# The Effects of Executive Function and Attention Training for Children: The Role of Motivation and Self-Concept

by

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B.A.H., McMaster University, 2007
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Supervisory Committee

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# Abstract

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The purpose of this study was to evaluate the efficacy of a cognitive and metacognitive intervention program (Caribbean Quest; CQ), on improving cognitive and social self-concepts (i.e., evaluative self-perceptions, including self-efficacy beliefs), executive function (EF), and attention. The effect of motivation on cognitive training derived benefits also was assessed. Motivation was examined both in terms of motivation specific to engagement in the CQ intervention (i.e., state motivation) and children's intrinsic motivation for learning situations in general. In addition, the relationship between age, motivation, and self-concept was investigated.

Participants included fifty-five male children, ranging in age from 6 to 12 years, with teacher reported deficits in EF and attention (29 controls, $M$ = 8.38 years; 26 intervention, $M$ = 8.35 years). The CQ intervention was delivered to children at school by trained educational assistants (EAs). On average, children completed 12 hours of intervention over 6 weeks. During CQ training sessions, EAs provided support to children in their game play, helping them to monitor their performance and utilize cognitive and metacognitive strategies. Each participant completed a battery of tests before and after the intervention, including measures of cognitive function, self-concept, working memory (WM), sustained attention, and intrinsic motivation. Teachers also provided ratings of children's intrinsic motivation. Following CQ sessions, children's state motivation was assessed.

Pre- and post-test analyses did not reveal significant intervention effects for self-concept. However, given known developmental differences in self-evaluations for children less than eight years of age as compared to children aged eight years and older, self-concept was analyzed separately within younger and older age groups. Results indicated that children younger than eight years of age showed significant improvements on cognitive and social self-concept compared to the control group, suggesting that self-concept may be more amenable to change in younger children. Transfer effects of cognitive training to neuropsychological measures of WM and attention were not significant, although findings trended in the direction of higher benefit for the intervention group. For participants in the intervention group, child-reported intrinsic motivation, but not teacher-reported or state motivation, predicted the extent of change on the self-concept questionnaire and the sustained attention task. Results indicated cognitive self-concept and state motivation increased with age for the younger group of children; for the older group of children, state motivation decreased with age.

In sum, results support the use of a cognitive and metacognitive training intervention for improving cognitive and social self-concepts in younger boys with EF and attention deficits. These findings highlight the importance of motivation as a key determinant of change and training derived gains. Future studies should further explore the relationship between motivation and training derived gains to better understand factors that might limit or enhance the effectiveness of cognitive intervention, as well as examine the value of concurrently targeting motivational factors in cognitive intervention.

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# Introduction

The objective of this study was to evaluate the efficacy of an executive function (EF) and attention training intervention on improving aspects of self-concept, EF, and attention, in 6- to 12-year-old children with cognitive deficits in these areas. With regard to self-concept, evaluative self-perceptions such as performance beliefs pertaining to cognitive and social domains of self-concept were investigated. In addition, the study examined the effect of motivation on training derived benefits, as assessed by pre-post performance improvements on measures of self-concept, EF, and attention. Motivation was examined both in terms of motivation specific to engaging in the current training intervention (i.e., state motivation) and intrinsic motivation (i.e., motivation towards learning in general).

This paper begins with a review of research on the constructs of EF and attention, including their relationship, with an emphasis on the clinical implication of these deficits in children. The next section summarizes cognitive treatment interventions, with the goal of highlighting pharmacological, process specific, and compensation approaches. The qualities of neuroplasticity and their relevance to effective clinical rehabilitation are also explored. This is followed by an overview of motivational constructs, psychological correlates of motivation, and the effect of motivation on intervention engagement and gains. The current research examining self-concept, including its development, clinical implications, and preventative and treatment programs, is presented. This is followed by the objectives, hypotheses, and methodology (including sample size, assessment measures, and intervention procedures) of the current project. Finally, the results of statistical analyses, and the implications and limitations of the current findings, are discussed.

**The Relationship between Executive Function and Attention**

EF is broadly defined as the ability to respond through effortful guidance and regulation of complex behaviours in order to attain a future goal (Lezak, Howieson, & Loring, 2004; Pennington & Ozonoff, 1996), especially in non-routine (i.e., novel or complex) situations (Banich, 2009). Traditionally, EF has been conceptualized as a single overarching ability or mechanism responsible for directing, regulating, and integrating higher-order cognitive skills (Baddeley, 1996; Norman & Shallice, 1986). Alternatively, other researchers argue that EF comprises a set of independent components, all of which depend upon the optimal functioning of one "central" EF (e.g., inhibitory control; Barkley, 1997; Dempster, 1992).

A third theoretical approach integrates these contrasting perspectives by characterizing EF as a multi-process system, encompassing numerous distinct but interrelated and interdependent cognitive processes that function as a coordinated system (Miyake et al., 2000; Stuss & Alexander, 2000). Proponents of the "unity and diversity" framework have demonstrated that performance across EF tasks cluster into distinct functional domains that reflect components of EF, such as inhibitory control, mental flexibility, self-monitoring and regulating, planning, working memory (WM), and decision-making (Collette et al., 2005; Miyake et al., 2000). These components of EF have been localized to cortical networks primarily associated with the prefrontal cortex and anterior cingulate cortex (Anderson, Levin, & Jacobs, 2002; Stuss et al., 2002).

Stemming from a lack of theoretical and conceptual clarity, definitions of EF overlap with terminology used to explain other cognitive processes, such as attention, memory, problem solving, and reasoning, leading to confusion in terms of how to operationalize and measure EF (Klenberg, Korkman, & Lahti-Nuuttila, 2001; Pennington & Ozonoff, 1996). In particular, the overlap between EF and attention has spurred much research in an attempt to clarify the redundancy in processes attributed to each construct and among the neuropsychological measures used to assess each construct (Barkley, 1996; Fletcher, 1998; Morris, 1996).

At a conceptual level, most researchers agree that the ability to control attention is necessary to focus on the non-routine EF task (Diamond, 2006; Wiebe, Espy, & Charak, 2008). According to this view, the fundamental ability to control attention provides a subordinate platform on top of which goal-directed activity operates. This attentional resource is not specific to EF, but considered to be a general (and limited) resource that is shared across all cognitive domains (Tombu & Jolicœur, 2003). In keeping with these arguments, factor analytic studies reveal that performance across EF tasks shares substantial common variance, which is interpreted as evidence of the supporting role of attention during EF activity (Glisky, Polster, & Routhieaux, 1995; McCabe, Roediger, McDaniel, Balota, & Hambrick, 2010).

Still, others have recast WM, a standard component across models of EF, as an attention process. This attentional resource biases the encoding of information towards relevant information, maintains the relevant information under conditions of interference and distraction, and performs a “rehearsal-like function” to keep the information active (Awh & Jonides, 2001; Cowan et al., 2005; Kane, Conway, Hambrick, & Engle, 2007; McNab & Klingberg, 2008). These researchers argue that variation in WM capacity in fact reflects the capacity of attentional focus, which explains the strong correlation between WM capacity and the ability to control attention (Cowan et al., 2005).

