, educators, and the FASD community-at-large share a desperate call for the development, evaluation, and dissemination of valid, school-based interventions that target core deficits like executive function and self-regulation (Bertrand, 2009). With this in mind, my work in this dissertation attempts to move the field forward in providing the education system with effective and feasible tools to meet the needs of children with FASD.

One line of research answering this call focuses on ‘serious games’ to target certain cognitive processes known to be impacted by PAE (Kerns, MacSween, Wekken & Gruppuso, 2010; Kerns, Macoun, MacSween, Pei & Hutchison, 2015). This dissertation extended a three-study program of research on *Caribbean Quest* (CQ), a serious game that is delivered in tandem with metacognitive training. The game consists of five cartoon-like computer games that place increasing demands on attention and working memory (WM). As the child plays, an “interventionist” works with the student to scaffold their use of metacognitive strategies.

Studies one and two established that CQ leads to improvements in attention and WM (interventionists in studies one and two were trained U of A research assistants), and study three, the capacity study, reported CQ effective when delivered by educational assistants (EAs) rather than research assistants (Kerns et al., 2015). Although effective, some educators (teachers and EAs) and administrators reported CQ would be more feasible if it could be used with more than one student at a time. Since CQ has never been delivered in groups, it is important to establish its effectiveness under this condition. Thus, the first aim of this research was to explore the effectiveness of group-delivered CQ, and to do so, I used an expanded neurocognitive and neurobehavioural test battery in combination with educator and child interviews. The second aim was to understand the feasibility of group-delivered CQ as a school-based intervention, and was explored with educator and child interviews following the completion of the intervention.

Chapter Two presents literature on the assessment and diagnostic processes, neurodevelopmental presentation, and current landscape of interventions for children with FASD. This literature review sets the stage for a review of the theoretical bases from which CQ was developed, a summary of the CQ program of research, and the goals for this dissertation. Chapter Three addresses the methods used to answer my research questions, and is followed by results in Chapter Four. An integrated discussion of neurocognitive and neurobehavioural findings with themes generated from the interviews is presented in

Chapter Five, which closes with study limitations and future directions.

Literature Review

School psychologists are key players in the success of students who are experiencing challenges in the educational environment. Some of these students may have been exposed to the adverse effects of prenatal alcohol exposure (PAE). Alcohol is a neurobehavioural teratogen, capable of disrupting normal fetal developmental and producing a wide range of adverse cognitive, behavioural, and physical outcomes. A number of alcohol-related disabilities are associated with PAE and the term fetal alcohol spectrum disorder (FASD) is used to collectively refer to individuals with one of several alcohol-related diagnoses. The incidence (14.2 to 43.8 per 1000 births) and prevalence of FASD (9 to 12 per 1000 births; Stade, 2009; Thanh et al., 2014), means that schools must be equipped with the knowledge and tools to meet the diverse needs of current and incoming students with FASD. The development, evaluation, and dissemination of evidence-based interventions for children with FASD is affected by many factors, including assessment and diagnosis of the disorder, understanding of the specific problems that arise from PAE, and understanding of optimal treatment approaches for those problems. The following literature review will discuss relevant developments in these areas, highlighting the importance of evidence-based and feasible interventions that can be delivered in the school setting.

The History of FASD

Seminal research identified a triad of features associated with PAE, including (1) facial dysmorphology reflected by microcephaly, shortened palpebral fissures, and a flattened philtrum area, (2) growth deficiency reflected in pre and/or postnatal weight and height <10^{th} percentile, and (3) central nervous system damage reflected by signs of neurological abnormality, developmental delay, and intellectual impairment (Jones &

Smith, 1973). This specific pattern of birth defects was classified as fetal alcohol syndrome (FAS), and in order to be diagnosed with FAS, impairment in all three areas was required. In the 40 years that have passed since this description, our knowledge and conceptualization of the effects of maternal alcohol consumption have expanded significantly, and in turn practices in assessment, diagnosis, and intervention have progressed. One very impactful finding was that the majority of individuals exposed to alcohol do not display all of the physical abnormalities necessary for a diagnosis of FAS; yet, they still present with significant neurodevelopmental impairments equivalent to or worse than those with FAS (Mattson, Riley, Gramling, Delis & Jones, 1998). Since the initial criteria for FAS did not account for children without facial dysmorphia, revisions to assessment and diagnostic standards were essential in order to meet the needs of the full population of individuals affected by PAE.

Several attempts have been made to diagnose the full spectrum of disorders resulting from PAE. The Institute of Medicine created a framework involving a number of diagnoses depending on the presence or absence of confirmed PAE, physical features, and central nervous system (CNS) dysfunction (1996). CNS dysfunction was evaluated on the basis of structural brain anomalies, cranial size, neurological hard and soft signs (such as impaired fine motor skills, neurosensory hearing loss, poor tandem gait, and poor hand-eye coordination), and/or evidence of a complex pattern of behaviour or cognitive abnormalities beyond what would be expected for developmental level and environment. Diagnostic recommendations included FAS (with or without confirmed PAE), partial FAS (pFAS), alcohol related neurodevelopmental disorder (ARND), and alcohol related birth defects (ARBD). All the diagnoses require confirmed PAE. Partial FAS requires evidence of some facial characteristics, and either growth, CNS deficits, or a complex pattern of behavioural or cognitive abnormalities. ARBD refers to individuals with some congenital physical abnormalities, and lastly, ARND includes those with CNS deficits or a complex pattern of behavioural or cognitive abnormalities.

The notion that PAE does not cause a dichotomous condition, rather the clinical features range along a continuum from normal to "full" FAS, is also seen in the 4-Digit Diagnostic Code for diagnosis of Fetal Alcohol Spectrum Disorders, put forth by the Fetal Alcohol Syndrome Diagnostic and Prevention Network (Astley & Clarren, 1999; Astley, 2004). This system assesses the magnitude of the expression (rather than the presence or absence as in the IOM) of the four components of the syndrome (i.e., growth impairment, facial dysmorphology, evidence of brain damage, and maternal alcohol use) on a scale from one to four. A score of one signifies normal functioning and a score of four indicates a finding reflective of "classic" cases of FAS. The four rankings are put together to form a 4-digit code, which then corresponds to a diagnosis on the spectrum (Astley, 2004).

The first edition of the Canadian guidelines for FASD diagnosis was published in 2005, and was a harmonization of the two existing systems: 4-Digit Code approach with IOM nomenclature of FAS, pFAS, and ARND (Chudley et al., 2005). The Canada FASD Network (CanFASD) and Public Health Agency of Canada embarked on a revision of these guidelines from 2012 to 2014 (CanFASD, 2012) and are due to be published in 2015. The revisions have been greatly informed by the extensive body of research elucidating the neurodevelopmental impairments associated with PAE.

Neurodevelopmental Functioning

Clinicians and caregivers often state that no two children with FASD are the same. The teratogenic effects of alcohol cause diffuse damage to the brain, and factors such as timing, duration, and amount of PAE, and the child's postnatal experiences result in diverse neurodevelopmental impairments across the FASD population (Roussotte, Soderberg & Sowell, 2010). Deficits are commonly seen in the domains of cognition (Davis, 2013), learning (Rasmussen & Bisanz, 2011), social development (Kully-Martens, Denys, Treit, Tamana & Rasmussen, 2012), memory (Pei, Job, Kully-Martens & Rasmussen, 2011; Greenbaum et al., 2009), executive function (Rasmussen & Bisanz, 2009), language (Wyper & Rasmussen, 2011), mental health (Pei, Denys, Hughes, & Rasmussen, 2011a), and adaptive living skills (Schonfeld, Paley, Frankel & O'Connor, 2006). Across these areas, performance tends to decrease as task complexity increases, which Kodituwakku (2014) terms a generalized difficulty in complex information processing. Efforts to find a common neurobehavioural phenotype in FASD are not conclusive, but studies have narrowed in on executive functions (EF) – a collection of higher-order processes – as particularly sensitive to PAE and as having significant functional implications at home, school, and the community (Mattson et al., 2010; 2013; Rasmussen, 2005; Schonfeld et al., 2006).

Conceptualizing executive functions. We owe much of our current understanding of EF to Luria (1966) who reported problem-solving behaviour was dependent on a number of overriding skills, or executive functions, which were dependent on the frontal lobes. Later, Lezak (1983) introduced the idea that human behaviour involves "knowing" (cognition) and "doing" (EF). Over time, definitions of EF have centralized around higher-order "doing" cognitive processes responsible for goal-directed behaviour in novel situations (Ardila, 2008). Emotion-related or motivational EFs (i.e., responses to reward and punishment) are also conceptualized under the EF umbrella (Zelazo & Carlson, 2012). Although a multitude of EF theories exist, there is general agreement that there are three core cognitive EFs: set shifting (a component of attention), working memory, and inhibition (Miyake, Friedman, Emerson, Witzki, and Howerter, 2000). Literature on attention and the three core EFs and the way they are impacted by PAE is reviewed next.

Attention. Attention is a multidimensional construct, involving several distinct, yet interrelated, subcomponents. Three theories used to understand attention in FASD are the clinical models of Sohlberg and Mateer (1987) and Mirsky, Anthongy, Dunca, Ahearn, and Kellam (1991) and the neuroanatomical model of Posner and Petersen (1990). Posner and Peterson (1990) break attention down into three major networks: (1) the posterior orienting system, which serves to orient one to events in one's environment; (2) the vigilance attention system, which serves to achieve and maintain one's attention in an alert state; and (3) the anterior or executive attention system, which controls and coordinates other brain regions in the execution of voluntary action. This model forms the basis of an experimental measure called the Attention Network Test (ANT). Children with FASD show slower reaction time, reduced accuracy, and impaired error detection and inhibition on the flanker test of the ANT, indicating deficits in the executive attention system (Kooistra, Crawford, Gibbard, Daplan, & Fan, 2011).

Mirsky et al.'s (1991) model includes focus (the capacity to selectively concentrate on a particular task), shift (the ability to move attention from one stimulus to another in a flexible manner), sustain (the ability to stay on task and demonstrate vigilance), encode (the capacity to hold information in memory while performing other related actions), and stable (the consistency of attentional effort). Coles and colleagues (1997) assessed children with FASD on these aspects of attention and found them to have difficulty on the encode and shift components, which were tested with the Paired Associate Task and the Wisconsin Card Sorting Test. This pattern of impairment was different from children with ADHD who were most impaired on measures of focused and sustained attention. Research also highlights the implications of poor encoding during WM tasks (i.e., on the ROCF in Pei, Job, Kully-Martens, & Rasmussen, 2011), suggesting that remediation at this level may be needed in multiple domains of cognitive functioning. Sohlberg and Mateer's (1987) model follows a similar taxonomy as Mirsky's and includes focused, sustained, selected, alternating, and divided attention. Their model is used to inform cognitive rehabilitation in the form of attention process training programs, rather than as a tool to assess attention components. Sohlberg and Mateer's model has been used to inform FASD research and will be reviewed in the intervention section of the literature review.

Working memory. Like attention, memory is a multifaceted construct, broadly known as the way we encode, store, and retrieve information for immediate use (short-term memory) or later use (long-term memory) and for information acquired without deliberate effort (procedural memory) or information we explicitly learn (declarative memory). Working memory (WM) is an aspect of declarative memory that concerns the short-term storage and manipulation of information required for diverse cognitive tasks (Baddeley & Hitch, 1974). WM is different from short-term memory (STM) in that STM is responsible for holding a small amount of information in an active, readily available state for a short period of time; whereas WM includes the processes used for doing something with that information (Cowan, 2008). Kodituwakku, Handmaker, Cutler, Weathersby, and Handmaker (1995) explored the possibility that WM deficits – and not attentional deficits as was once thought – pose as the underlying cognitive mechanism responsible for the impairments in self-regulation (i.e., distractibility, perseveration, and impulsivity) seen in FASD. Since then, numerous studies have shown that children with FASD perform poorly on tasks of WM, many of which have used Baddeley's WM model to guide their interpretations (e.g., Carmichael-Olson, Feldman, Streissguth, Sampson & Bookstein, 1998; Pei, Rinaldi, Rasmussen, Massey, & Massey, 2008).

The theoretical framework by Baddeley and Hitch (1992) breaks WM into a four-component system involving a visuospatial sketchpad, phonological loop, central executive, and episodic buffer. The visuospatial sketchpad is for holding and manipulating visual and spatial images, and the phonological loop is for holding and rehearsing speech-based information (Baddeley, 1992). The central executive, an attentional control system, coordinates, monitors, and makes use of the information in the visual and verbal subsystems (Baddeley, 1996). Lastly, the episodic buffer acts as a storage and integration system for incoming information (Baddeley, 2002). With respect to verbal WM, children with FASD often show deficits on the backward trial of the Wechsler digit span task, which engages the central executive to reverse lists of orally presented digits (Carmichael-Olson et al., 1998; Jacobson et al., 1998; Streissguth, Barr & Sampson, 1990). Also, children with PAE scored significantly lower than controls on the Spatial Working Memory (SWM) test in two studies with the CANTAB (Green et al., 2009; Rasmussen, Soleimani & Pei, 2011). This test engages the visuospatial sketchpad of Baddeley's WM model to manipulate visual information. Significant differences in brain activation patterns are observed between

FASD and control groups during spatial and visual WM tasks. Children with FASD show lower activation than controls in frontal lobes on spatial tasks (Malisza, et al., 2005) and in several structures in the right hemisphere on visual WM tasks (Astley et al., 2009).

Pei, Rinaldi, Rasmussen, Massey, and Massey (2008) reported that encoding deficits (i.e, the operations of the phonological loop) were responsible for memory and learning deficits based on immediate versus delayed recall of verbal and visual information on the Children's Memory Scale. This trend was also seen on the Rey-Osterrieth Complex Figure, on which children with FASD demonstrate low organization and integration of visual information and memory decay across trials (Pei et al., 2011b). The encoding process is integral to learning and memory, because if encoded incorrectly, the ability to accurately recall information in a meaningful way will be compromised. Research exploring the nature of WM suggests that even in people with developmentally appropriate WM capacity, taxing WM beyond a certain threshold can result in decreased cognitive performance, including inhibition (Roberts, Hager & Heron, 1994). Indeed, children with FASD do show more commission errors (an indicator of inhibition) on WM tasks (Astley et al., 2009).