An alternative approach is to conceptualize attention itself as a unique component of EF necessary for successful goal-directed activity. Indeed, many terms have been coined to refer to the attention processes invoked during EF tasks, including (but not limited to) executive attention (Engle & Kane, 2004; Kane et al., 2007; McCabe et al., 2010), executive control (Logan, 2003; Posner & Fan, 2008; Rueda et al., 2004), attentional control (Anderson, 2002; Jurado & Rosselli, 2007), attention control (Osaka et al., 2004), controlled attention (Engle, Tuholski, Laughlin, & Conway, 1999), and cognitive control (Depue, Banich, & Curran, 2006; Jacoby, Bishara, Hessels, & Toth, 2005).

As one example, Anderson (2002, 2008) proposed "attentional control" to constitute one of four independent domains that together form the "executive control system model." Anderson's attentional control domain involves the capacity to selectively attend to information, sustain attention, self-regulate, monitor action, and inhibit responses. As another example, Posner and DiGirolamo (1998) construe "executive attention" as the EF component responsible for monitoring and resolving conflict (i.e., among thoughts, feelings, and responses) that typically arise in EF situations involving stressful or difficult conditions, planning, decision-making, and executing unfamiliar or new responses (Posner & Fan, 2008; Raz & Buhle, 2006).

## Clinical Implications of Executive Function and Attention Deficits

Regardless of the characterization of the EF-attention relationship, it is clear that attention is extensively involved in the execution of purposeful, complex behaviour.

Clinical developmental research has further substantiated the significance of this association. For example, problems with EF and attention tend to co-occur in typical (Aronen, Vuontela, Steenari, Salmi, & Carlson, 2005; Gathercole et al., 2008) and atypical populations of children (Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005; Martinussen & Tannock, 2006). Poor attention skills, reflected by higher levels of inattention *or* hyperactivity/impulsivity, in school age children are indicative of deficits in EF (Barkley, 1997; Diamantopoulou, Rydell, Thorell, & Bohlin, 2007; Nigg, 2000, 2001). One study even found that attention skills *at each year* in an unselected population of 7- to 14-year-old children predicted performance on EF measures of inhibitory control, WM, and set shifting at age 17 (Friedman et al., 2007). Indeed, clinical presentations of executive dysfunction manifest as maladaptive behaviours that clearly reflect the pivotal role of attention, including inability to focus or maintain attention, forgetfulness, poor self-monitoring and work quality, difficulty shifting flexibly between task demands or rules, disorganization, perseveration, and impulsivity.

Deficits in aspects of both EF and attention are implicated in a variety of disorders observed in childhood, including attention-deficit/hyperactivity disorder (ADHD; Castellanos, Sonuga-Barke, Milham, & Tannock, 2006), autism spectrum disorder (ASD; Robinson, Goddard, Dritschel, Wisley, & Howlin, 2009), fetal alcohol spectrum disorder (FASD; Mattson, Crocker, & Nguyen, 2011), traumatic brain injury (TBI; Levin & Hanten, 2005), conduct disorder (CD) and oppositional defiant disorder (ODD; Sergeant, Geurts, & Oosterlaan, 2002), obsessive-compulsive disorder (OCD; Penadés, Catalán, Andrés, Salamero, & Gastó, 2005), Tourette's disorder (Eddy, Rizzo, & Cavanna, 2009), learning disorders (LD; Passolunghi & Siegel, 2001; Schuchardt, Maehler, & Hasselhorn, 2008), language impairment (Im-Bolter, Johnson, & Pascual-Leone, 2006; Martin & McDonald, 2003), spina bifida and hydrocephalus (Burmeister et al., 2005), cerebral palsy (CP; Bottcher, Flachs, & Uldall, 2010), type 1 diabetes (Gaudieri, Chen, Greer, & Holmes, 2008), lead exposure (Chiodo, Jacobson, & Jacobson, 2004), phenylketonuria (Leuzzi et al., 2004) and epilepsy (Culhane-Shelburne, Chapieski, Hiscock, & Glaze, 2002), as well as children with central nervous system (CNS) cancer or who have been treated for cancer (Wefel, Kayl, & Meyers, 2004) and children from low socioeconomic status backgrounds (Kishiyama, Boyce, Jimenez, Perry, & Knight, 2009). These disorders do not merely delay the acquisition of EF and attention skills; rather, EF and attention skills may fail to develop or severe secondary disorders of EF and attention may develop (Marlowe, 2000).

Scholastically, EF and attention skills are related to academic achievement in all subject areas, including math, reading, writing, social sciences, and second language instruction (Barry, Lyman, & Klinger, 2002; Best, Miller, & Naglieri, 2011; Diamantopoulou et al., 2007). Regardless of the etiology of EF and attention deficits, these children are at greater risk of grade retention and more likely to require extra instructional assistance and placement in special classes (Biederman et al., 2004). Investigation into long-term educational outcomes indicate EF and attention skills are associated with high school graduation and post-secondary education attainment (Barkley, Fischer, Smallish, & Fletcher, 2006).

Functionally, EF and attention skills are related to real-world adaptive behaviour (Clark, Prior, & Kinsella, 2002; Healey, Brodzinsky, Bernstein, Rabinovitz, & Halperin, 2010; Kerns & Mateer, 1996; Miller & Hinshaw, 2010), social and emotional behaviours

(Best, Miller, & Jones, 2009; Diamantopoulou et al., 2007), and mental health (e.g., antisocial behaviours, substance dependence, mood and anxiety disorders; Aronen et al., 2005; Biederman et al., 2006). These relationships persist into adolescence and adulthood (Bagwell, Molina, Pelham, & Hoza, 2001; Stavro, Ettenhofer, & Nigg, 2007), influencing aspects of occupational status and adjustment and even driving ability (Barkley & Fischer, 2011; Barkley, Murphy, Dupaul, & Bush, 2002). Although causality cannot be inferred from these studies, it seems reasonable to assume that EF and attention deficits contribute to serious long-term difficulties affecting multiple functional domains.

Overall, there is substantial comorbidity in EF and attention deficits reported for children with and without developmental disorders. Without intervention, these deficits show limited spontaneous improvement (Ozonoff & McEvoy, 1994) and have a cumulative impact on numerous functional abilities, resulting in concurrent and future problems (Miller & Hinshaw, 2010). Hence, intervention to ameliorate these cognitive deficits may have profound immediate and long-term benefits.

**Treatment Approaches for Executive Function and Attention Deficits**

Pharmacological based treatments for children to ameliorate deficits in EF and attention have been utilized with varying degrees of success. Comprehensive review articles estimate that 30% of children with a diagnosis of ADHD fail to derive benefit from the use of stimulant medication (Biederman & Spencer, 2008; Spencer et al., 1996). Research suggests that pharmacological treatment is less effective for preschool children and adolescents (Charach et al., 2013; Wolraich et al., 2005), and when there is comorbidity of ADHD (Pliszka, 2009). Even for children treated successfully with medication, deficits in EF, attention, memory, and other cognitive processes are only partially remediated (Gualtieri & Johnson, 2008; Tucha et al., 2006) and academic and learning difficulties persist (Powers, Marks, Miller, Newcorn, & Halperin, 2008). Moreover, the benefits of pharmacotherapy for EF and attention deficits attenuate over time and may generate adverse side-effects (Rabipour & Raz, 2012).

In light of pharmacological treatment limitations and ongoing concern about the long-term efficacy and effects of stimulant consumption (Molina et al., 2009; Morein-Zamir & Sahakian, 2011), parents and clinicians are oftentimes reluctant to embrace drug-based therapy, especially for younger children (Rabipour & Raz, 2012). The past two decades demonstrate a marked increase in research on alternative treatment approaches for cognitive deficits. In particular, internally focused interventions, designed to directly change an individuals' abilities or behaviour, have become increasingly popular (Diamond, 2012; Diamond & Lee, 2011). These interventions can be divided into process specific (i.e., restorative) and compensation approaches.

**Process specific approach.**

Direct "process specific" interventions involve sufficient repetition of hierarchically organized cognitive exercises to facilitate improvements in underlying cognitive function (Sohlberg & Mateer, 1987). These functional improvements are purportedly driven by neuroplasticity, the mechanism through which the brain undergoes functional and structural alterations in response to encoding new experiences. Relevant to a process specific rehabilitation approach, Kleim and Jones (2008) identified key principles of experience-dependent neuroplasticity that influence rehabilitation outcomes. The principle "use it and improve it" refers to the notion that targeting and training a specific cognitive ability can lead to an enhancement of the ability through the active engagement of underlying neural circuits. Essential principles of "repetition," "intensity," and "salience" indicate that engaging neural systems to induce lasting change requires repetition of a salient behaviour at a sufficiently high level of intensity. These factors have clear implications for rehabilitation – process specific interventions that incorporate principles of experience-dependent neuroplasticity will maximize neural system reorganization and behavioural change.

Accumulating evidence from neuroscience research demonstrates that process specific training is associated with underlying neuroanatomical, neurochemical, and functional changes (Kelly, Foxe, & Garavan, 2006). For example, training related improvements in WM have been associated with changes to regions of the brain that subserve WM, including reduced regional gray matter volume of the bilateral dorsolateral prefrontal cortex, bilateral parietal regions, and left superior temporal gyrus (Takeuchi et al., 2010), increased structural connectivity in the white matter regions adjacent to the intraparietal sulcus and anterior part of the corpus callosum (Takeuchi et al., 2011), and altered activation patterns in the prefrontal, anterior cingulate, and parietal cortical regions (Chein & Schneider, 2005; Haut, Lim, & MacDonald, 2010; Olesen, Westerberg, & Klingberg, 2004). Similarly, attention training has also been associated with altered activation patterns in areas of the brain modulated by visual attention demands, including prefrontal, anterior cingulate, and parietal cortices (Chen et al., 2011; Kim et al., 2009).

Although the majority of neuroimaging studies have involved adults, electrophysiological techniques have commonly been used to investigate the efficacy of cognitive interventions in children. One study utilized a computerized attention training program with children with FASD (MacSween, Gruppuso, Baker, & Kerns, 2011). Post-intervention, children evidenced electrophysiological amplitude reductions during tasks of attention, suggestive of improved information processing efficacy. Several studies also indicate that typically developing preschool children benefit from computerized EF and/or attention training as indicated by altered electrophysiological activity in the anterior cingulate cortex, as well as changes in the timing and topographic distribution of event-related potentials (Rueda, Checa, & Cómbita, 2012; Rueda, Rothbart, McCandliss, Saccomanno, & Posner, 2005). Finally, Johnstone and colleagues concluded that following EF training, children with ADHD evidenced a significant N1 amplitude increase, indicative of earlier attention processing, as well as electroencephalography band power distribution alterations (Johnstone, Roodenrys, Phillips, Watt, & Mantz, 2010). Importantly, these studies concluded that cognitive training altered brain activity to more closely resemble that of typically developing older children and adults.

Post-intervention neural changes were also associated with cognitive improvements on measures of nonverbal reasoning, affective decision-making, WM, and attention, and behavioural gains such as increased task accuracy, decreased reaction time, and reduced symptoms of inattention and hyperactivity (Johnstone et al., 2010; MacSween et al., 2011; Rueda et al., 2012, 2005). In sum, converging evidence supports that neural change occurs as a consequence of cognitive training *and* that these changes underlie training and transfer effects (Buschkuehl, Jaeggi, & Jonides, 2012).

**Compensation approach.**

An alternative internally focused approach is compensation, which involves teaching the individual strategies that compensate for cognitive impairment (Mateer, Kerns, & Eso, 1996). In contrast to process specific training, compensation interventions target change at the level of activity or behaviour to promote functional gains (Sohlberg & Powell, 2011). For example, children with FASD and Down's syndrome were taught to use rehearsal strategies to increase verbal WM span (Conners, Rosenquist, Arnett, Moore, & Hume, 2008; Loomes, Rasmussen, Pei, Manji, & Andrew, 2008).

The most common type of compensation approach used in rehabilitation is metacognitive strategies to help the individual self-monitor, evaluate, and control their own cognition (Shimamura, 2000). Specifically, these strategies allow an individual to intentionally allocate cognitive resources as well as select and implement strategies, by considering task demands, available cognitive resources, types of strategies, and previous performance outcomes. Before, during, and after the implementation of a strategy, the individual monitors and evaluates the ongoing effectiveness of performance, flexibly adopting a more viable strategy if necessary. For example, planning, monitoring, and evaluation metacognitive strategies are frequently utilized in educational settings to improve reading, writing, and mathematics (Dignath, Buettner, & Langfeldt, 2008). Interestingly, integrative interventions that combine instruction of cognitive, metacognitive, and motivational strategies are the most effective in the context of self-regulated learning (Dignath et al., 2008).

#### Integration of process specific and compensation approaches.

Several meta-analyses conclude that process specific training is most effective when delivered in conjunction with metacognitive training for remediation of EF, attention, and memory deficits (Cicerone et al., 2011; Kennedy et al., 2008; Sohlberg et al., 2003). The combination of process specific and compensation approaches is posited to promote the development of strategies, foster generalization of skills and strategies to real world tasks, and generate positive functional outcomes.

In a series of studies, van’t Hooft and colleagues investigated the efficacy of an attention and memory intervention comprised of hands-on activities for children with acquired brain injury (van’t Hooft et al., 2005, 2007; van’t Hooft, Andersson, Sejersen, Bartfai, & von Wendt, 2003). The intervention, delivered by a trained parent or teacher, incorporated metacognitive elements into the attention and memory exercises, such as the provision and practice of cognitive strategies, questions that encouraged reflection about strategies, and weekly performance reviews. Across the studies, post-intervention results indicated significant improvements on psychometric measures of attention and memory, parent and teacher behaviour ratings of learning ability, and teacher behaviour ratings of social and emotional behaviour. Moreover, six months after the completion of the training, children exhibited additional significant improvements on measures of attention and memory (van’t Hooft et al., 2007).