Inhibition. Inhibition is commonly conceptualized as the ability to suppress irrelevant information in order to facilitate efficient, goal-directed cognitive processing and behaviour (Fryer, 2009). The literature differentiates between behavioural aspects and cognitive aspects of inhibition, defining behavioural inhibition as "the withholding of a prepotent response (e.g. motor inhibition, delay of gratification, impulse control)", and cognitive inhibition as "the active suppression of cognitions held in working memory (e.g. thought suppression, direct forgetting)" (Fryer, 2009, p.17). In the classroom environment, poor inhibition, and consequently inattention and impulsivity, can manifest in poor behavioural functioning, such as responding before the task is understood, answering before sufficient information is available, allowing attention to be captured by irrelevant stimuli (i.e. distractibility) or failing to correct obviously inappropriate responses (Schachar & Logan, 1990). Response inhibition is the deficit widely implicated in Attention Deficit-Hyperactivity Disorder (ADHD) and given the high rate of co-morbid ADHD among children with PAE (Fryer, McGee, Matt, Riley, & Mattson, 2007) researchers began examining this aspect of cognitive functioning in alcohol-affected individuals.

Classic response inhibition tasks include the Stroop Test, which assesses for an interference effect, and the Go/No-Go paradigm, which requires the child to perform an action under certain rules and inhibit that action under a different set of rules. Children with FASD make more errors than typically developing children on many versions of these tests, including Inhibition on the D-KEFS (Rasmussen & Bisanz, 2009) and the Stroop Color-Word Test (Connor, Sampson, Bookstein, Barr & Streissguth, 2000). Furthermore, several studies show that children with FASD are impaired relative to controls on the Wisconsin Card Sorting Test, a classic neuropsychological measure that relies heavily on inhibitory control (Kodituwakku et al, 1995; Carmichael-Olson et al., 1998; Coles et al., 1997). A common pattern on functional MRI scans of children with FASD is increased activation in one part of a network associated with a cognitive task and decreased activation in another part of that network (Fryer et al., 2007). The network associated with inhibitory control, the frontal-striatal network, is a pathway between the frontal lobe regions and the basal ganglia. Individuals with FASD show increased activation in the prefrontal cortex (part of the frontal lobe) and decreased activation in the caudate nucleus (part of the basal ganglia) relative to control subjects during a response inhibition go/no-go task (Fryer et al., 2007). Some hypotheses extending from this and other fMRI research (e.g., Malisza et al., 2012) are that increased recruitment of certain regions might be to mitigate reduced network efficiency; that the networks are immature; or that activation in one region is to offset the effects of structural damage in another region (Nunez, Roussotte & Sowell, 2011). This imaging research has helped to establish inhibition as a key area for remediation in children with FASD and PAE.

Functional Implications of Executive Function Deficits

EF skills are essential for mental and physical health, success in school and in life, and cognitive, social, and psychological development (Diamond, 2013). These abilities allow for planning, organizing, and learning from past mistakes, and deficits can lead to life-long difficulties adapting to and functioning in society, especially in children with FASD (Moore & Green, 2004; Rasmussen, 2005). EF measures can distinguish alcohol-exposed participants from controls in samples of higher intellectual functioning children with FASD (i.e., mean IQ of 90 [FAS] to 100 [ARND] in Quattlebaum & O'Connor, 2012) and lower intellectual functioning children with FASD (i.e., mean IQ of 74 in Mattson et al., 2013). Thus, the functional implications of EF deficits should be considered for all children exposed to alcohol prenatally, regardless of intellectual functioning. Eslinger's perspective is particularly suited for the present research because it emphasizes the role of memory and attention as foundational skills from which goal-driven behaviour is built upon (1996).

> Executive functions perhaps make possible many of the goals we live for and permit ways to identify and achieve those goals. However, to know where one is going, it

> is necessary to know where you have been and where you are. In this sense, development and elaboration of executive functions are critically dependent on memory and attention and, when built upon this foundation, can provide a basis for continuing adaptation, adjustment, and achievement throughout the life span. (Eslinger, 1996 p. 392)

When WM and attention are framed as, “where you have been” and “where you are”, their link to day-to-day functioning becomes very evident. Parents of children with FASD rated their children’s performance in everyday situations in the clinical range on all subscales of EF on the Behavior Rating Inventory of Executive Function (BRIEF), a questionnaire that assesses real-life EF behaviours. Working memory and inhibition emerged as relative weaknesses (Rasmussen, McAuley & Andrew, 2007). In fact, a large portion of parents rated their child’s ability to hold information in their mind to complete a task (WM) and to control their behaviour (inhibition) in the clinically significant range (78% and 75% respectively). The nature of these neurobehavioural impairments can negatively impact the child’s home and school functioning; so much so that EF impairments explains a significant percentage of the variance in parent and teacher ratings of social skills and behaviour problems (Schonfeld et al., 2006). For parents, poorer behaviour regulation (including Inhibit, Shift, and Emotional Control subtests on the BRIEF) predicted more social skills deficits and behaviour problems. In contrast, teachers viewed metacognition (involving WM, Initiate, Plan/Organize, and Organization of Materials) as the most relevant predictor of social skills. The term ‘metacognition’ is used to describe people’s insight and understanding into their own thinking (Flavell, 1979). This construct has been linked to problem solving and the use of various learning strategies, thus, it is fitting that teachers see the relationship between metacognitive aspects of EF and solving problems in the social setting. Furthermore, Denys, Zwaigenbaum, Andrew, Tough, and Rasmussen (2011) found BRIEF scores to be a better predictor of adaptive functioning over intelligence scores. EF deficits are also implicated in poor social competency and social problem solving (Schonfeld et al., 2006; McGee et al., 2008), externalizing disorders such as ADHD (Burden, Jacobson, Sokol, & Jacobson, 2005), and poor numerical processing (Coles, Kable & Taddeo, 2009; Rasmussen & Bisanz, 2011) within the FASD population.

Interventions for Children with FASD

Traditionally, educators and caregivers have been trained to act as an ‘external brain’ for their student or child with FASD. The brain damage caused by PAE has been thought of as permanent and the first line of treatment for promoting success and preventing adverse outcomes has been creating a circle of support around the child (Clarren, 2000). This means helping them think through decisions, behaviours, and consequences as well as helping them remember their routine and how to complete tasks assigned to them. Programs following this line of thinking include the various mentorship programs across North America (e.g., WrAP Project). As the state of the evidence accumulates on the brain’s ability to reorganize itself with treatment, more and more attention is turning to interventions that ‘habilitate’ some elements of brain function in children with FASD. It is important to note here that efforts to develop and implement such interventions are meant to *enhance* existing wraparound services, not *replace* them.

Kodituwakku (2010) put forth a neurodevelopmental framework for the development of successful FASD interventions that includes providing training in attention and self-regulation early as targeting these abilities may produce greater generalizability than those aimed at domain-specific skills (e.g., reading). He states further,

> A successful intervention can be characterized as a series of planned and guided experiences that give rise to a chain of reciprocal interactions between neural activities and structures, ultimately resulting in improved performance. . . . Type of experiences, intensity and frequency of practice, and suitability can all contribute to therapeutic outcomes (p.723).

Peadon and colleagues (2009) also recommend investigating interventions that target specific clinical and neuropsychological deficits, including EF and self-regulation. Outside of the FASD literature, Diamond (2013) reports three main efficacious activities that improve children's EFs: (1) computerized training, (2) physical activity, and (3) school curricula. The following section describes the theoretical bases of computerized training and how 'serious games' are being investigated as a promising intervention approach for children with FASD. For studies on exercise and general school curricula in FASD see Christie (2011) and Miller et al. (2014).

Serious games. Serious games are computer and video games specifically designed to improve physical and cognitive abilities, and have been examined extensively in individuals with attention deficits due to a neurodevelopmental disability (e.g., ADHD) or brain injury (e.g., stroke). The appeal in using them with children with disabilities is trifold, coming from the (1) brain, (2) motivation, and (3) learning theory literature. First, games can be programmed in a way that operationalizes principles of neuroplasticity – use it or lose it, use it and improve it, specificity, repetition, intensity, time, salience, age, transference, and interference (Kleim & Jones, 2008). Second, because they are fun, novel, rewarding, and can be delivered in a safe environment that allows students to learn from their mistakes without judgment or penalty, children are motivated to play (Green, Cook, & Pei, 2014). Research comparing WM training in a serious game format versus non-game format indicated that children trained on the game version spent more time training, showed better training performance, and performed better on WM tests post-training (Prins, Dovis, Ponsioen, ten Brink, & van der Oord, 2011). Third, technology also allows us to optimize active learning in the child's zone of proximal development – the area of skill development between what a learner can do with and without help – and scaffold learning within that zone (Edmonds & Li, 2005). Additionally, technology can deliver programming with a controlled pace, multimodalities, and immediate and private feedback from activities (Edmonds & Li, 2005).

Two kinds of serious games are reported in the FASD literature: skills-based safety training and process specific training for attention and WM. Coles, Strickland, Padgett and Bellmmoff (2007) taught children with FASD fire and street safety using computer games that employed "virtual worlds". After playing the game until mastery, children showed significantly better knowledge of the targeted safety skills, suggesting that computerized virtual world programs may provide an effective method for teaching safety skills to high-risk children who have learning difficulties. Kodituwakku (2010) suggests that the hands-on experiences in this intervention are ideal for facilitating encoding of information in children with FASD.

The other kind of serious game, process specific training, operationalizes the principles of neuroplasticity by systematically targeting cognitive processes – most often attentional – through repetitive practice on graded exercises and reorganizing neural pathways to improve functioning (Sohlberg & Mateer, 1987). Vernescu (2008) used the *Pay Attention* program to train sustained, selective, divided, and alternating attention in 20 children with FASD and reported improvements on correct responses, omission errors, and response time variability. Kerns, Macsween, Vander Wekken and Gruppuso (2010) investigated the response of ten children with FASD to the *Computerized Progressive Attention Training* (CPAT) program, an intervention based on Posner and Peterson's (1990) model of attention. After 16 hours of training, 10 children aged eight to 15 showed changes on measures of distractibility and reaction time (no control group). They demonstrated longer reaction times and fewer commission errors, suggesting that children sacrificed speed to gain accuracy. Children also improved on measures of WM, reading fluency, and math fluency, despite not being directly trained in the game. The authors proposed an overlap between attention and other skills whereby systematic improvements in the attention processes allowed for 'on task' performance on the WM tasks and better proficiency on the fluency tasks (Kerns et al., 2010). Given these 'far transfer' improvements in WM and fluency following attention training, Pei and Kerns (2012) reported on a serious game that would train not only attention, but also directly train WM. This program is called *Caribbean Quest* and is the focus of this dissertation. The following section reviews the literature on this intervention and provides the rationale and objectives for my study.

Caribbean Quest

Caribbean Quest (CQ) was developed based on a beta platform, *Cognitive Carnival.* CQ consists of five underwater cartoon-like computer games with progressive levels of difficulty. Each game differentially targets attention and WM, and drawing on principles of neuroplasticity, incorporates massed and repeated practice of these cognitive skills. The games were developed to increase and decrease in difficulty based on the child's unique performance, enabling every child to play the game with success. Part of the CQ intervention is that a trained interventionist works with student and delivers metacognitive training. This combined approach – game play plus coaching – is based on evidence from the cognitive rehabilitation literature, which recommends coupling cognitive training with metacognitive training to promote self-directed use of learned strategies and to foster generalization to real world tasks (Cicerone et al., 2011; Sohlberg et al., 2003). From Loomes and colleagues' (2008) study, we know that children with FASD can improve their WM span after being taught a rehearsal strategy (one type of metacognitive strategy). Thus, the CQ game provides the platform to administer both process specific training and metacognitive training in tandem.

Pilot study. A pilot study on *Cognitive Carnival* (CC) was completed in 2010 using a randomized control design with 18 children six to 12 years of age (all with an FASD diagnosis). Pilot results revealed that both the treatment and control groups made gains pre- to post-test on several measures; however the treatment group still appeared to make more significant improvement (Pei, 2011). Diffusion tensor imaging (DTI) testing was completed to assess changes in white matter tractography. DTI results revealed differences between pre- and post-intervention scans of the treatment group children that were much greater than would typically be expected with natural variability or typical brain development, offering preliminary evidence of the impact of CC on brain neuroplasticity (Pei, 2011c).

Efficacy study. Formative changes were made in terms of the programming of CC, study design, and assessment tools, and the efficacy study was completed in 2011. Twenty-

one children with FASD were divided into Group A and Group B. Using the new study design, Group A received the 12-week intervention, whereas Group B served as the control group, and Group B then received the intervention once Group A had completed it. The efficacy study also revealed significant attention and WM gains from pre- to post-intervention plus continued improvement 12 weeks post-intervention (Pei, 2011c).
During the efficacy study, interventionists tracked the types of strategies children were using as they played CC. By the end of the study, participants had used 25 different metacognitive strategies to aid their gaming performance (Hutchison, 2011). The strategies used were aimed at holding more information in their memory, improving attention abilities, reducing impulsive responding, managing negative emotions, goal setting, and focusing on their strengths. Participants were able to increase the number of strategies they used spontaneously and decrease the number of strategies used through prompting over the course of the intervention (Hutchison, 2011).

Capacity study. *Caribbean Quest* (CQ), the "new and improved" version of CC, was ready for use in 2012 and was first examined in a "capacity building study". This study examined the efficacy of CQ when delivered by an Educational Assistant (EA)/teacher rather than a research assistant from the university. The goal was to assess whether neurocognitive improvements persisted when school professionals delivered the intervention. Online training materials were developed to educate EAs and teachers on the background behind process specific training, the principles of neuroplasticity, neurocognitive features of FASD, metacognitive strategies, and scaffolding techniques. Participants in this study were students with either FASD (n=10) or autism spectrum disorder (ASD, n=7). Pre-post test comparisons indicated significant improvements on distractibility, divided attention, WM, and oral reading fluency tasks with effect sizes ranging from .45 to 1.3 (Kerns et al., 2015). EAs were successfully trained to deliver CQ through the online learning platform, suggesting that interventionist training can be done remotely, and thus EAs at distance or otherwise less accessible schools could effectively deliver the CQ program to students in need (Kerns et al., 2015).