Across a second series of studies, Tamm and colleagues investigated the efficacy of an attention training intervention consisting of visual and auditory tabletop tasks for children with ADHD (Tamm et al., 2010; Tamm, Epstein, Peugh, Nakonezny, & Hughes, 2013). Throughout the intervention, a metacognitive training approach was simultaneously emphasized, as researcher-interventionists engaged children in discussion about their performance, taught children strategies to improve performance, and brainstormed with children how to apply specific strategies in their home or school setting. After treatment, significant improvements were evidenced by child performance on measures of EF (i.e., fluid reasoning, cognitive flexibility, planning efficacy, and WM), self-report of attention abilities, as well as parent and clinician ratings of EF, attention, and ADHD symptoms. A subsequent study by these authors utilized a combined parent and researcher delivery model (i.e., intervention was delivered both in a clinic setting and at home) to implement an EF and metacognitive training protocol for children with ADHD (Tamm, Nakonezny, & Hughes, 2014). Pre-post comparisons revealed significant gains on child assessment measures of EF that paralleled reductions on parent and clinician behaviour ratings of EF and symptoms of inattention, demonstrating the feasibility of training parents to deliver an intervention.

Several researchers have identified an acute need for school-based cognitive interventions as training typically requires multiple sessions spanning several weeks, posing logistical and financial challenges (Kennedy et al., 2008). The convenience of school-based training may help circumvent barriers to care delivery (Mezzacappa & Buckner, 2010) and increase accessibility to and participation of children in need (Diamond & Lee, 2011). Moreover, the school provides a naturalistic setting that may facilitate the transfer of training derived skills to real-world tasks and situations (Sjö, Spellerberg, Weidner, & Kihlgren, 2010).

For example, Kerns and colleagues trained research assistants to deliver a computerized attention training intervention to children with FASD in the school setting (Kerns, MacSween, Vander Wekken, & Gruppuso, 2010). Assistants also taught and supported children’s use of metacognitive strategies across the duration of the intervention. Post-intervention results revealed significant gains on tasks of sustained and selective attention, and untrained measures of WM and academic fluency. More recently, Kerns and colleagues trained educational assistants (EAs) to deliver an WM and attention training intervention to children with ASD and FASD at school (Kerns, Macoun, MacSween, Pei, & Hutchison, 2016). Pre- and post-testing revealed significant improvements on measures of distractibility, divided attention, WM, and reading fluency. Likewise, other studies have reported successful delivery of cognitive and metacognitive training protocols in schools by trained research associates (Holmes, Gathercole, & Dunning, 2009; Mezzacappa & Buckner, 2010), classroom assistants (Holmes et al., 2010), and teachers (Sjö et al., 2010). Overall, training interventions delivered within the school setting were perceived positively by teachers, parents, and children, with negligible concerns related to scheduling, missed class time, or incomplete classwork (Kerns et al., 2010; Kerns et al., 2016; Mezzacappa & Buckner, 2010).

In sum, interventions that combine process specific and compensation approaches lead to significant functional improvements for children with EF and attention deficits of varying etiology. Benefits derived from cognitive training have been shown to translate into cognitive, behavioural, academic, social, and emotional gains. School-based interventions, delivered by trained research or school staff, appear to be feasible, and likely enable more children to receive the intervention and facilitate transfer of cognitive and metacognitive skills.

## The Role of Motivation in Intervention

Motivation, defined as the attribute that moves an individual to take action, varies in orientation (i.e., type) and level (i.e., amount; Eccles & Wigfield, 2002). On one dimension, motivation ranges from intrinsic, which refers to doing an activity because of its inherent satisfaction (e.g., personal interest, enjoyment, or challenge), to extrinsic, when action is taken because of an externally applied factor, such as a tangible reward, verbal feedback, or to avoid a punishment (Ryan & Deci, 2000). A second common distinction is made between state, which is the motivation experienced in the present moment while engaged in an activity, and trait, which refers to an individual's standard level of motivation in a specific context or towards a certain type of task (e.g., school or learning; Vallerand, 1997). Whereas trait motivation is seen as a relatively stable and enduring characteristic, state motivation is viewed as temporary and transitory. In general, state motivation is viewed as a narrower and more proximal function of trait motivation (Vallerand, 1997).

Motivation has important psychological outcomes. For example, higher intrinsic motivation is associated with positive affect and vitality (Isen & Reeve, 2005), low levels of anxiety (Gottfried, 1990), self-perceived competence and autonomy (Vallerand, 1997), effort and persistence in activities (Standage, Duda, & Ntoumanis, 2006), and an adaptive attribution style (Robertson, 2000). On the other hand, extrinsic motivation is associated with the reverse of the outcomes listed above (Deci, Koestner, & Ryan, 1999; Lepper, Corpus, & Iyengar, 2005).

Motivational constructs have been extensively examined in the fields of social and educational psychology. Motivation for learning has profound implications for the success and quality of any learning outcome, consistent with the strong, positive correlation observed between children's intrinsic learning motivation and academic ability (Broussard & Garrison, 2004; Morgan & Fuchs, 2007). Intrinsic motivation is associated with numerous academic outcomes, including grades and other measures of achievement, classroom adaptation, and school satisfaction (Gottfried, Gottried, Morris, & Cook, 2008; Mitchell, 1992; Niemiec & Ryan, 2009). Interestingly, converging evidence shows that children's intrinsic motivation towards academic learning steadily declines from Grade 3 (or age eight), as children advance through school (Corpus, McClintic-Gilbert, & Hayenga, 2009; Lepper et al., 2005; Otis, Grouzet, & Pelletier, 2005). The developmental decline in intrinsic motivation is speculated to be the cumulative effect of extrinsic consequences on intrinsic motivation, extrinsically oriented school and home environments, and increasing awareness and significance of performance evaluations in school, sports, and other activities (Gottfried, Fleming, & Gottfried, 2001; Lepper et al., 2005). To date, two conflicting studies have examined academic intrinsic motivation in younger children prior to the age of eight years. Although one longitudinal study reported that intrinsic motivation decreased across the ages of six to eight in a sample of typically developing children (Bouffard, Marcoux, Vezeau, & Bordeleau, 2003), a cross-sectional study reported increasing levels of intrinsic motivation in an equivalent sample of children (Broussard & Garrison, 2004).

Research on motivation in clinical populations of children has been sparse, though there is preliminary support to suggest that intrinsic motivation is negatively related to difficulties with attention (Chang & Burns, 2005; Harris, Robinson, Chang, & Burns, 2007) and learning (Sideridis, 2003, 2006). Another study reported that children with ADHD have significantly less intrinsic motivation compared to a control group based on parent- (effect size = 1.70), teacher- (effect size = 1.28), and self- report measures (effect size = 0.59; Carlson, Booth, Shin, & Canu, 2002). Functional imaging research indicates that children with ADHD also evidence brain abnormalities in motivational neural networks such as increased activation in the orbitofrontal and superior temporal cortices (Rubia et al., 2009; Umemoto, Lukie, Kerns, Müller, & Holroyd, 2014), which persist into adulthood (Cubillo, Halari, Smith, Taylor, & Rubia, 2012).

In general, children with EF and attention deficits are more likely to experience school non-success, be subjected to disciplinary actions, and encounter failure in learning situations, which would likely reduce learning motivation, interest, and desire, as well as the perceived value of school activities (Grolnick & Ryan, 1990). Children with ADHD are also more likely to believe that cognitive abilities are fixed and unmalleable, have an external locus of control, become discouraged and discontinue earlier on difficult tasks, and gauge their performance based on external feedback rather than internal standards, which are factors negatively associated with intrinsic learning motivation (Carlson et al., 2002; Dunn & Shapiro, 1999). Over time, these beliefs and reactions can accrue into a persistently disengaged and unmotivated attitude towards learning.