For the most part, the capacity study supported the feasibility of incorporating and implementing a computer-based intervention under regular school day conditions with minimal interference with other curriculum activities or scheduling conflicts (Kerns et al., 2015). However, some school administrators, teachers, and EAs cited time as a barrier to the successful implementation of CQ in their schools (Hutchison, Pei, Kerns, MacSween, & Rasmussen, 2013). Although administrators were supportive of the research and valued the potential for improvements in their students, they expressed that 30 minutes per student, three times per week amounted to a significant period of time for EAs to be out of the classroom and away from other duties. Addressing this barrier is critical given that schools are a primary source of mental health services for children with FASD (Wyper & Kully-Martens, 2012). Understanding guidelines and frameworks for evidence-based interventions in schools is an important part of this process.

According to the Task Force on Evidence-Based Interventions (EBIs) in School Psychology (hereafter known as Task Force), an intervention should carry the evidence-based designation when information about its contextual application in actual practice is specified and when it has demonstrated efficacy under the conditions of implementation and evaluation in practice (Kratochwill & Shernoff, 2013). The Task Force outlines four types of studies that progress from lab to classroom: (1) efficacy studies; (2)

transportability studies; (3) dissemination studies and (4) system evaluation studies. Efficacy studies evaluate the intervention in a controlled research context. Transportability studies add feasibility and implementation considerations, and evaluate the degree to which intervention effects generalize and the feasibility of implementing the acceptability of EBIs in practice settings. Dissemination studies use intervention agents that are part of the system (e.g., school or mental health centre). Lastly, in system evaluation studies, the sustainability of an intervention is investigated upon the withdrawal of investigator support, such as staff funding and research activities (e.g., materials, supervision). Under this framework, efficacy is the standard for evaluating interventions in a controlled research context, whereas effectiveness is the standard for evaluating interventions in a practice context.

FASD treatment programs (habilitation programs only) from the academic literature are positioned within Task Force study types in Table 1. Encouragingly, Table 1 represents growth in the number of published studies compared to earlier reviews by Peadon et al., (2009) and Bertrand et al., (2009), who used terms such as “left behind” and “paucity” to describe the state of FASD intervention research. Although the majority sits within the Type I phase, it is encouraging to see several studies being replicated or adapted within the Type II phase, where real-world implementation is considered. In particular, we see the MILE program and Children’s Friendship Training transition from phase one to two, and CQ moving to phase three with the current study.

Table 1.

FASD Intervention Studies According to the Evidence-Based Interventions in School Psychology Framework.

Study Type	FASD Studies
Type I: Efficacy Studies *Is the intervention effective?*	Cognitive Control Therapy (Adnams et al., 2001, Riley et al., 2003) Children's Friendship Training (O'Connor et al., 2006; Keil et al., 2010) Fire and street safety (Coles et al., 2007) Working memory (Loomes et al., 2008) Mathematics Interactive Learning Experience (Kable et al., 2007; Coles et al., 2009) Cognitive Carnival (Pei et al., 2012) Neurocognitive Habilitation Program (Wells et al., 2012) Alert Program for Self-Regulation (Nash et al., 2015)
Type II: Transportability Studies *Is the intervention effective in the real world?* *How does the intervention work in the real world and who can and who will conduct the intervention, under what conditions, and to what effect?*	Language and literacy (Adnams et al., 2007) Children's Friendship Training (O'Connor et al., 2012) Saturday Cognitive Habilitation (Millians et al., 2014) Caribbean Quest (Kerns et al., 2015) Mathematics Interactive Learning Experience (Kable et al., 2015)
Type III: Dissemination Studies *What do interventionists find when implementing interventions in practice?*	Current project - Caribbean Quest

The Current Study

The progression of CQ through these phases is depicted in Figure 1. Altogether, the efficacy studies on *Cognitive Carnival* and the transportability/capacity study on *Caribbean Quest* established that: (1) there is a high level of engagement by children; (2) children have marked gains on the game itself and positive observations with respect to changes in cognitive skills, ability to engage in cognitively demanding tasks over time, and self-regulation, all within the training sessions; (3) there are significant pre-post improvements on measures of attention and WM; (4) there are 'far transfer' effects to academic fluency; (5) children acquire metacognitive strategies throughout the program; and (6) EAs have been successfully trained to deliver CQ (Pei, 2011; Hutchison, 2011; Pei & Kerns, 2012; Kerns et al., 2015). Through the capacity study we also learned that the intervention is too time intensive for some schools when delivered in a one-on-one format. Therefore, in the current dissertation I sought to examine whether and how CQ is effective under the condition of group delivery (transportability) and to explore the extent to which group-delivered CQ is a feasible means of providing attention and EF intervention for children with FASD at school (dissemination).

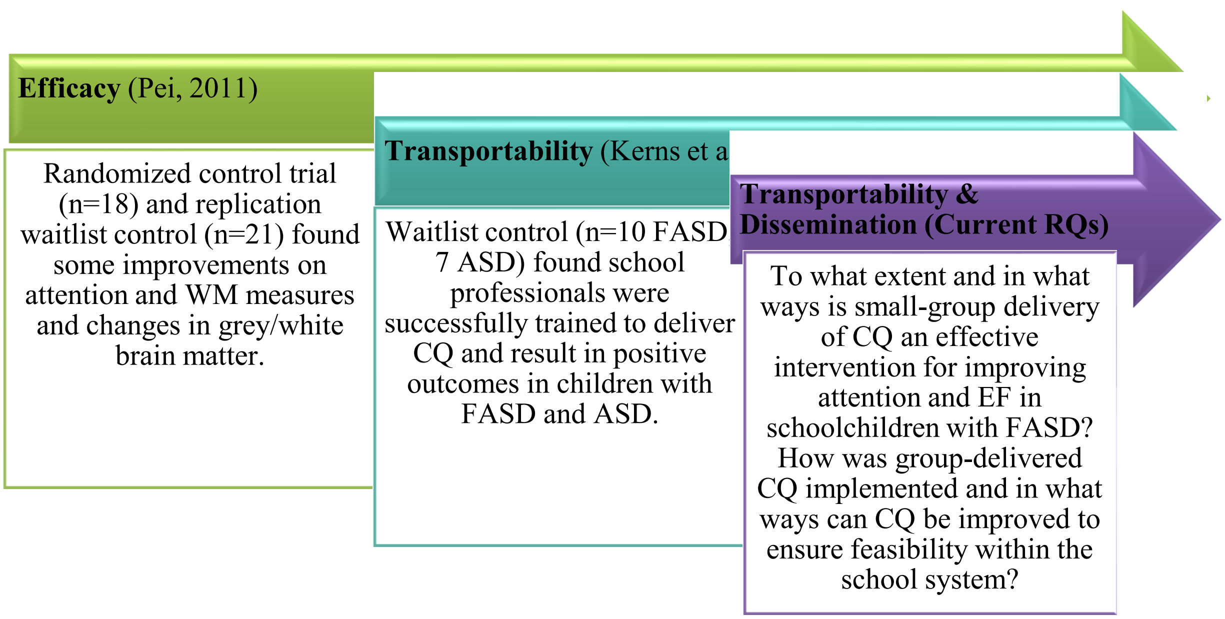

Figure 1. CQ program of research.

Implications

School systems across Canada have voiced a strong commitment to meeting the needs of individuals with FASD, but at present, there are few evidence-based interventions for schools to take action. The work in this dissertation, as part of the larger program of research, will help fulfill this need identified by the FASD community. Participants in this research will be pivotal in helping find out whether we can improve cognitive processes impacted by PAE and whether we can do so in a way that schools find manageable. Ultimately, this work will set the stage for future evaluation of whether we can positively alter the developmental, educational, and vocational paths of these youth through early school-based intervention.

Research Questions and Hypotheses/Anticipated Outcomes

Research question one. To what extent and in what ways is small-group delivery of CQ an effective intervention for improving attention and EF in schoolchildren with FASD?

Hypothesis one. Based on the near transfer effects of attention training to WM in Kerns (2010), and attention and WM training to academic fluency in Kerns et al. (2015), the current test battery was expanded to assess for changes across the triad of executive functions. I hypothesized significant improvements pre- to post-intervention on neurocognitive and neurobehavioural measures of attention and the three core EFs: set shifting, working memory, and inhibition.

Anticipated outcome. Teachers, EAs, and children will discuss how CQ targeted functional attention and EF deficits throughout the intervention and what changes they observed in these skills pre- to post-intervention.

Research question two. How was group-delivered CQ implemented and in what ways can CQ be improved to ensure feasibility within the school system?

Anticipated outcome. Teachers and EAs will present strengths and limitations of CQ as a school-based group intervention that will inform future development of the program.

Method

Research Design

To answer effectiveness and feasibility questions about group delivered CQ, the intervention was examined in a non-experimental pre-test/post-test design. Multiple methods of data collection occurred concurrently, before and after the intervention (Figure 2). At time one and two, quantitative and qualitative data was collected to inform effectiveness (question one) and at time two, qualitative data was collected about feasibility (question two).

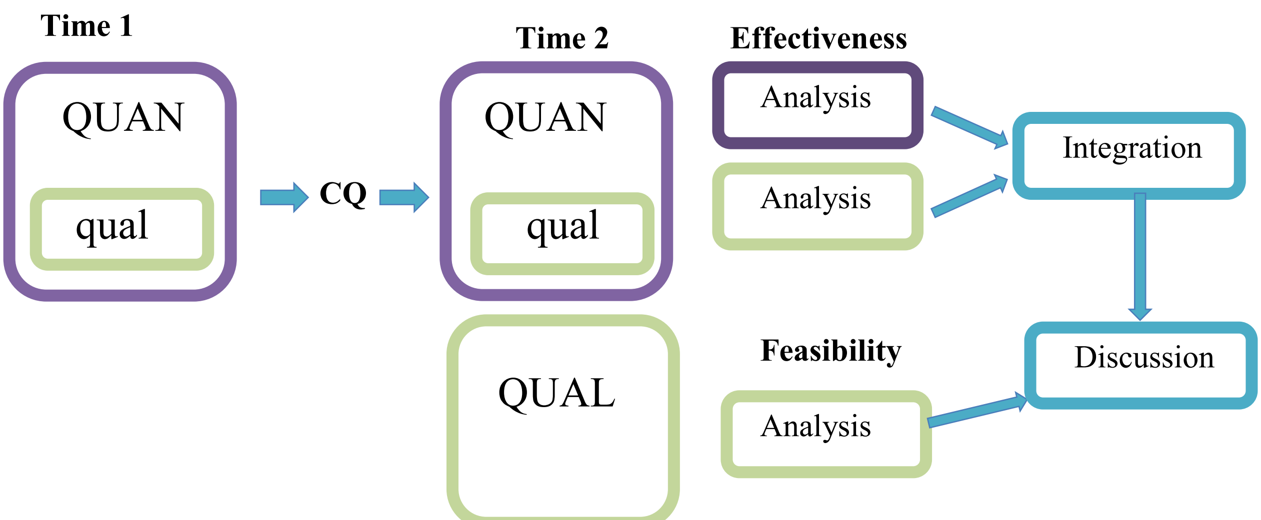

Figure 2. Non-experimental pre-test/post-test design.

Recruitment and Participants

School board recruitment efforts began in February 2013. Keewatin Patricia District School Board (KPDSB) and Winnipeg School Division (WSD) enrolled three elementary schools and three EAs (one per school) in the study and participant recruitment began in January 2014 following ethics approval. Districts distributed information packages to caregivers and legal guardians of children who were between the ages of six to 13 years and were identified as having FASD or receiving services based on PAE and suspected

FASD. Caregivers and legal guardians received information and consent packages, which were returned to the school, and forwarded to myself by administrators. I contacted caregivers and legal guardians to follow up on consent and answer questions about the study. Exclusionary criteria included history of brain injury, other neurodevelopmental disorder, or inability to complete baseline testing.

Participants were nine students, six to 12 years old, each with either an FASD diagnoses or suspected FASD/record of PAE on their student record. Five students were in mainstream classrooms and four students were members of a specialized FASD classroom (see Millar et al., 2014 for background). Two schools enrolled four students each and one school enrolled one student. The school with one student originally had consent for more students to participate; however, children's services withdrew their participation due to administrative policies. Sometimes, peers of the single student played CQ to create a group effect. They were not included in any form of data collection.

Table 2.

Group Demographics

Group	Sex	Age Range
1	2 male 3 female	11 to 12 years old
2	3 male 1 female	7 to 11 years old
3	1 male	6 y.o

Procedures

Once participant recruitment was finalized, EAs were trained, children were baseline tested, teachers completed questionnaires, and teachers and EAs (educators) were interviewed. The same data collection procedures were conducted after the intervention with the addition of child interviews. These procedures are presented in Figure 3 and described below in chronological order.

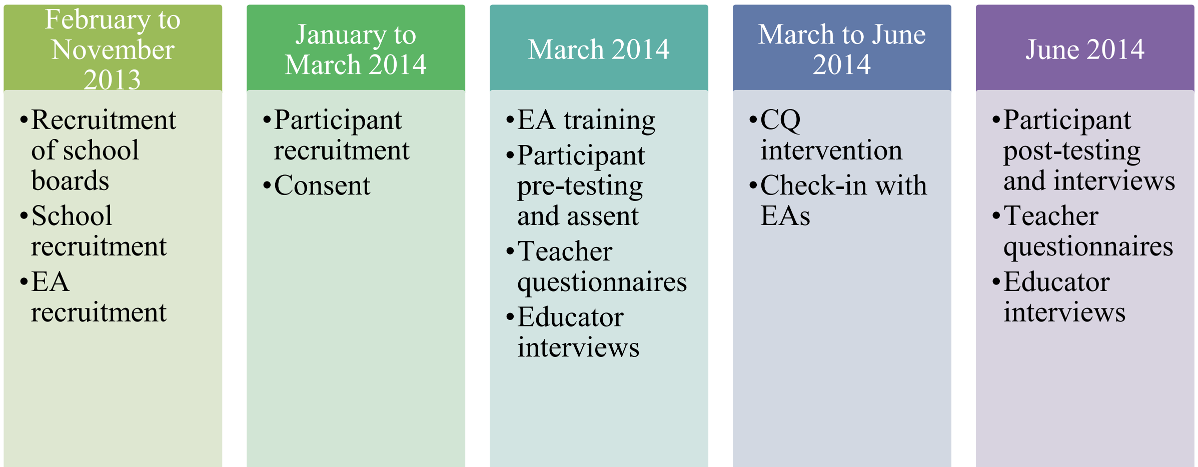

Figure 3. Procedures flowchart.

EA Training. Each EA (n=3) received 2 hours of individual in-person training at their school. Training was based on the materials previously developed for the capacity study by (Kerns et al., 2015). Modules included lay information, research findings, and educational videos on the cognitive deficits associated with FASD, process specific training, brain plasticity, the CQ program, metacognitive strategies, self-regulatory scripts, progress tracking, and how to promote generalization of skills to the classroom and other settings. I worked through the information with EAs and used videos to demonstrate concepts of neuroplasticity and scaffolding. This information was also printed and placed in binders for EAs with record forms for each session (see Appendix A for sample training materials).

Pre-intervention testing and interviews. Baseline testing, including intellectual (for demographics) and attention and EF measures, took place in a quiet space at each school. Testing lasted approximately two hours and the intervention commenced within one week of pre-testing. Interviews conducted with educators were approximately an hour long and took place in a quiet room at the schools. Teachers also completed neurobehavioural questionnaires pre-intervention. Caregiver questionnaires were also distributed at pre- and post-intervals but return rate was low.

Treatment fidelity. To promote treatment fidelity, I shadowed one session during the first week of the intervention and modeled different ways to engage students in using metacognitive strategies. I was in regular contact with EAs throughout the intervention to answer implementation questions.

Intervention procedure. The CQ is a serious game designed and programmed as a joint project between the Departments of Psychology and Computer Science at the University of Victoria to target and strengthen skills of attention and WM through massed practice. The CQ program consists of a series of 5 hierarchically structured tasks presented as self-adjusting mini-games. A 90% accuracy level on each game aimed at improving attention was required to advance through the hierarchy of tasks, whereas progression through the hierarchy of WM tasks was dependent upon achieving a specific number of trials correct. To enhance motivation, the CQ game suite included internal motivators to each cognitive task. Following the successful completion of each cognitive task, children were presented with a variety of 'fun games' that allowed them to gain *sand dollars*. These sand dollars could be spent in the CQ store where children purchase trophies to decorate the screens in the game. The intervention was delivered via laptop and desktop computers for 12 training hours, roughly equally divided between each of the five cognitive tasks. In general, participants completed 20 to 30 minute sessions two to five times a week over eight to 10 weeks. The exact number of sessions per week and total weeks varied as a result of absences and school events. The objectives, as told to the children, and a screenshot of each game are below.

Scuba. Here you will need to navigate around a coral reef to collect samples of different coloured garbage in order to clean up the coral to help it live. The rules and sequence length of items to be collected change over time, so you need to pay careful attention to exactly what you need to pick up. As levels advance, you'll need to use caution to avoid puffer fish, listen to the items with your ears, and carefully read the instructions so you know how to collect the items. Use the ARROW KEYS on the keyboard to move your scuba diver around.

Figure 4. Scuba (left) and Submarine (right).

Submarine. Now you're inside a submarine watching different types of fish swim by. You'll need to collect samples to investigate the fish that live in this region of the ocean. It takes some time to collect the right amount of fish for observation. Sometimes fish swim faster depending on the ocean current and fish species, so you'll need to respond quickly and accurately. We can only take in your total sample of fish at the end if you collect at least 90% of the correct fish, otherwise there will be too many fish that we don't want. That means you have to pay attention! To collect the fish, you need to press the DOWN ARROW KEY on the keyboard when the fish is in the CENTER PORTHOLE.

Wave. You're the captain of your crew's ship, and you need to steer your ship into certain items that are floating in the water so your crew can pick them up. But… only certain things need to be picked up at a time, so pay careful attention to the instruction before starting each game so that you know which items to avoid! Use the ARROW KEYS on the keyboard to move your ship from left to right.

Delicatessan. You and your crewmembers are very hungry from all the hard work, and it's your responsibility to make everyone sandwiches. But everyone wants different toppings on their sandwich and they want the toppings to be put on in a specific order. It's your responsibility to make your team happy and full! Use your MOUSE to click on each topping in the correct order.

Figure 5. Wave (left) and Delicatessan (right).

Squidditch. As captain, you must become the expert at perceiving small differences between fish in order to identify certain species. By looking carefully through the large submarine window, indicate whether a specific fish species is present by pressing the UP ARROW KEY if it is present, or the DOWN ARROW KEY if it isn't present. This way, your crew knows whether or not to get into their scuba diving outfits to observe the fish.

Figure 6. Squidditch.

Bonus rounds and trophy store. To enhance motivation, the CQ game suite includes internal motivators associated with each cognitive task. Following the successful completion of each cognitive task, children are presented with a variety of 'fun games' that allowed them to gain *sand dollars*. These sand dollars can be spent in the CQ store where children can purchase trophies to decorate the screens in the game. Children are told, "With all the sand dollars you collect throughout the game, you can purchase trophies for different prices. Some you'll need to save up for over many bonus games. Try to collect them all."

Post-intervention testing and interviews. Participants were post-tested on the same neurocognitive battery within about one week of completing the intervention. During the testing session, children were asked two main questions about their CQ experience (e.g., what they liked/disliked and what they learned). Educators completed exit interviews and teachers completed questionnaires at the end of the intervention. Caregiver questionnaires were distributed at pre- and post-intervals but return rate was low.

Quantitative data collection. A battery of valid and reliable neurocognitive tools was selected to assess changes pre- to post-intervention (Table 2). The use of norm-referenced tests allowed for a comparison of the child's scores to a sample of the population of the same age at each time point[1].

Table 3.

Neurocognitive and Neurobehavioural Test Battery.

Domain	Instrument
Intellectual Functioning	Wide Range Intelligence Test (WRIT)
Attention	
Sustained/Selective	NEPSY-II Auditory Attention
Alternating/Shifting	NEPSY-II Response Set
Selective	NIH Toolbox Flanker Inhibitory Control and Attention Test
	Shift scale (BRIEF)
Working Memory	
Verbal STM & WM	Digit Span Forward and Backward (WISC-IV Integrated)
Visual STM & WM	Spatial Span Forward and Backward (WISC-IV Integrated)
Verbal & Visual WM	NIH Toolbox List Sorting Memory Test
	Working Memory scale (BRIEF)
Inhibition	NEPSY-II Inhibition
	NIH Toolbox Dimensional Change Card Sort Test
	Inhibit Scale (BRIEF)
Metacognition/Ratings of overall EF	Metacognition Index (BRIEF)
	Behavior Regulation Index (BRIEF)
	Global Executive Composite (BRIEF)

[1] The The *Inventory of Metacognitive Self-Regulation* (IMSR; Howard, McGee, Shia & Hong, 2000), a self-report 32-item assessment of students' awareness about and use of regulatory skills of planning, monitoring, and evaluating, was originally in the test battery. At pre-testing, it became apparent the IMSR was too abstract for these students to complete (even when read to them), and it was removed from the battery.

Wide Range Intelligence Test (WRIT). The WRIT was used to collect IQ as a demographic variable. The WRIT is a brief measure of verbal and nonverbal cognitive abilities in individuals age 4-85. The WRIT provides verbal (Vocabulary and Verbal Analogies subtests) and visual (Diamonds and Matrices subtests) IQ scores, which together yield a measure of general IQ. Although the WRIT is a brief test of IQ, it is highly correlated with lengthier versions such as the Wechsler Intelligence Scale for Children (WISC-III, 0.90).

NEPSY-II Auditory Attention and Response Set. The child listens to a series of words and touches the appropriate circle when he or she hears a target word. Auditory Attention is designed to assess selective auditory attention and sustained attention (vigilance). Response Set is designed to assess the ability to shift and maintain a new and complex set involving both inhibition of previously learned responses and correctly responding to matching or contrasting stimuli. Raw scores were converted to scaled scores (mean SS=10, SD=3) and the Auditory Attention and Response Set Total Correct and Combined scaled scores were the outcome measures. Reliability studies of the NEPSY-II suggest that most subtests have adequate to high internal consistency, and that test retest reliability is also adequate. Moreover, interscorer agreement within the norm sample was very high (.98 to .99). Additionally, the pattern of correlations between subtests on the NEPSY-II indicate strong construct validity (Korkman et al., 2007).

Flanker Inhibitory Control and Attention Test. The Flanker task measures both a participant's attention and inhibitory control. The computerized test requires the participant to focus on a given stimulus while inhibiting attention to stimuli (fish for ages 3-7 or arrows for ages 8-85) flanking it. Sometimes the middle stimulus is pointing in the same direction as the "flankers" (congruent) and sometimes in the opposite direction (incongruent). Scoring is based on a combination of accuracy and reaction time, and the test takes approximately 3 minutes to administer. The combined standard score (mean = 100, SD=10) was the outcome measure.

Spatial Span. Spatial Span is a spatial WM subtest from the WISC-IV Integrated and includes forward and backward trials. The trials were administered using a board with 10 square blue blocks attached in random locations to the surface of the board. For each forward span item, the experimenter touches a series of blocks, and the participant is required to touch the same blocks in the same order as the experimenter. For each backward span item, the experimenter touches a series of blocks, and the participant is required to touch the same blocks in reverse order. The scaled scores from the forward and backward trials and raw scores for 'longest trial' were the outcome measures.

Digit Span. The aurally administered digit span forward and backward subtests from the WISC-IV measured verbal WM. For each forward span item, the experimenter reads aloud a list of numbers and the participant is required to repeat the numbers in the same order. For each backward item, the experimenter reads aloud a list of numbers, and the participant is required to repeat the items in the reverse order. The scaled scores from the forward and backward trials were the outcome measures.

List Sorting Working Memory Test. This computerized test requires immediate recall and sequencing of different visually and orally presented stimuli. Pictures of different foods and animals are displayed with accompanying audio recording and written text (e.g., "elephant"), and the participant is asked to say the items back in size order from smallest to largest, first within a single dimension (either animals or foods, called 1-List) and then on 2 dimensions (foods, then animals, called 2-List). The score is equal to the number of items recalled and sequenced correctly (from 0 to 26). The standard score (mean = 100, SD = 10) was the outcome measure.

NEPSY-II Inhibition. This timed subtest is designed to assess the ability to inhibit automatic responses in favor of novel responses and the ability to switch between response types. The child looks at a series of black and white shapes or arrows and over three conditions either (1) names either the shape or direction (Inhibition-Naming), (2) names its opposite (Inihibition-Inhibition), or (3) gives the correct or opposite name depending on the color of the shape or arrow (Inhibition-Switching). Raw scores were converted to scale scores (mean SS=10, SD=3) and the Time and Combined scaled scores for each of the three conditions were the outcome variables.

Dimensional Change Card Sort Test (DCCS). DCCS is a computerized measure of cognitive flexibility. Two target pictures are presented that vary along two dimensions (e.g., shape and color). Participants are asked to match a series of bivalent test pictures (e.g., yellow balls and blue trucks) to the target pictures, first according to one dimension (e.g., color) and then, after a number of trials, according to the other dimension (e.g., shape). “Switch” trials are also employed, in which the participant must change the dimension being matched. For example, after 4 straight trials matching on shape, the participant may be asked to match on color on the next trial and then go back to shape, thus requiring the cognitive flexibility to quickly choose the correct stimulus. Scoring is based on a combination of accuracy and reaction time, and the combined standard score (mean = 100, SD = 10) was the outcome measure.

Behavior Rating Inventory of Executive Function (BRIEF). The BRIEF is an EF rating scale designed for individuals between the ages of 5 and 18. The teacher version used in this study consists of 86 items across eight clinical scales: three scales that comprise the Behavioral Regulation Index (BRI): Inhibition (ability to not act on an impulse), Shift (ability to change freely from one situation, activity, or thought to another as the situation requires), Emotional Control (ability to regulate emotions) and five scales that comprise the Metacognition Index: Initiate (ability to self-start tasks or problem solve on one's own), working memory (hold information in mind to complete a task), Plan and Organize (plan and manage current and future task demands), Organization of Materials (ability to organize work, play space, etc.), and Monitor (ability to monitor own work or behavior). The BRI and MI combine to form the Global Executive Composite (GEC), a composite measure of all subscales. Based on the child's chronological age, raw scores were then computed into T scores, which have a mean of 50 and a standard deviation of 10. Higher scores indicate more difficulty and abnormally elevated scores suggesting clinical significance are indicated by T-scores of 65. T scores between 60 and 64 indicate borderline clinically significant scores. The Cronbach alpha measure of internal consistency is 0.80 and test-retest reliability correlation is r=0.88 for the teacher form (Gioia et al., 2001).

Quantitative data analysis. Pre- and post-treatment differences on neurocognitive and neurobehavioural measures were evaluated using a paired samples t-test after ensuring the data met the four assumptions required for this procedure: (1) dependent variables are measured on continuous scales; (2) the same subjects are present in both groups; (3) there are no significant outliers in the differences between the two related groups; and (4) the distribution of the differences in the dependent variables between the two related groups is approximately normally distributed (>.05 results in Levene's homogeneity of variance test). Cohen's *d* was calculated to determine effect size. Analyses were performed using SPSS 22.0.

Qualitative data collection. Three sets of semi-structured interviews were conducted: (1) with teachers and EAs pre- and post-intervention to gather qualitative information about how CQ targeted functional attention and EF deficits throughout the intervention and what kinds of changes they observed in these skills pre- to post-intervention (research question one); (2) with teachers and EAs post-intervention to understand the utilization and feasibility of CQ in the context of their school and ways CQ can be improved to ensure feasibility with in the school system (research question two); and (3) with children post-intervention to see whether and how they thought CQ helped them at school (research question one) and what they liked and didn't like about CQ (research question two). See Appendix B for interview protocols. Educator interviews were approximately an hour long at each time point and took place in a quiet room at the schools. The child's interview questions were asked during post-testing, and took approximately five minutes.

Qualitative data analysis. Data analysis involved the creation of themes through an interpretive approach, described by Braun and Clarke (2006): (1) familiarization with the data, (2) initial code generation, (3) searching for themes, (4) reviewing themes, (5) defining and naming themes, and (6) production of report. I paid particular attention to coding units of data that related to process elements of the intervention, neurocognitive bases of behaviour, impact of the behaviour on classroom functioning, group dynamics, formative improvements, and feasibility. The findings were then written into a descriptive account, where each theme was supported by particularly vivid examples or extracts from participants.