Motivation quality and quantity, as described above, has clear implications for the success of internally focused treatment interventions, as motivation affects the extent to which new skills are practiced, learned, and generalized. Despite this, few studies have considered the impact of motivation on cognitive treatment interventions. In one study, Jaeggi and colleagues compared training gains across studies that had utilized the authors' WM training paradigm with adults to differentiate the effects of intrinsic and extrinsic motivation on cognitive intervention (Jaeggi, Buschkuehl, Shah, & Jonides, 2014). Consistent with the finding that extrinsic motivation undermines intrinsic motivation and performance, paid participants (i.e., ranging between $130 – $800) evidenced shallower training curves and no transfer effects to untrained neuropsychological outcome measures. In contrast, participants who were not paid at all or paid only a modest amount (i.e., $20) evidenced considerably steeper training curves as well as significant improvements on untrained psychometric measures. These findings suggest that intrinsic motivation is particularly important in facilitating both cognitive training gains and transfer effects. Subsequently, this finding was replicated in a meta-analytic review, which concluded that remuneration for study participation was negatively correlated with post-training gain (Au et al., 2015).

As both of these reviews relied on cognitive training research conducted with adults, it is unclear how these results apply to children. However, meta-analytic review of studies exploring the effect of extrinsic rewards on intrinsic motivation for children during brief activities (e.g., word games and construction puzzles) indicate that tangible rewards, but not verbal rewards, undermine intrinsic motivation when the rewards are expected or contingent on task engagement or completion (Cameron, Banko, & Pierce, 2001; Deci, Koestner, & Ryan, 2001). Interestingly, although tangible rewards have a detrimental effect on children's intrinsic motivation, these rewards have a positive impact on task performance (Luman, Oosterlaan, & Sergeant, 2005). This effect appears to be even stronger for children with EF and attention deficits, such as children with ADHD, particularly when rewards are frequent, salient, and immediate (Luman et al., 2005). This suggests that children's intrinsic motivation, as well as the use of rewards, may be important in the context of cognitive training with children with EF and attention deficits.

When considering the impact of state motivation on intervention outcomes, research suggests that the use of computerized programs with game elements enhances a variety of state motivational factors, such as level of engagement, interest, and arousal (Ota & DuPaul, 2002; Shaw, Grayson, & Lewis, 2005). Several rehabilitation programs for children with cerebral palsy have combined physical exercises with motivating video games. Compared to traditional approaches, these studies indicate that participants evidence greater treatment adherence and physical ability improvements (Bryanton et al., 2006; Hernandez et al., 2012; Hernandez, Ye, Graham, Fehlings, & Switzer, 2013). In another study, Cordova and Lepper (1996) investigated the effect of motivation on computerized remedial math activities in elementary school-aged children by contrasting a non-fantasy control version of the math program to two fantasy versions. Findings indicated that state motivation (based on children's ratings of how much they liked the computer game and the extent to which they would recommend the computer game to friends) was higher for the fantasy versions of the remedial math program, and positively correlated with overall learning, degree of task involvement and engagement, preference for more challenging versions of the game, and perceived math competence.

In terms of cognitive interventions, the inclusion of game elements in computerized training activities also enhances state motivation. For example, Prins and colleagues compared a standard computerized WM intervention to a game version, which included animation, a story line and goal, rewards, and a personalized game character (Prins, Dovis, Ponsioen, ten Brink, & van der Oord, 2011). Children with ADHD who trained with the game version showed significantly greater training motivation (as reflected by time spent training and total number of trials completed), training performance, and post-training performance on an untrained WM task.

Preliminary findings from cognitive training research with typically developing children and adults suggest that individual differences in training derived gains may reflect the impact of state motivational factors. In one study, typically developing children in elementary and middle school completed a minimum of 15 training sessions on a computerized WM task (Jaeggi, Buschkuehl, Jonides, & Shah, 2011). To assess motivation for training, children completed a post-intervention questionnaire about the computerized training program that was comprised of three variables: enjoyment, difficulty, and self-perceived improvement. Findings indicated that children who rated the training as "challenging but not overwhelming" evidenced significant improvement on the WM training task *and* untrained fluid intelligence task, whereas children who rated the program as "difficult and effortful" failed to show training or transfer gains. Hence, the authors concluded that motivation, as reflected by the ability to cope with frustration when the task became more challenging, has a substantial impact on the degree of improvement on the training task and untrained outcome measures. Of note, children's enjoyment ratings were unrelated to training and transfer gains, and the authors did not report on the relationship between the third motivation variable (i.e., self-perceived improvement) and the effects of cognitive training.

In a second study, adults rated their level of engagement (i.e., state motivation) during each training session that consisted of computerized auditory and visual WM activities (Jaeggi et al., 2014). Results indicated that participants who completed the study reported consistently high levels of engagement, whereas those who dropped out of the study reported lower levels of engagement that declined across sessions. More importantly, there was a significant, positive correlation between self-reported level of training engagement and amount of training gain within the group of participants who completed the study and within the group of participants who did not complete the study. In sum, across both cognitive training studies, higher state motivation affected cognitive training performance and facilitated subsequent transfer of learned skills to untrained outcome measures.

The relationship between state motivation and process specific interventions for younger children (i.e., less than seven years of age) has not been empirically examined. Younger children may be at a disadvantage due to difficulty maintaining motivation in the context of repetitive training sessions and activities. For example, younger children are less able to self-regulate, control and focus attention, persist when faced with difficulties, and ignore distractions or competing opportunities, which could lower state motivation (Bandura, 1993; Eccles & Wigfield, 2002). Younger children may also have more difficulty understanding and retaining the potential benefit and value of the training activities (Hidi & Harackiewicz, 2000), ultimately lowering their motivation to comply with the training protocol. In contrast, older children may be better able to sustain training motivation throughout the duration of a cognitive intervention as a result of developmental improvements in self-regulation and other cognitive skills, as well as greater insight into the value of training.

Given that preliminary research findings suggest that factors related to motivation significantly impact (and possibly confound) training performance and treatment outcomes, motivation should be considered when investigating the efficacy of cognitive training intervention (Green, Strobach, & Schubert, 2014; Jolles & Crone, 2012; Karbach & Unger, 2014; Titz & Karbach, 2014). Examining the role of motivation may in fact explain (and in the future reduce) conflicting results across cognitive training studies. Specifically, the impact of intrinsic/extrinsic *and* state motivation on cognitive training gains and transfer effects should be considered. Moreover, the impact of motivation on cognitive intervention may also vary as a function of age.

**The Role of Self-Concept in Intervention**

Self-concept is defined as an individual's collective evaluative self-perceptions that: (a) form through experiences with and interpretations of the environment; (b) are influenced by the reinforcements and evaluations of significant others, as well as self-attribution styles; and (c) become increasingly multidimensional over the course of development (Harter & Pike, 1984; Marsh, Craven, & Debus, 1991). Self-concept encompasses self-efficacy (i.e., an individual's beliefs about their performance capabilities) in addition to other types self-evaluations, such as physical appearance self-perceptions (Schunk, 1991). It is noteworthy that these evaluative self-perceptions reflect an individual's beliefs and interpretations, which may or may not be realistic or accurate (Baumeister, Campbell, Krueger, & Vohs, 2003).