Results

Participant Characteristics

Nine children participated in this study. The mean general IQ was 93 (range 81 to 106), mean verbal IQ was 86 (range 66 to 113), and mean visual IQ was 102 (range 90 to 114). Mean age was 10 years old (range 6 to 12). Mean scores on all measures at pre- and post-test are presented in the first column of Tables 4 through 7. These scores indicate that at baseline, neurocognitive EF abilities in this sample were in the low average to average range. However, teacher ratings on the BRIEF indicate significant neurobehavioural issues with respect to attention, WM, and inhibition with each of these scales and broader indices falling in the Clinically Significant range at pre-test.

Question One: Quantitative Results

I hypothesized pre-post neurocognitive and neurobehavioural data would reveal significant improvements pre- to post-intervention on neurocognitive and neurobehavioural measures across attention and the three core EFs: set shifting, working memory, and inhibition. According to Cohen's (1988) and Rosenthal's (1996) guidelines for effect size interpretation, a *d* value between 0 and 0.3 is a small effect size, between 0.3 and 0.6 is a medium effect size, and greater than 0.6 is a large effect size. For attention (Table 4), effects were large for accuracy (*d*=.75) and reduced commission errors (*d*=.83) on sustained attention (Auditory Attention). No improvement was seen on auditory set shifting (Response Set) or the BRIEF Shift scale. In terms of WM tasks (Table 5), large effect sizes were demonstrated on auditory WM (*d*=.74; Digit Span trend level significance), spatial WM (*d*=.95; Spatial Span), and the BRIEF WM scale (*d*=1.01). Improvements on inhibition measures were large (Table 6). Effects sizes ranged from .98 to 1.9 for improvements in speed, accuracy, and error reduction on two of three visual inhibitory tasks (Inhibition – Naming and Inhibition – Switching). Effects were not significant for the BRIEF Inhibit scale. No significant differences were observed on the computerized NIH Toolbox measures. All three BRIEF composites indices were significant with effect sizes ranging from .267 to 1.618 (Table 7).

Table 4.

Pairwise comparisons of attention and set-shifting measures pre- to post-intervention.

Subtest	Mean Score	*t*	*p*-value	Cohen's *d*
Auditory Attention Total Correct[a]	Baseline: 8.3 Post-test: 10.4	-2.259	.054*	.75
Auditory Attention Combined[a]	Baseline: 8.1 Post-test:10.5	-2.511	.036*	.83
Response Set Total Correct[a]	Baseline: 9.2 Post-test: 8.3	.723	.490	.24
Response Set Combined[a]	Baseline: 9.1 Post-test: 9.6	-.514	.621	.17
NIH Flanker	Baseline: 87 Post-test: 85	.384	.400	.32

Note. ** p<.01, *p<.05, ^ trend toward significance. [a]Results presented as scaled scores (M=10, SD=3). [b]Results presented as standard scores (M=100, SD=15).

Table 5.

Pairwise comparisons of working memory measures pre- to post-intervention.

Subtest	Mean Score	*t*	*p*-value	Cohen's *d*
Digit Span				
Forward[a]	Pre-test: 7.5 Post-test: 8.5	-1.604	.147	.53
Backward[a]	Pre-test: 8.1 Post-test: 9.1	-1.279	.237	.43
Total[a]	Pre-test: 7.1 Post-test: 8.4	-2.219	.057^	.74
Spatial Span				
Forward Total[a]	Pre-test: 9.5 Post-test: 11.7	-1.739	.120	.58
Forward Longest[c]	Pre-test: 5.0 Post-test: 6.11	-2.857	.021*	.95
Backward Total[a]	Pre-test: 10	-.463	.655	.15

	Post-test: 10.4			
Backward Longest[c]	Pre-test: 5.44 Post-test: 5.88	-.206	.842	.07
NIH List Sorting WM Test[b]	Pre-test: 95 Post-test: 102	.384	.713	.14

Note. ** p<.01, *p<.05, ^ trend toward significance. [a]Results presented as scaled scores (M=10, SD=3). [b]Results presented as standard scores (M=100, SD=15). [c]Results presented as raw score.

Table 6.

Pairwise comparisons of inhibition measures pre- to post-intervention.

Subtest	Mean Score	*t*	*p*-value	Cohen's *d*
Naming Combined[a]	Pre-test: 7.2 Post-test: 10.8	-5.33	.001**	1.9
Naming Time[a]	Pre-test: 8.1 Post-test: 9.8	-2.843	.026*	1
Inhibition Combined[a]	Pre-test: 10.3 Post-test: 10.1	.163	.875	.06
Inhibition Time[a]	Pre-test: 9.3 Post-test: 9.6	-.224	.829	.08
Switching Combined[a]	Pre-test: 8.8 Post-test: 11.6	-2.762	.028*	.98
Switching Time[a]	Pre-test: 8.3 Post-test: 9.8	-1.240	.255	.44
Total Errors[a]	Pre-test: 9.2 Post-test: 11.6	-2.967	.021*	1.9
NIH Dimension Change Card Sort[b]	Pre-test: 91 Post-test: 93	-.898	.399	.32

Note. ** p<.01, *p<.05, ^ trend toward significance. [a]Results presented as scaled scores (M=10, SD=3). [b]Results presented as standard scores (M=100, SD=15).

Table 7.

Pairwise comparison of teacher-rated EF pre- to post-intervention.

Subtest	Mean Score	*t*	*p*-value	Cohen's *d*
BRIEF WM Scale[d]	Pre-test: 71 Post-test: 64	3.629	.015*	1.01
BRIEF Shift[d]	Pre-test: 77 Post-test: 74	.928	.396	.550
BRIEF Inhibit Scale[d]	Pre-test: 79 Post-test: 76	1.052	.341	.168

BRIEF BRI[d]	Pre-test: 84 Post-test: 79	2.712	.042*	.267
BRIEF MI[d]	Pre-test: 72 Post-test: 67	2.990	.030*	1.618
BRIEF GEC[d]	Pre-test: 79 Post-test: 73	11.619	.000**	.925

Note. ** p<.01, *p<.05, ^ trend toward significance. [d]Results presented as T-scores (M=50, SD=10).

Descriptive statistics for the percent of participants who showed no positive change, and who improved by less than one standard deviation, one standard deviation or more, and two standard deviations or more is presented for the measures reaching statistical significance on the pairwise comparisons. Figure 7 presents the breakdown for the significant neurocognitive measures and Figure 8 presents the breakdown for the significant BRIEF scale and indices.

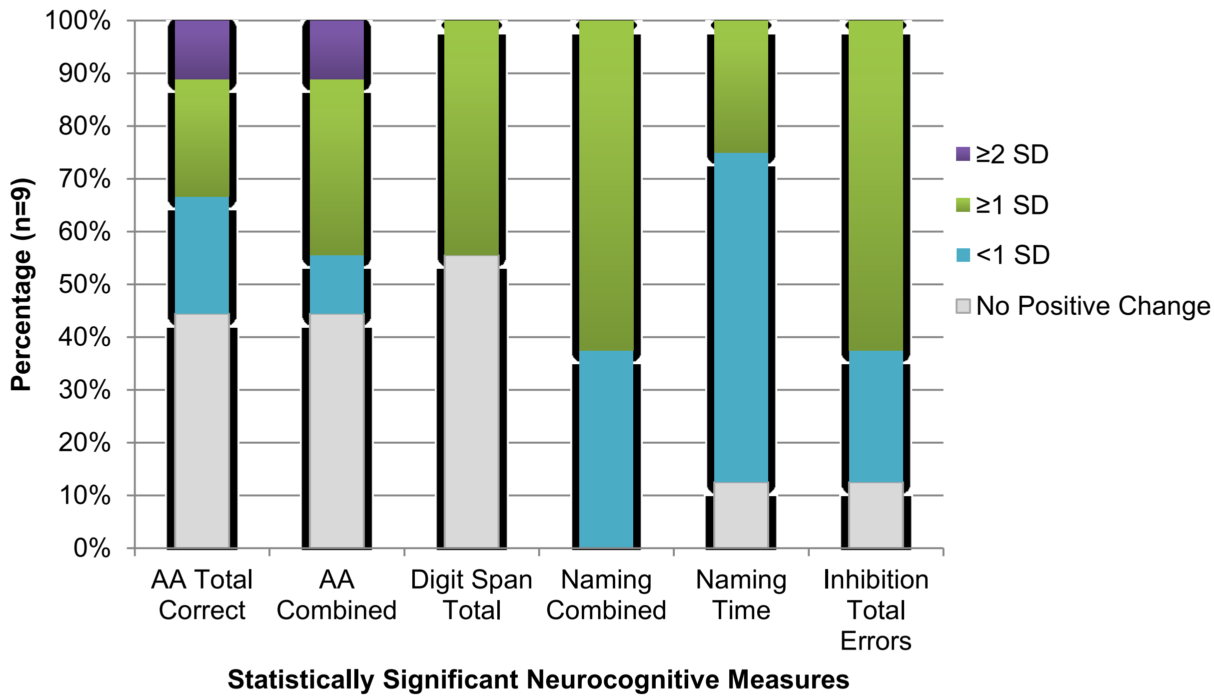

Figure 7. Participant improvements on statistically significant neurocognitive measures.

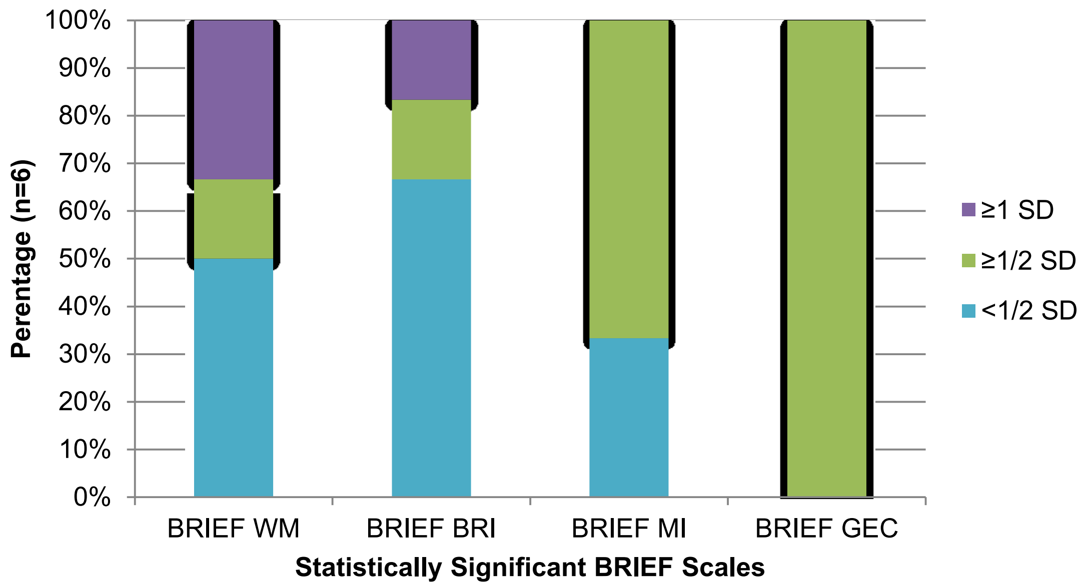

Figure 8. Participant improvements on statistically significant neurobehavioural measures.

Question One: Qualitative Results

Interviews provided insight into the functional skills CQ targeted throughout the intervention and additionally, what elements supported these changes. Five additional understandings of CQ emerged: Finding Focus, Zone of Engagement, Quest for Success, Hidden Curriculum, and Metacognition in Action.

Finding focus. Pre-intervention, teachers reported that many of their students struggled with attention, characterizing them as "easily distracted," "very unsettled," and having a "busy brain." One teacher noted that he doesn't "think of his student as an auditory learner because you don't have his attention." To address this in class, educators reported children typically fidget, use headphones, or sit in a rocking chair. However, teachers thought many students were without any specific strategies to help them pay attention in class. Educators agreed that a key benefit of the CQ program is that it helped with focus and attention deficits. One group played CQ in the morning, and the teacher found it “helps them focus and settles them for the day,” which for one student “is an important predictor of how her day is going to go.” Also, one student was learning to read, and the EA found the instruction passages acted as literacy training and at post-test, his teacher stated his reading has “taken off…I don’t know if it’s that he was just ready, or if memory improvements helped, or if his ability to focus helped.” During the intervention, one student tended to fidget with the keyboard, which caused him to make errors, especially on Wave. His EA used this as an opportunity to find a new focusing strategy, stating that she enjoyed “testing new things and show[ing] him how different strategies are needed for different situations.” The new strategy (keeping the cursor lower on the screen) was effective for this student, and he used it on later Wave levels.

Zone of engagement. A theme from pre-test interviews was how discerning the students were of their learning weaknesses. For example, educators would describe how students would “cover up weaknesses” or “shut down if something is hard,” but would “work hard if feeling successful.” During training, EAs stated that the students operated from a “this is easy” or “this is hard” perspective, but instead of feeling successful when they aced the levels, EAs found the students bored and disengaged. They said that, “once it became more difficult, they were more engaged but when it became more challenging, there was more frustration.” Similarly, finding a game “too young” but also “too challenging” at the same time was disheartening and EAs often labeled students affect as frustrated. Despite these challenges, students demonstrated a commitment to the game, persevering, adapting, and “always coming back after giving up.” It seems that students found their zone of proximal development in the game, and EA support was needed during this time, with one EA noting “the one-on-one time is critical” and another reporting “I wouldn’t have him play on his own.”

Quest for success. Pre-intervention, teachers and EAs discussed at length the link between students’ self-confidence and behaviour. Some EAs explained that the students “want to be successful but lack self-confidence.” Specifically, they want to learn, but have barriers accessing the curriculum. Educators hoped for students to “become an independent learner,” “learn how to deal with complications,” “test his patience,” and “stop comparing [herself to other students].” Recognizing this vulnerability, one EA set children up for success by posting visual reminders of their metacognitive strategies, calming activities, the children’s own drawings, and encouraging statements (see Figure 6). One teacher liked calling it a ‘program’ rather than ‘treatment’ or ‘intervention,’ in order to set a positive tone for the students and after the program, she described it as “excellent because it built confidence.” For this reason, this educator placed high value in CQ as an educational intervention. For EAs, “the opportunity to learn how a student learns” and “seeing them learn and be successful” was personally rewarding and made them feel successful in their role in return. A student whose behaviour regulation was so impaired he was described as a “slow-moving train wreck” was “noticeabley better” at post-test and his teacher stated that “his train isn’t going off the tracks.” EAs reported that students practiced “working through frustration” and were more likely to ask for help from the helping adults, ask for a break, and ask to use their calm kit in class.

Hidden curriculum. Most of all, CQ became a social experience and EAs reported that “each of them at some point in the game was being positive toward each other” and it “encouraged interaction between two students who didn’t know each other.” Prior to the intervention, teachers reported copying their peers as one of the group's only strategy to compensate for forgetfulness. CQ created an environment to learn and practice new memory strategies, especially repetition and rehearsal, and provided a platform to ask peers for help in appropriate ways. While one student mostly refrained from sharing strategies and progress, favoring to keep them to herself as predicted at pre-test, others were often helpful to their peers. However, two students from one group had a very hard time with the group dynamic, either trying to get others to be silly or distracting them by talking. The use of verbal rehearsal strategies did create a problem for one group in that one student "has a real hard time paying attention in groups and will talk a lot out loud, which bothers other students", impacting their own ability to focus. For this group, "some days four students at one time were too many because of different personalities."

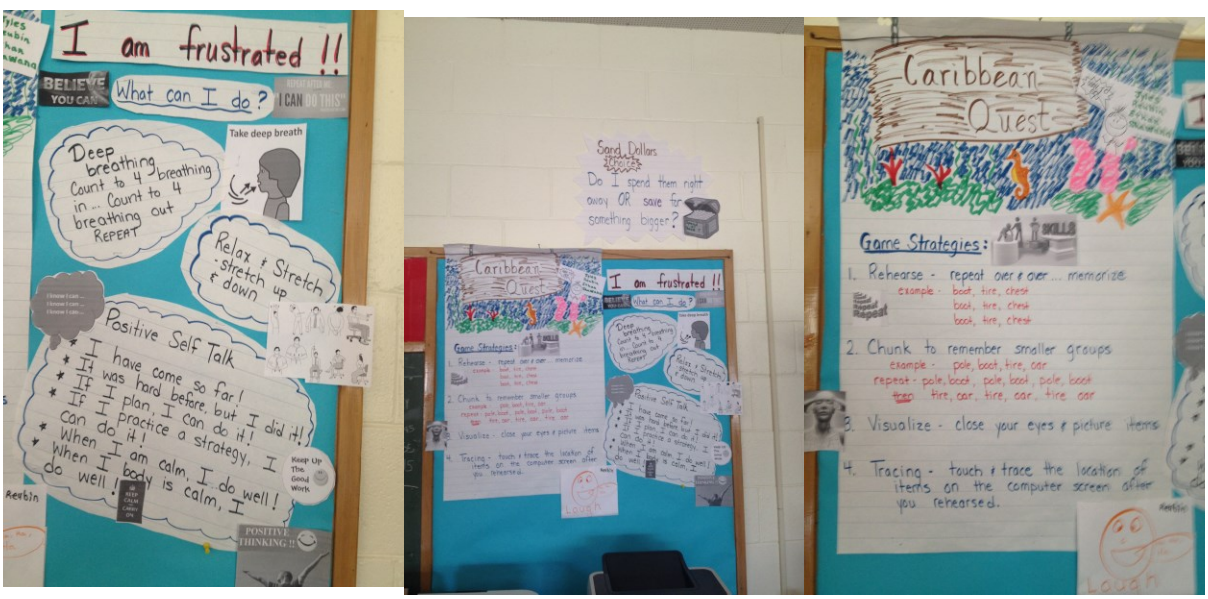

Figure 9. Bulletin "success" board.

Metacognition in action. Although the vocabulary in the *Inventory of Metacognitive Self-Regulation* proved too advanced to use in the assessment battery, students spoke to the different concepts of metacognitive knowledge (person, task, strategy knowledge) when describing whether and how they thought CQ helped them in school. For example, one student stated, "I'd play every day because it helps me remember. My memory isn't very good and it helps me," demonstrating understanding of her own capabilities (person knowledge). Many described Scuba and Deli as the hardest of the CQ games because there was "lots to remember," "it was hard to do it in order and remember the colour," and "level 16 was hard!" (task knowledge). They also spoke freely of the different strategies they used while playing CQ (strategy knowledge). To combat confusion during Deli, one student described, "I remembered the colours because I didn't know the names." A different student opted to remember the first letter of the item to help her. During the spatial span task at post-testing, one student traced the numbers on the table as I read them aloud for digit span and said, "the game helped me" as he followed my finger on spatial span.

Question Two

Post-interviews collected service-users' perspectives about their processes implementing CQ, how feasible it was to deliver within the context of their school, and how it can be modified to better meet the needs of the school system. These interviews produced five more understandings of the CQ program: Capturing Success, Missing Link, Managing your Tools, Timing Matters, and Giving Voice.

Capturing success. For this study, EAs used pen-and-paper sheets to track time playing the game, strengths and weaknesses during the session, and general observations. Educators offered insightful recommendations for improving tracking student progress, first of which was a game-based entry assessment followed by weekly summary reports of the students' progress on specific benchmarks, similar to the math software *Dreambox.* A way to track strategies *within the game,* for example a checklist on the computer after each session, was also requested in order to more simply track usage, share progress with teachers and caregivers, and encourage generalization between environments.

Missing link. As taught in their training, EAs coached students to regulate their cognition and emotions during gameplay through the use of different metacognitive strategies. In terms of promoting the use of these strategies outside of CQ, EAs reported that they were better able to encourage strategy generalization "with the children [they] worked with outside of the intervention than with the children who [they] worked with solely for the intervention." There was common agreement that pull-out delivery of CQ hindered generalization because teachers were not exposed to the learning taking place during CQ and therefore could not reinforce strategy use. For example, students might be using strategies during math, but because the EA wasn't there to see it, the student might not receive reinforcement of that skill. Teachers were unable to pinpoint any specific changes in attention, WM, and inhibition strategies in the classroom, which they attributed to them having little exposure to the intervention themselves. Teachers reported seeing students use some new regulatory strategies in the classroom (e.g., laugh to deal with frustration), but did not see the more metacognitive strategies (e.g., chunking, rehearsal) transfer. Improvements were important, but more general, such as "more settled," "asking for help," and "now attending two thirds of the day rather than half."

Managing your tools. EAs reported several issues related to CQ's operating system and technology platform that impacted its delivery in their schools. Two of three schools did not have a computer lab, and students instead had individual iPads or netbooks. Unfortunately, CQ does not run on iPads and the resolution and screen size of the netbooks was too small to show the full CQ display. Furthermore, the CQ program currently runs on *Microsoft Silverlight,* which limits it to running on certain operating systems. An EA stated that if CQ were on the iPads, "the whole class could play at the same time." Using iPads would also eliminate the chance for students to "mess with the computer."

A second technological critique was that students must play on the same computer throughout the intervention in order to access their personal gaming profile. If CQ were hosted on the school's network, "the students could log in from anywhere in the school and build on their progress." Further, if CQ was web-hosted, students could login from home and play with their caregivers, siblings, and peers outside of school. Several small programming issues seemed to frustrate students and the additive effects created a negative impression of the game. EAs reported the yellow and orange colours in Squidditch and red and brown colours in Wave looked very similar, which made it difficult for students to select items correctly. The music and clicking sound of the mouse was "annoying" to many of the older students. Lastly, CQ did not "jive" well with one school's computers, and the game would crash mid gameplay, sometimes causing the student to lose their progress. Educators stated this "presented a scenario to practice regulatory strategies", but the unpredictability of the software was understandably frustrating, even for the professionals, so much so that the teacher stated the "glitches *must* be fixed" in order for her to use CQ in her class again.

Timing matters. EAs discussed both the day-to-day timing aspects of delivering CQ and also the developmental and educational timing of when to enroll a student in the intervention. One EA preferred short and frequent sessions (20 minutes, five times per week), as it maximized opportunities for repetition, stating that the child may have "lost strategies if [delivered] only twice a week." A different EA scheduled sessions at the same time in the morning three days a week as it "helps them focus and settle them for the day." In this classroom, four students played CQ while the rest of the class (four students) read silently. Developmentally, the EA with students aged 6 to 12 found the "younger students got more out of it because they were more focused." The older students frequently claimed the games were "for little kids," but at the same time, found the game challenging.

Giving voice. During post-testing, children were asked what they liked and disliked about CQ. One student said, "I wouldn't play it if I had the choice," but another in the same group said she would, and another said, "it's better than doing math." This student also told her EA, "this game would be good to help others to train their brain to think in a different way." The different levels, bonus rounds, and store were viewed positively and "fun" and one student suggested using "the things you buy in the store to help you in the game." Some students remarked they disliked the clinging sound of the coins and the background music. Technical difficulties seemed to happen most often during Scuba, which frustrated the students.

Discussion

Currently, school-based interventions are limited for children with FASD (Green, 2007) and feasible and accessible evidence-based interventions are needed to support cognitive development and mitigate adverse outcomes (Petrenko, Tahir, Mahoney & Chin, 2014). In this dissertation, I extended a program of research on an attention and WM intervention, *Caribbean Quest,* developed especially for children with FASD to meet the above needs. The aims were to examine the effect of group-delivered CQ on attention and executive functions and explore the feasibility of CQ as a school-based intervention. This was a non-experimental pre-test/post-test multi-method study where quantitative and qualitative data were collected and analyzed separately, and are now merged at the discussion level to collectively examine effectiveness (research question one) and feasibility (research question two).

Impacts of small-group delivery of CQ on attention and EF in schoolchildren with FASD

Overall, quantitative improvement in sustained attention, elements of selective attention and working memory, and inhibition were seen in the CQ group implementation. The qualitative changes observed by the educators do not fully map onto the quantitative changes but rather provide a thematic framework from which to conceptualize formally measured outcomes. Thus, to blend these ideas, the cognitive change is first presented and then discussed in the context of the theoretical framework from which it may be best understood and translated.

On pre- and post-testing, results indicated improved sustained attention (maintain focus over time) and selective attention (maintain focus in the face of distraction) on one of two measures, congruent with previous CQ work (Kerns et al., 2015), but not alternating/shifting attention (shift focus between tasks). Additionally, questionnaire results of behavioural manifestations of shifting attention did not reveal change over the course of the intervention. Thus, improvement applied only to more basic attention tasks and was not observed for more complex attention either in cognition or behaviour. This is in line with Nash and colleagues' (2015), where children with FASD improved most on simple rather than complex tasks (Nash et al., 2015). Educators provided insight into the process by which attentional changes may have taken place. They described students as preferring tasks of sustained attention (Submarine and Scuba), possibly reflecting an interaction between interest and success where there is greater interest in a task that is more 'trainable' or alternatively, there is more cognitive change because they are motivated and engaged in training. Contrary to my hypothesis, findings do not show 'near transfer' to alternating/shifting attention (the set shifting component of EF), suggesting this cognitive process may require direct training. Future research is planned to build a set shifting game into CQ to better meet the needs of students with autism (Kerns et al., 2015), and the current findings add further support for this decision for children with FASD to determine whether shifting attention is a cognitive process sensitive to training.

There is evidence of some verbal and spatial WM improvements based on pre-post neurocognitive and neurobehavioural evaluation, but changes in WM did not emerge within educator interviews. Thus it seems the changes in WM do not yet extend to functional improvement but may indicate a trend that could have greater impacts over a longer duration or with a different approach to transfer. Based on acquisition of metacognitive strategies within session, as reported by educators, it appears more time may be needed for full effects of transfer to take place. Improvements and strategies may be context-sensitive and children may need cues embedded in classrooms to facilitate transfer to the new environment (Ylvisaker, 2003). In general, future research is needed to identify moderating factors and underlying mechanisms that influence transfer effects following cognitive rehabilitation (Parvinchi, Wright, & Schachar, 2014). It may be that a more rigorous process approach, such a process-oriented examination of treatment outcomes as in Nash and colleagues (2015), is needed to reveal whether cognitive changes generalize to functional changes following CQ.

Remarkably, out of all the neurocognitive measures, pre- to post-test gains were largest on inhibition tasks. Thus, it appears CQ is targeting basic inhibitory processes alongside attention and WM. This may be attributed to the repetitive use of inhibitory and self-regulatory strategies or perhaps to the ‘near transfer’ effects of attention and WM improvements to inhibitory control as Kerns and colleagues (2010) saw with attention training to WM. In either case, results from the present study add to accumulating evidence that inhibition is sensitive to intervention in children with FASD (Nash, 2015; Wells et al., 2012). The ability to inhibit and delay gratification is a pressing concern for these youth and opportunities to reduce impulsive decision-making is needed (Kully-Martens, Treit, Rasmussen, Pei, 2013). Understanding which training component led to inhibitory improvements – and how we can translate these cognitive changes into functional changes in behaviour – will be a critical next step in the CQ program of research to mitigate adverse outcomes.

Broader impacts. Complementing formal measures, educators reported observing pre-to-post changes in improved focus, attributing the intervention with helping to settle the students so they were better able to pay attention both in the session and later in their school day. However, the other changes educators observed from pre- to post-intervention did not map directly onto the neurocognitive and neurobehavioural changes discussed above. Instead, they reported CQ had broader impacts on functioning within and outside the intervention. In particular three additional areas of impact were discussed: engagement in learning, socialization, and metacognition. Each of the themes put forth by educators and participants linked to success, suggesting the cognitive change formally measured transpired within a success-oriented environment. EAs optimized the interaction between the child's individual skill set, CQ training, and the training environment, demonstrating FASD-informed practices by offering visual, environment, and task structure to supplement the intervention process and create success.

Three hypotheses are generated from this success-oriented framework – first that the impact of CQ on the child's well being and success within the learning environment is the most *visible* outcome; second, CQ may be a means of creating a more positive future in students with FASD by shaping their attitude toward learning; and third, capitalizing on the educators' skills – providing them with both a place to use existing tools and with new tools as well as – may impact educator capacity. Promoting success to improve the quality of schooling experience is a need identified by both caregivers and teachers of children with FASD (Phung, Wallace, Alexander & Phung, 2011; Miller et al., 2014). Objective assessment of self-efficacy and attitudes toward learning in both children and educators in relation to the CQ program will be a complementary next step in understanding these broader impacts and the effectives of CQ.