Self-concept is hierarchically organized such that self-concepts in specific domains are subsumed into progressively more generalized self-concepts (Marsh, 1990). A basic premise of this structure is that self-concept becomes increasingly stable as the nature of the self-evaluation moves towards the apex of the hierarchy, away from situation-specific evaluations (Marsh, 1990). Specifically, the base of the hierarchy is comprised of self-evaluations of singular experiences in specific situations. These combine into domain subareas (e.g., physical ability and physical appearance), which in turn merge into larger domains (e.g., physical self-concept). Finally, the apex of the hierarchy consists of global self-evaluations with no reference to competence domains or subdomains. These generalized self-evaluations, reflecting the sum of the abstracted version of self-concepts, are referred to as self-worth, self-esteem, or global self-concept (Schunk, 1991).

The construction of the self is a dynamic process that unfolds over the course of development. Beginning around age four, young children have the language and cognitive ability to represent and discuss the self, and are able to reliably differentiate facets of the self, articulate judgments, and rate self-competence in multiple domains, including various activities (e.g., reading, music, and sports), cognitive abilities, physical abilities, social acceptance, and behavioural conduct (Davis-Kean & Sandler, 2001; Penn, Burnett, & Patton, 2001; Trzesniewski, Donnellan, & Robins, 2003). However, children younger than eight years of age tend to use less comparative standards to judge their abilities, relying more on intra-individual comparisons, and place more weight on social feedback (i.e., praise), whereas older children tend to base their self-evaluations on inter-individual (i.e., social) comparisons and objective feedback (Stipek & Mac Iver, 1989). Younger children also lack the ability to integrate self-concept domains into an overall abstracted or generalized concept of their worth as a person (Harter & Pike, 1984). As well, self-concept becomes increasingly multidimensional across the lifespan, in that a growing number of discrete self-evaluative domains can be articulated and differentiated (Harter, 2012b). For example, domains such as job competence, romantic relationships, and morality only emerge in adolescence or adulthood. For these reasons, self-concept research and psychometric measures for younger children assess fewer domains of self-concept and focus more on categories of self-description and age-related differences in self-conceptions, whereas research and assessment tools for older children evaluate a broader range of self-concept domains and focus primarily on individual differences in the evaluative aspects of self-concept (Eder & Mangelsdorf, 1997).

Longitudinal research indicates that self-concept in all areas (e.g., academic ability, athletic ability, physical appearance, and social relationships) decreases each year beginning at the age of five through to adulthood (Broussard & Garrison, 2004; Fredricks & Eccles, 2002; Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002; Marsh, Craven, & Debus, 1998; Wigfield et al., 1997). Decreasing self-concept is believed to be the result of greater reliance on perceived evaluations of peers, recognition of the importance of abilities and achievements, increased use of normative and social comparative grading, and (negative) feedback at school (Fredricks & Eccles, 2002; Robins & Trzesniewski, 2005).

Self-concept is viewed as an important psychological factor that promotes mental and physical health and well-being (Mann, Hosman, Schaalma, & de Vries, 2004). For example, self-concept is negatively associated with susceptibility to mental health disorders (DuBois & Flay, 2004) and positive self-evaluations serve as a buffer against stress, depression, and eating disorders (Mann et al., 2004; Rice, Ashby, & Slaney, 1998; Vohs, Bardone, Joiner, Abramson, & Heatherton, 1999). Self-concept is also positively associated with quality of life in survivors of childhood cancer (Langeveld, Grootenhuis, Voûte, de Haan, & van den Bos, 2004), functional outcomes after a stroke (Chang & Mackenzie, 1998), length of survival after bone marrow transplantation (Broers et al., 1998), and mortality rates in nursing home residents (O'Connor & Vallerand, 1998). Individuals with positive self-concept are more likely to graduate from college or university and obtain long-term employment (Trzesniewski et al., 2006). These individuals are also less likely to endorse having work or financial problems (Trzesniewski et al., 2006).

On the other hand, low self-concept functions as a nonspecific risk factor for mental and physical health problems (Mann et al., 2004). Poor self-concept is related to externalizing (e.g., aggression, antisocial behaviour, delinquency, violence, and substance abuse; Donnellan, Trzesniewski, Robins, Moffitt, & Caspi, 2005; Pisecco, Wristers, Swank, Silva, & Baker, 2001) and internalizing problems (e.g. depression, suicidal tendencies, eating disorders, and anxiety; Mann et al., 2004; McGee & Williams, 2000). Low self-concept is associated with lower educational achievement and negative consequences in adulthood, including job dissatisfaction, unemployment, risky health behaviour, and criminal behaviour (Mann et al., 2004; Trzesniewski et al., 2006).

In considering children with EF and attention deficits, it is conceivable that they may be at greater risk of low self-concept. For example, as a result of the cognitive and behavioural issues associated with these particular deficits, these children are more likely to receive negative evaluation and fare less favourably in peer competition and social comparison, which would negatively impact self-evaluations (Covington, 1992). In addition, a child's performance itself is negatively impacted by these cognitive deficits and manifests behaviourally as task procrastination or avoidance, poor effort, excuse making, and avoidance of challenging tasks (Covington, 1992). The problematic behaviours and lowered performance may lead to additional negative evaluations, peer competitions and social comparisons, and ultimately to even lower self-concept.

Indeed, many childhood disorders that involve deficits in EF and attention are associated with low self-concept, including ADHD (Barber, Grubbs, & Cottrell, 2005), ASD (Williamson, Craig, & Slinger, 2008), FASD (Baer, Barr, Bookstein, Sampson, & Streissguth, 1998), TBI (Souza, Braga, Filho, & Dellatolas, 2007), CD (Barry, Frick, &

Killian, 2003), ODD (Klassen, Miller, & Fine, 2004), OCD (Doron, Kyrios, & Moulding, 2007), Tourette's disorder (Elstner, Selai, Trimble, & Robertson, 2001), LD (Harter, Whitesell, & Junkin, 1998), language impairment (Jerome, Fujiki, Brinton, & James, 2002), hydrocephalus (Fernell, Gillberg, & von Wendt, 1992), spina bifida (Appleton et al., 1994), cerebral palsy (Russo et al., 2008), type 1 diabetes (Luyckx & Seiffge-Krenke, 2009), phenylketonuria (Smith & Knowles, 2000), and epilepsy (Baker, Spector, McGrath, & Soteriou, 2005), as well as children who have been treated for cancer (von Essen, Enskär, Kreuger, Larsson, & Sjödén, 2000) and children from low socioeconomic status backgrounds (Twenge & Campbell, 2002).

However, other studies that have focused exclusively on the competency aspect of self-concept report that children with ADHD or LD exhibit a "positive illusory bias." This bias refers to the tendency to overestimate one's own competency or task performance as compared to an external criterion, such as actual performance, teacher ratings, or parent ratings (Heath & Glen, 2005; Owens, Goldfine, Evangelista, Hoza, & Kaiser, 2007). For example, Hoza and colleagues found that boys with ADHD overestimated their competence relative to teacher report significantly more than boys without ADHD within academic, social, and behavioural domains (Hoza, Pelham Jr, Dobbs, Owens, & Pillow, 2002). Thus, studies examining self-perceptions in children with ADHD are contradictory, with evidence supporting both higher and lower self-concepts.