Feasibility within the school system

One justification for embedding CQ in schools is so that we can provide training in attention and self-regulation early, and in order to do so, schools require an intervention that is feasible for them to incorporate in their programming. Thus, it was important to hear from school professionals themselves ways that CQ can be best designed for optimal school-based delivery. Overall, educators were able to feasibly integrate CQ into their timetables to deliver services and meet both FASD best practices for structure and consistency (Kodituwakku, 2010) and general routine and repetition principles that apply to cognitive rehabilitation and neuroplasticity (Kleim & Jones, 2008). Group delivery proved challenging for some groups due to conflicting personalities, which may also have been age-related. As seen in students' dichotomy of "this is too young" but "this is hard", merging chronologically appropriate materials with developmentally appropriate demands walks a fine line. Given the added social piece of group delivered CQ, the role of the EA appears two-fold – to provide metacognitive coaching and to create a positive social environment.

EAs highly valued capturing the students' successes and recognized gaps in their ability to both share progress with teachers and caregivers and reinforce generalization of strategies. Unfortunately, this flies in the face of one of the reasons for having CQ delivered in schools, which is to capitalize on opportunities for skill generalization to everyday academic and social situations through EA support and reinforcement (Sjö, Spellerberg, Weidner, & Kihlgren, 2010). In addition to computerized assessment and reporting strategies, educators raised whole-class delivery as a solution to this barrier, which then raises questions about the best way to meet the needs of students with FASD – specialized or inclusive? Separating services and treatment tracks for children with FASD from other children was debated at the Institute of Health Economics Consensus Development Conference (Jonsson, Dennett & Littlejohn, 2009). Coles stated, “we must develop and use focused treatments that take into account the characteristics of FASD” (p.132). On the other hand, McLennan reasoned, “promising treatment approaches [for children with FASD] work, or are likely to work, with non-FASD populations that share the difficulty targeted by the treatment” (p.145). EAs echoed McLennan’s sentiments that many students have difficulties with executive dysfunction, and may benefit from the program, or in the words of a student, “the game would be good to help others to train their brain to think in a different way.”

Lastly, the technological landscape is changing in schools, and since the goal is for schools to independently administer CQ, they believe it is important for CQ to work on different platforms, including school networks and iPads. Engaging educators in this work was critical in the context of the evidence-based intervention movement (Kratchowill & Shernoff, 2004). The transportability of evidence-based interventions to practice is a serious challenge (Chorpita, 2003), and formative programmatic recommendations such as these are taken seriously because the additive effects of small “annoyances” are unfavorable both to the motivation children have to play and to the value service delivery systems place in the program. The educators’ experiences and recommendations highlighted accessibility and feasibility issues previously unrecognized as barriers by the researchers. Next, it will be important to build on this momentum and evaluate outcomes when the school system implements CQ on its own, hopefully on a longitudinal basis and on the adverse outcomes we are hoping to mitigate.

Limitations

Peadon and colleagues (2009) reported that in general, FASD intervention studies have methodological problems including inadequate study design, small sample sizes, variation in diagnostic inclusion criteria, and minimal follow-up. It seems that in intervention research, as in other fields, several studies within a program of research are necessary to gain a full understanding of outcomes and employ optimal methodologies. For example, Kable, Coles and Taddeo (2007) employed a randomized control trial of a mathematics intervention (MILE) and had a relatively large sample of 61 children. Several studies later, their community adaptation of this program included only five participants, but contributed a level of depth of inspection similar to the current study (Millians & Coles, 2014). Thus, the value of small studies must not be overlooked when conducted within a larger program of research, and when appropriate reservations about the generalizability are acknowledged and taken into consideration when interpreting results, as is done here.

First, although the original study design was quasi-experimental and included a wait-list control group, barriers in recruitment led to smaller sample sizes than expected, and numbers were too low to conduct a wait-list design. I recognize that having no control group can influence the quality of reported training effects by inflating the amount of training benefits, and ignoring the possibility of naturally occurring improvements in line with development, ultimately threatening internal validity. However, the previous work on

CQ included a randomized control group and a waitlist control group, and treatment effects were observed in those more rigorous designs as well. Second, results were not corrected for multiple comparisons. Given my small sample size, I would have needed a very large effect to use the correction, which would likely have washed out these findings. Third, although my sample was sufficient to detect treatment effects, like much of the FASD intervention literature (Kerns et al., 2015; Nash et al., 2015), I was unable to examine additional important factors related to outcome, such as comorbidities, IQ, and gender, which may have contributed to outcomes. Fourth, since this study was conducted in the spring term, with post-testing in June, follow-up was not possible. Fifth, caregiver questionnaires were not completed and only six of nine teacher questionnaires were returned at both pre- and post-intervals, further reducing the sample size and subjecting results to statistical inflation.

A final concern is that my sample may not generalize to the larger FASD population as the measures selected for this study did not reveal pervasive clinically impaired functioning in attention or EF pre-intervention. By nature, FASD is a heterogeneous disability and this means that children with FASD will present differently, even on EF tests; hence the search for the “elusive” neuropsychological profile (Mattson & Riley, 2011, p. 54). Selection bias may have played a role in the composition of this sample, as the four students from the specialized classroom were chosen because school staff thought they would be the best fit for the program. Nevertheless, all students in the study fell on the spectrum or had documented PAE, presented with EF difficulties at school that very closely match Rasmussen’s (2007) BRIEF profile study, and the group still responded to the intervention with cognitive and behavioural improvements. This is especially interesting in light of Diamond's (2012) report that children with the weakest EFs benefit the most from intervention. It does appear that the lower scores at baseline were the ones that improved significantly. For example, when we examine baseline data across the three Inhibition tasks, Naming and Switching scores improved significantly and were lower than Inhibition, which did not improve. Rasmussen and colleauges (2013) also found children with FASD were impaired relative to controls on Naming and Switching, but not on Inhibition (although it neared significance). In other FASD intervention work, children who benefited most from hostile attribution training were those with the most intact EF abilities at baseline (Keil, Paley, Frankel, & O'Connor, 2010; Schonfeld, Paley, Frankel, & O'Connor, 2009). Thus, the pattern of functioning and response to intervention does seem to fall in line with prevailing trends within FASD literature.

Future Directions

Capturing the external validity of CQ, including the generalizability of EF improvements outside of the intervention, has been difficult to establish and until now, has largely been anecdotal. There has been consistent feedback throughout the program of research suggesting "improved focus and alertness, decreased hyperactivity, less resistance to engaging in new or challenging activities, and increased academic engagement and mastery" (Kerns et al., 2015), but it has been difficult to capture the nature of these changes in a rigorous way. Teacher BRIEF ratings from my study point to some generalized EF improvements, but teacher and EA interviews suggest metacognitive thinking or strategies are not being observed, encouraged, or reinforced with any level of intensity and frequency over the course of the regular school day. It is possible we are not be seeing functional improvements because we have not assessed for them appropriately (false negative). A process-oriented evaluation of treatment outcomes as discussed above may be a productive avenue for establishing external validity. Alternatively, we must consider that the current intervention approach is not maximizing the potential for functional improvements and we are overestimating the impact of CQ on classroom functioning (false positive). Currently, the CQ program includes computerized training plus metacognitive coaching. A third component, such as a manualized approach to generalization, may be needed.

The washout metacognitive questionnaire *Inventory of Metacognitive Self-Regulation,* is a fruitful topic of discussion for next steps. Throughout our CQ research, we have amassed much evidence of students using metacognitive strategies (Hutchison, 2011; Kerns et al., 2015). However, there are other aspects of metacognition that we have not assessed for, namely metacognitive knowledge. Metacognitive knowledge is what individuals know about their own knowledge base, how one perceives the difficulty of a task, and their understanding of effective learning strategies (Flavell, 1976). I attempted to measure metacognitive knowledge in my sample, but the first four students I pre-tested responded “I don’t know” to most of the questions. This is an ever-present challenge in metacognitive literature because the act of metacognition is an internalized process – thinking about your thinking. Brown, Bransford, Ferrara, and Campione (1983) emphasized how young children often have difficulty explaining their processes and may provide unreliable reports of those processes. Most interesting to me is that metacognitive training is emerging across FASD interventions (CQ, MILE, Alert Program), but we know very little about the “profile” of metacognitive knowledge in children with FASD. In fact, we do not know whether children with FASD have absent, immature, or normal metacognitive knowledge or metacognitive regulation compared to typically developing children. A problem solving experiment may be one way to assess these abilities and inform intervention (e.g., prediction task in Garrett, Mazzocco & Baker, 2006). In the same vein, we do not know whether improvements are a result of playing CQ, of metacognitive training, or a combination of both. Kerns and colleagues (2015) recommended a study comparing the efficacy of the full training protocol (i.e., CQ and metacognitive training) to its constituent components (i.e., CQ intervention alone and metacognitive training alone) to assess the incremental value and impact of each component. The results of the current study will contribute to the development of a metacognitive training unit that will be used in such follow-up research.

Lastly, it will be important to monitor in roads in EF intervention research outside of the FASD arena. The larger field of EF intervention work has many questions yet to be answered; for example, what distinguishes children who benefit from EF interventions from children who do not? What is the optimal dose, frequency, or duration of an EF intervention? Which kind of program helps children most at which age? Much like children with FASD, we must learn by example when moving forward with the CQ program of research.

Conclusions

Taken together, results from this study suggest four important findings. First, we continue to see cognitive change even when CQ is completed in small groups. Second, CQ impacted attention and two of three core executive functions – WM and inhibition, but not set shifting. Third, although teachers reported improved EF on questionnaires, educators spoke to broader impacts of CQ, and valued the way CQ engaged students in a success-oriented activity that built confidence and prepared them for learning. Fourth, CQ, including group delivery, was feasibly integrated into these schools, and educators offered additional ways to improve the program to improve accessibility and feasibility.

This study adds additional evidence on CQ as an effective and feasible school-based program for children with FASD, and in doing so, we have moved one step closer to providing schools with the means to intervene early in the lives of at-risk students. On a final note, although group delivery remained effective, was feasible, and went well for most students, it doesn't *need* to be delivered in groups if a school has the capacity to deliver individualized intervention or if a student has barriers that prevent them from benefiting from CQ in a group. Responding to the individual needs of a child remains the most important factor when developing a treatment plan, and working in pairs or individually may be a better fit for some children. Still, it was important to demonstrate to schools that it *can* be done in groups and produce similar outcomes as one-on-one treatment. The voices of students and educators were integral in reaching these findings, and will continue to be influential in the next steps for CQ. Moving forward, group delivery will afford schools the opportunity to reach many students, and allow us to evaluate longer-term outcomes of CQ on the lives of these youth.

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Appendix A: Sample EA Training Materials

What is process specific training?

Process specific training is a term used to describe an approach to target the same function systematically and repetitively through practice and exercise on related tasks. Through massed practice on specific attention and working memory exercises that place demands on these mental functions, eventually that skill is mastered. Once this occurs, a more demanding exercise that targets the same mental skill is available to continue the training. The idea behind process specific training is that the activities must be arranged hierarchically, so that each task leads to the mastery of progressively more difficult skills. Repetition must be provided in order for the skills to be firmly established. The concept of plasticity, the idea that the brain can reorganize itself and change, is what allows Caribbean Quest to effectively change the way the brain functions to perform at its maximum capacity.

Who does process specific training work for?

There is increasing evidence of experience-dependent plastic changes that occur through improvements in the brains of both children and adults as demonstrated through performance on objective cognitive testing and even neural imaging. Process specific training, such as attention and working memory training, has shown benefits for typical individuals looking to improve these cognitive abilities, as well as individuals with deficits in these areas due to:

1) developmental or acquired brain injury

2) attention deficit hyperactivity disorder (ADHD)

3) borderline intellectual disabilities

4) learning disorders or special needs

5) extremely low birth weight

6) cancer

7) cochlear implants

8) individuals with schizophrenia

9) and any other individual who wants to improve working memory or attention abilities!!

How does process specific training work?

Research on process specific training has identified several important principles that increase the effectiveness of these programs.

Principle 1: Use it…or lose it!!

Commonly used neural brain circuits are stronger than neural circuits that are not actively engaged for an extended period of time. Hence, in order to improve a specific area, you need to use the brain parts that rely on these circuits. If you don't routinely use a skill, it becomes weaker over time.

Principle 2: Use it…to improve it!!

Following from Principle 1, use of the specific skills will lead to improvements over time. So, if the goal is to improve attentional and working memory capacity, you need to engage in tasks that demand these cognitive abilities. Furthermore, as you gain mastery within a certain skill, in order to continue to make benefits and improve, you need to make the task more difficult. Just as you increase the amount of weights you lift over time to increase muscle size and strength, you need to increase the difficulty level of tasks. Caribbean Quest does just that - the difficulty level of the training is adjusted in real time based on the player's performance. The means that every player will always be training at the very edge of his or her cognitive capacity. Whoever you are, Caribbean Quest training will always challenge your brain!

Principle 3: Specificity

The learning or skill needs to be specifically targeted to produce significant, long-term changes in patterns of neural connectivity. The computerized, cognitive exercises are designed to target key cognitive functions of attention and working memory that have been proven to be fundamental to executive function and learning in general. The program is designed to be focused on developing these skills, and yet also provides slight variations to exercise specific aspects of these skills.

Principle 4: Repetition

Once certain skills are acquired, continued performance and practice of that skill over time is required to maintain that skill. Have you ever heard the saying: "Practice makes perfect, and repetition creates mastery?" It's true, isn't it? When we practice something long enough, we eventually master it. Think about what happens when we learn to swim, ride a bike, drive a car, or play a musical instrument. Something magical happens when we practice repeatedly. That's when things start to click. Eventually, it becomes automatic and we can perform the skill without consciously thinking about it. Perhaps some sort of "auto-pilot" inside our brain takes over. We've practiced so long and done it so many times that we've mastered it. And now we can do it automatically, without thinking about it. The same thing happens when you use the Caribbean Quest program. Your brain is practicing tasks requiring working memory and attention over and over again. After many days of practice, you will have mastered the skills, and peak performance of tasks that require attention and working memory will become easier and more ‘automatic’.