The importance of self-concept has stimulated a plethora of research investigating preventative and therapeutic interventions designed to enhance self-concept. Meta-analytical review of 116 intervention studies for children indicated significant overall improvement in self-concept and/or self-esteem (effect size = 0.27), with concurrent significant improvements in academic, behavioural, and personality functioning (Haney & Durlak, 1998). Interventions designed to specifically target self-concept (effect size = 0.57) were found to be more efficacious than programs that targeted other areas of adjustment (effect size = 0.10). In addition, treatment programs that targeted children with low self-concept (effect size = 0.47) were more effective than prevention programs that included all children regardless of self-concept level (effect size = 0.09).

Since self-esteem and domain-specific self-concepts are comprised of self-evaluations, including perceived competence and ability, interventions that improve underlying cognitive ability may have a positive impact on self-evaluations. Indeed, several researchers theorize that benefits derived from cognitive training, such as improved cognitive performance and reduced ADHD symptoms, lead to gains in self-concept (Morrison & Chein, 2011; Rabipour & Raz, 2012; Rubia, 2009). In support of this hypothesis, EAs and parents anecdotally reported higher self-concept in children with ADHD, FASD, and ASD following WM and attention training (Kerns et al., 2016; Steiner, Sheldrick, Gotthelf, & Perrin, 2011).

To date, two cognitive training studies have utilized formal assessment measures of self-concept. In the first study, Rattok and colleagues evaluated the efficacy of three interventions for adults with acquired brain injury (Rattok et al., 1992). All treatments included 80 hours of attention training and 60 hours of community activity engagement (i.e., brief daily group exercise designed to foster a sense of group belonging and improve social appropriateness). Treatments varied in terms of time spent on individualized cognitive remediation (i.e., cognitive training modules involving reasoning, visual information processing, eye-hand coordination, and finger dexterity), group-based interpersonal communication training, and individual and/or couples counselling. Post-intervention, all three treatments led to a significant increase on a self-report measure of self-concept, in addition to improvements on neuropsychological, behavioural, and interpersonal outcome measures. Of note, all treatments led to improvements on psychometric measures of attention; however, only the two treatments that involved cognitive remediation evidenced psychometric improvements on additional measures of attention, dexterity, and reasoning.

More recently, Harrison and colleagues employed a 6-week yoga meditation intervention comprised of techniques to promote alertness, attention to the present moment, self-awareness, and attention control for children with ADHD and their parents (Harrison, Manocha, & Rubia, 2004). Compared to a waitlist control group, post-intervention results indicated significant gains on standardized parent rating scales of ADHD symptoms, child-parent relationship, and child self-concept. Child self-reported self-concept on a standardized questionnaire did not change significantly; however, the authors noted that these scores were near ceiling at both measurement points.

Although both of these studies involved cognitive training as one of several core treatment components, it is unclear whether cognitive training made a significant independent contribution to gains in self-concept. Hence, the effect of "pure" cognitive training interventions on self-concept requires further investigation.

Of particular interest, research findings suggest that self-concept and motivation may be mutually influential constructs. For example, individuals who hold positive self-evaluations and beliefs of self-competency invest more effort in a task, persist in response to failure, and set more challenging goals (Baumeister et al., 2003; Souvignier & Moklesgerami, 2006; Zimmerman, 2000). Similarly, individuals are motivated to engage in activities that lead to, reinforce, or boost positive self-evaluations and to avoid activities that may negatively affect self-perceptions (Deci & Ryan, 2008; Leary & Baumeister, 2000; Ryan & Deci, 2000). Furthermore, correlational analyses indicate particularly strong associations between academic self-concepts and motivation for learning (Bong, 2001; Pajares & Graham, 1999; Zsolnai, 2002). However, within the context of treatment interventions, the relationship between self-concept and motivation, including state motivation specific to engaging in an intervention, has not been examined.

In summary, children with deficits in EF and attention, regardless of etiology, are at greater risk of low self-concept. Self-concept deficits in childhood persist into adolescence and adulthood (Mannuzza & Klein, 2000; Shaw-Zirt, Popali-Lehane, Chaplin, & Bergman, 2005). Given the importance and enduring nature of self-concept, interventions that improve self-concept are prudent. Although preliminary results suggest that cognitive training may lead to concomitant gains in self-concept, more research is necessary to better quantify and replicate these findings, and to determine the extent to which self-concept is impacted specifically by cognitive interventions. Further examining the interplay of self-concept and motivation is of particular value to clarify the relationship between state motivation for cognitive training and self-concept, as well as between motivation and the extent of any changes in self-concept.

**Objectives of the Current Study**

Previous research on cognitive training has provided some information as to the parameters of effective process specific interventions, including training variables, participant characteristics, and other factors that contribute to treatment efficacy. However, further research is necessary for several important reasons.

1) Although motivation is actively considered in other fields of research concerned with learning, motivation has been widely ignored in literature on cognitive remediation. The extent to which training induced improvements are affected by motivational components is unclear and understudied (Green & Bavelier, 2008; Jolles & Crone, 2012; Karbach & Unger, 2014; Titz & Karbach, 2014). Research into the significance of motivational factors on the efficacy of cognitive and metacognitive interventions may reveal for whom training interventions are most useful and possible adaptations to increase intervention efficacy for other individuals (Jaeggi et al., 2011).

2) Cognitive training research has frequently excluded younger children for a number of reasons. For example, younger children are assumed to have more difficulty maintaining attention throughout training sessions and engaging with training materials over the course of multiple sessions and weeks (Wass, Scerif, & Johnson, 2012). Additionally, fewer cognitive and behaviour assessment tools are applicable for younger children and pre-post assessment comparisons may be less reliable due to methodological issues, such as variability in mood and behaviour, fatigue, and limited understanding of instructions (Akshoomoff, 2002; Luciana & Nelson, 2002).

Despite these challenges, early childhood intervention may lead to greater benefit when utilizing cognitive (Anderson et al., 2003; Nores & Barnett, 2010; Rueda et al., 2005; Wass et al., 2012) and metacognitive training approaches (Dignath et al., 2008; Hendy & Whitebread, 2000). For example, intervention with younger children may prevent or reduce the severity of EF- and attention-related pathologies (Papazian, Alfonso, Luzondo, & Araguez, 2009; Thorell, Lindqvist, Nutley, Bohlin, & Klingberg, 2009). Other researchers argue that early intervention can generate more widespread transfer of training effects (Wass et al., 2012) and mitigate the compounding development of long-term adverse academic and social outcomes (Burger, 2010; Dowsett & Livesey, 2000; Nutley et al., 2011; Rueda et al., 2012).