Principle 5: Intensity

As is the case with the acquisition of most skills, higher frequency of training leads to better improvements in working memory and attention. For cognitive training programs, it is typically recommended that the player devote 15-30 minutes, 2-4 times a week playing the various games. Just like going to the gym only once a week versus 2-4 times a week, faster and stronger improvements will be seen when training is more intense.

Principle 6: Time

Process training is not a single, isolated event – it is a process that unfolds over time. Further, there are thought to be certain ‘windows’ of time where certain skills can be improved more easily than at other times. However, with regards to attention and working memory training, research has shown that individuals of any age can make improvements in these areas.

Principle 7: Saliency

The training materials in general need to catch and maintain your attention, so that you are engaged throughout game-play. Caribbean Quest was designed to be fun and motivating, with lots of colourful visual and auditory displays. Playing bonus games, and winning points and trophies also increases motivation.

Principle 8: Age

Brain changes are often reported as being more intense and occurring faster in younger brains than in older brains, simply because younger brains are thought to be more flexible and it is easier to make new or stronger neural connections. However, the brain continues to make substantial changes throughout one's entire lifespan. Thus, cognitive training for attention and working memory skills can be beneficial for individuals of all ages.

Principle 9: Transference

This principle refers to the plasticity and changes within one set of neural circuits (attention and working memory) to promote beneficial change in other skill sets. This means that improvements in attentional and working memory capacity may generalize to improvements in behaviours, such as learning, in other areas. You will be better able to pay attention, resist distractions, hold information in mind, self-manage, and learn. There are many training programs for various skills such as reading, math, or time management. Caribbean Quest acts on a more basic level, targeting lower level skills (attention and working memory) and building from the level of skill you already posses. Therefore, the goal is that once attention and working memory improves, the acquisition of many other skills may be easier.

What is FASD?

Fetal Alcohol Spectrum Disorder refers to a set of diagnoses that include a pattern of difficulties resulting from brain damage caused by alcohol use during pregnancy. These difficulties may be cognitive, behavioural, emotional, and/or physical. Students with FASD exhibit a wide range of cognitive abilitites and disabilities that reflect differing degrees of brain damage. It is important to recognize that the prenatal effects of alcohol are varied, and no two individuals affected will have identical characteristics or needs.

Some of the general characteristics of school-aged children with FASD include:

- Difficulty listening and paying attention
- Appearing to know something one day but forgetting in the next day
- Misinterpreting or misunderstanding what others are saying
- Difficulty learning concepts, organizing, sequencing, and problems solving
- Impulsiveness and poor judgment
- Difficulty developing age-appropriate social skills and working with others
- Difficulty making and keeping friends
- Difficulty recognizing and setting boundaries

Individuals with FASD also demonstrate impaired executive functioning (EF). Executive functions refer to the higher-order cognitive processes under conscious control, necessary for thought and action in complex goal-directed behaviour and adaptation to environmental changes and demands. Executive functions include:

- Flexible thinking, e.g. the ability to monitor and change behaviour when necessary.
- Strategy employment, e.g. reacting appropriately and efficiently when faced with new situations and tasks
- Initiating and stopping actions
- Planning
- Working memory
- Sustained attention

This means that during the Caribbean Quest training, you may notice:

- Difficulty learning from mistakes
- Difficulty persevering and completing tasks as tasks become more difficult
- Inconsistent skill performance, i.e. child may do really well on one task one week, and very poorly the next week
- Knowledge gaps, or prominent skill set strengths and weaknesses
- Problems with behavioural regulation and self coping skills

- Poor frustration tolerance, especially when demands and stress increase
- Reactions of anger or acting out behaviours when faced with difficult tasks
- Avoidance of or decrease in motivation to try cognitive tasks – ‘learned helplessness’
- Limited self-regulation of learning
- Inconsistent self-regulation of mood and emotion

Common Misinterpretations of Typical Responses in Students with FASD*

Behaviour	Misinterpretation	Accurate Interpretation
noncompliance	▪ willful misconduct ▪ attention seeking ▪ stubborn	▪ difficulty translating verbal directions into action ▪ doesn't understand
repeatedly making the same mistakes	▪ willful misconduct ▪ manipulative	▪ can't link cause to effect ▪ can't see similarities ▪ difficulty generalizing
not sitting still	▪ seeking attention ▪ bothering others ▪ willful misconduct	▪ neurologically-based need to move constantly, even during quiet activities ▪ sensory overload
doesn't work independently	▪ willful misconduct ▪ poor parenting	▪ chronic memory problems ▪ can't translate verbal directions into action
does not complete homework	▪ irresponsible ▪ lazy ▪ unsupportive parent	▪ memory difficulties ▪ unable to transfer what is learned in class to the homework assignment
often late	▪ lazy, slow ▪ poor parenting ▪ willful misconduct	▪ can't understand the abstract concept of time ▪ needs assistance organizing
poor social judgement	▪ poor parenting ▪ willful misconduct ▪ abused child	▪ not able to interpret social cues ▪ doesn't know what to do
overly physical	▪ willful misconduct ▪ deviancy	▪ hyper or hyposensitive to touch ▪ doesn't understand social cues regarding boundaries
stealing	▪ deliberate dishonesty ▪ lack of conscience	▪ doesn't understand concept of ownership over time and space ▪ immature thinking ("finders keepers")
lying	▪ deliberate ▪ sociopathic behaviour ▪ lack of conscience	▪ problems with memory and/or sequencing ▪ unable to accurately recall events ▪ trying to please by telling you what they think you want to hear

EA's Role

As a coach, you will accompany students as they play Caribbean Quest. The coach's role is to offer different **strategies** to help students be more successful and to encourage children to think about their performance and how they could improve. The coach will use **scaffolding, routine** and **positive behaviour support** to create an environment that helps students move through the games and experience success.

Strategies

The games in Caribbean Quest challenge students to engage their memory and attention skills. Since these are likely areas of weakness for these students, they often require some explicit strategies to help them progress and experience success.

Remember that all children learn differently and have their own unique strengths and challenges. The best approach is to keep trying different strategies until you find the ones that work effectively with an individual student.

- Some students may come up with strategies on their own (opportunity to praise!) while others may need you to teach them.
- Some students may remember to use a certain strategy each time they approach the task while others may forget about its helpfulness. Likewise, what works one day will not necessarily work the next.
- Some students may transfer a learned strategy to a different task, while others may use it exclusively on the task on which they learned the strategy.

Just like students are building a stronger brain, they are building a larger strategy toolbox (or treasure chest!). We have found the following strategies listed below to be helpful for students as they complete the training tasks. These strategies can be used one at a time or in combination. It is important to recognize that each child will be different, in that while one strategy may work best for one child, a different strategy will work best for another child.

Memory Strategies:

1) Rehearsal

- Repeat a string of items until it is memorized and easily recalled.

2) Chunking

- Divide a string of items into multiple smaller groups of items. For example, if the sequence is ‘fishing pole, boot, tire, oar’, have the child say ‘fishing pole, boot, fishing pole, boot’ and then ‘tire, oar, tire, oar’. In this way, 4 items become 2 items by chunking them into groups.

3) Visualization

- Have the child close his or her eyes and imagine the items in mind.

4) Tracing

- Use physical touch (i.e., tracing the location of items on the computer screen, tracing a pattern on the desk) to rehearse the order of items.

5) Substitution

- Reduce the amount of information to remember by substituting more difficult items with something else that is easier to remember. For example, rather than remembering ‘fishing pole’ just remember ‘pole’. Or rather than remember ‘treasure chest’, remember the letter ‘c’.

6) Elaboration

- Attach items to a more meaningful story or schema. For example, when trying to remember the sequence ‘fishing pole, tire, boot’ you could create a story such as: One morning I was going fishing with my mom. I grabbed my pole and jumped into the car. On the way, we got a flat tire, so before we could go fishing we had to stop at the gas station to fix the tire. Finally, we arrived at the lake. I jumped out of the car, put on my rubber boots, and off we went!

Other Self-regulation Strategies:

1) Deep breathing

- Deep breathing can help trigger relaxation when students become stressed, anxious, or agitated. Teach the student how to do deep belly breaths when they are calm so they can use it as a strategy when they are having difficulty controlling their emotions. Here is a script that we have found helpful:

- “Let's relax right now. First, let your body relax a bit. Reach up, high above your head, stretching your arms... stretching your body very tall. Now let your arms relax. Place them at your sides, loosely.
- Do the same thing again, but this time, breathe in as you reach up. Stretch.... and now breathe out as you relax and place your arms at your sides.
- One more stretch, arms up, breathing in... and relax, arms down, breathing out.
- Just sit now, letting your arms rest at your sides.
- See how your breathing can relax you by taking slow, deep breaths. Breathe in.... hold your breath.... and now breathe out, slowly. Breathe in.... and out.”

2) Compare to where they started

- Sometimes students forget how much they have progressed and need some encouragement that their memory span has increased or their ability to inhibit responses has improved. They might need gentle reminders to reflect on how their practice has paid off. For example, reminding them that in the beginning remembering three items was difficult and now they can do five.

3) Connect feelings and attitudes to performance

- The intervention provides a great opportunity for you to coach your student to recognize how their internal feeling states might be impacting their cognitive performance. Tune them into this connection by commenting, “I noticed you collect more fish on Submarine when both your feet are planted flat on the floor instead of shaking. It seems like you do better when your body is calm. Let’s try to calm your body with some deep breaths before the next trial” or “I noticed you have a hard time with Delicatessan and don’t really like playing it. What can we do to fix this?”

Self-Regulatory Scripts

One important role of an interventionist is to encourage and monitor the students’ use of strategies to promote and increase success. At first, it will be **your responsibility** to help the child implement an appropriate strategy, and gradually you will teach the child how to do this. Overtime the amount of help and guidance you provide will gradually lessen, as the child will be able to take over this role.

You will need to teach the student how to identify **when, why, what and how** to use a strategy, as explained in the 5 steps below. You may wish to make a cue card listing the 5 steps, and have the child practice going through each step of the script after you have modeled the use of the script several times.

An example of a self-regulatory script used with children:

<u>1) Identify the issue (when)</u>

- ‘Hmm. So I notice that you’re always able to remember 4 items in the right order, but 5 items seems to be much harder.’

<u>2) State the reason for the issue (why)</u>

- ‘This is probably because when the number of items increases, there is more information for you to try to remember, which makes the task harder.’

<u>3) Select and implement a strategy from the list below, or from your own knowledge of helpful strategies (what)</u>

- ‘So, let’s try to use one of our strategies to help us remember the longer sequence. This time, before we start collecting the items, we’re going to sit on our hands and repeat the sequence out loud 4 times before we start collecting the items. Let’s try one now!’

<u>4) Evaluate the outcome of the strategy (how)</u>

- After the strategy is used several times, review the usefulness of the strategy. If the strategy seems to help the child remember the longer sequence, then continue to use the strategy. If the child is still struggling, go through the script once more and this time use another strategy.

<u>5) Once a strategy is that works is found, **celebrate success!!**</u>

- For example, you may wish to offer praise and encouragement, or reward the student with a sticker or other small prize.

Scaffolding

Scaffolding is the process by which coaches deliver support to students.

What is Scaffolding?

Scaffolding is an instructional technique whereby the coach models the desired learning strategy or task, then gradually shifts responsibility to the students.

What is its purpose?

Scaffolding essentially means doing some of the work for the student who isn't quite ready to accomplish a task independently. Like the supports that construction workers use on buildings, scaffolding is intended to be temporary. It is there to aid the completion of a task and it is eventually removed.

How can I do it?

- Model performance
- Think out loud - “Show your work” (i.e., the process that led you to choose a certain strategy). This way, students learn important problem solving processes and skills.
- Provide prompts, cues, hints, links, partial solutions, guides and structures.
- Narrate or think out loud for the student (i.e., “I noticed you divided that list of items into two groups like a phone number – that must have been because the list was too long to remember in a single group.
- Fade when appropriate - as students begin to demonstrate task mastery, the assistance or support is decreased gradually in order to shift the responsibility for learning from coach to student

Transfer to the Classroom

An ultimate goal is for students to be able to transfer what they've learned in their training sessions to the classroom. Many academic tasks and activities depend on working memory and attention. With your help, we'd like students to see how they can use the strategies they've learned to use in Caribbean Quest for activities like math, remembering instructions, focusing on the teacher, etc.

Some ways to encourage strategy use in the classroom:

1. Start this process in the training sessions. Make connections between the computer games and academic tasks. Provide examples of tasks students are currently working on.

2. Have students repeat and show how they could use the strategy in the classroom.

3. In the classroom, give periodic prompts and reminders to use strategies.

4.Try out the self-regulatory script format when students are working on a challenging academic task.

Appendix B: Interview Protocols

Pre-Intervention Interview Protocol for Educators

1. Tell me about ___________:
2. How does he/she fit into the routine of the day?
3. What are his/her strengths?
4. What are his/her challenges?
5. How would you describe his/her ability to pay attention, avoid distractions, focus on one thing at a time?
6. Does he/she have any strategies to help pay attention?
7. How would you describe his/her ability to control his/her actions and behaviour?
8. Does he/she have any strategies to help manage behaviour?
9. How would you describe his/her ability to remember things from minute to minute, day to day, and week to week?

8. Does he/she have any strategies to help memory?

10. What kind of learner is he/she?
11. What kind of things does he/she do to solve problems?

Post-Intervention Interview Protocol for Educators

1. What were your overall impressions of the intervention? What did you like/dislike?
2. What was each student's experience like with the intervention? What strategies did they use? Tell me about his/her attention/WM/impulse control at this time.
3. Do you think there is potential for skills learned in CQ to be transferred to classroom activities? Did you see any transfer in these students? If not, how could we better encourage skill generalization?
4. Were you surprised by the students' performance in any way?

5. Did delivering this intervention provide you with development of your own skills in any way? If so, how? In what ways was delivering the intervention a valuable experience for you?

6. What would make the intervention even more feasible/accessible for you to deliver and for the students to use? How would you change CQ if anything was possible (magic wand question)?

7. Do you have any recommendations for the pre-training of EAs that would make delivering the intervention better for you?

8. How would you like to use the intervention in the future (i.e., how would it fit into programming, what age group, number of students)?

9. Any other thoughts/recommendations?

Post-Intervention Interview for Students

1. Tell me about CQ. What did you like about it? What did you dislike?

2. What was it like playing CQ? Do you think it helped you in school? How so?