3) Cognitive intervention research primarily investigates treatment efficacy within specific and narrowly defined clinical populations or typically developing children. This practice deliberately excludes children with an unconfirmed, unclear, or unsubstantiated diagnostic etiology but who suffer cognitive deficits, as may be the case for children with risk factors such as prenatal alcohol or drug exposure (Bauman, 2010; Hoyme et al., 2005). This procedure also limits the inclusion of younger children who are less likely to have received a formal diagnosis due to difficulty ascertaining diagnoses and barriers in diagnostic practices (Mandell, Novak, & Zubritsky, 2005; Pinto-Martin, Dunkle, Earls, Fliedner, & Landes, 2005). Finally, this practice omits children who evidence significantly impairing cognitive deficits but do not meet study inclusion criteria because their deficits are manifested as a result of a disorder other than the diagnosis of interest or because of diagnostic comorbidity. Given that diagnostic etiology of underlying cognitive dysfunction is not a critical factor for effective intervention (Marlowe, 2000; van't Hooft et al., 2005), inclusion of these children should not impact the efficacy of cognitive training and would provide important support for the external validity of intervention results.

4) Although there is a necessary evolutionary sequence in the rigour of research methodology to evaluate newly developed treatments (Gonzalez-Rothi, 2006), much of

the cognitive remediation literature involves low quality research and uncontrolled single subject and group designs (Green & Bavelier, 2008; Robinson, Kaizar, Catroppa, Godfrey, & Yeates, 2014; Rohling, Faust, Beverly, & Demakis, 2009). Systematic review articles routinely identify the need for increased experimental rigour in neurorehabilitation research, such as the inclusion of appropriate comparison groups to control for confounding variables (Cicerone et al., 2005; Green et al., 2014; Robinson et al., 2014), as these shortcomings limit the conclusions that can be drawn regarding the clinical effectiveness and applicability of cognitive intervention.

Given these limitations, the first objective of the current study was to assess the efficacy of the Caribbean Quest (CQ), a cognitive remediation intervention, for improving self-concept, WM, and attention in children with deficits in these areas. For the purposes of this study, self-concept was defined as a child's collective evaluative self-perceptions, including beliefs about performance capabilities. Children with cognitive deficits are at risk of suffering from low self-concept, and this construct has significant long-term impacts across a variety of functional domains. Based on previous research investigating the efficacy of cognitive intervention for children, it was hypothesized that participating in the CQ intervention would increase children's self-concept, WM, and attention.

The second objective was to examine the relationship between motivation and training derived gains on measures of self-concept, WM, and attention. Despite amassing evidence that motivation has a significant impact on learning and physical rehabilitation, very few studies have considered motivational factors in cognitive remediation research. In this study, three measures of motivation were employed. Child- and teacher-report questionnaires were used to assess intrinsic and extrinsic motivation for learning (i.e., motivation to engage in a learning activity because of inherent preference for challenge, independent mastery, and curiosity/interest). In addition, state motivation (i.e., motivation to engage in the CQ intervention as reflected by high interest/enjoyment and appropriate level of difficulty/effort) was assessed based on a series of yes/no questions asking children about their daily experience with the CQ intervention. Based on the research summarized above, it was hypothesized that children with higher intrinsic and state motivation would derive greater benefit from the CQ intervention, as reflected by larger pre-post change on outcome measures.

The third objective was to examine the effect of age on motivation to determine whether children's level of intrinsic learning motivation and state CQ training motivation varied as a function of age. Multiple studies document a predictable yearly decrease in children's intrinsic motivation from age eight onwards, attributed to the negative effects of extrinsic consequences, extrinsically oriented school and home atmospheres, and increasing frequency of performance evaluations, but findings are inconsistent as to motivation changes prior to eight years of age. Given that these factors are present at all age levels, it was anticipated that intrinsic motivation would decrease from age six to 12. On the other hand, state motivation for the CQ intervention was expected to increase from age six to 12 because of factors related to brain development and cognitive maturation, including children's ability to sustain motivation for the duration of the intervention and their understanding of potential training benefits. In addition, it was anticipated that state motivation would not change over the course of the intervention in relation to the number of training sessions completed. However, to the author's knowledge, this question has not yet been empirically investigated.

The fourth objective was to examine the effect of age on self-concept to investigate whether children's self-concept varied as a function of age. Research indicates that self-concept decreases with age as a result of greater access to and reliance on peer social comparisons, heightened awareness of the importance of abilities and achievements, use of normative and social comparative grading, and (negative) feedback at school. Hence, self-concept domains were anticipated to decrease with age.

The fifth objective was to investigate the relationship between self-concept and motivation within the context of a cognitive training intervention. Research suggests that self-concept and motivation may be linked together in a reciprocal causal relationship, such that motivation influences, and is simultaneously influenced by, self-perceived competence and self-evaluations (Vallerand, 1997; Zsolnai, 2002). Hence, it was hypothesized that children's self-concept and motivation would be positively related.

**Hypotheses**

Based on review of pertinent literature as detailed above, the following hypotheses were proposed:

1) Children in the CQ intervention group will evidence significant increases on a self-report measure of self-concept (i.e., Cognitive/Scholastic and Peer/Social self-concept) as well as on neuropsychological measures of WM and attention.

2) Children in the intervention group with higher intrinsic and state motivation will evidence larger training gains, as reflected by pre-post change on a measure of self-concept (i.e., Cognitive/Scholastic and Peer/Social self-concept) and neuropsychological measures of WM and attention.

3) Intrinsic motivation will decrease with age and state motivation will increase with age.

4) Self-concept will decrease with age.

5) Children with higher self-concept will have higher levels of intrinsic and state motivation, whereas children with lower self-concept will have lower levels of motivation.

6) State motivation will not change significantly (i.e., increase or decrease) over the course of the CQ intervention.

# Method

## Participants

Participants were recruited from 13 schools within School Districts 62 (Sooke) and 64 (Gulf Islands) as part of a larger study investigating the long-term efficacy of the CQ training intervention. Letters were sent to school district personnel and administrators to provide information about the study. School district personnel and administrators identified schools interested in participating, and then school staff (i.e., principals and learning assistance teachers) identified EAs and children who they believed would be eligible and interested in participating. Guidelines were provided to school staff to assist with the identification of children eligible to participate in the study (see Appendix A).

Study criteria were that children were between 6 and 12 years of age and according to school staff, exhibited difficulties with EF and attention, regardless of any diagnostic status. Exclusionary criteria included moderate or severe intellectual disability (i.e., IQ < 55 standard points). These exclusion criteria were employed to ensure that participants could understand intervention task instructions. In addition, research indicates that children with mild intellectual disability are able to benefit from cognitive interventions (Conners et al., 2008; Galbiati et al., 2009; Van der Molen, Van Luit, Van der Molen, Klugkist, & Jongmans, 2010), but children with moderate to severe intellectual disability show little to no improvement in performance post-training, suggesting that a certain level of baseline cognitive capacity may be necessary (Conners et al., 2008; Söderqvist, Nutley, Ottersen, Grill, & Klingberg, 2012).

For 11 of the 13 schools, random assignment to active intervention or control group was completed at the level of the school rather than child. Random assignment of schools enabled children who did not have access to EA services to be paired with a child in the school who received EA services. In this way the intervention could be delivered to both children in a 1:2 (EA:child) delivery model. However, due to limited EA staff and resources for two of the larger schools, child participants, rather than entire schools, were randomly assigned to the intervention or control group. EAs at these two schools were instructed not to utilize intervention materials or strategies with the children assigned to the control group.

Child participants were pre-screened for the study through a telephone screening and demographic interview with the child's parent or guardian to ensure the child was between 6 and 12 years of age and had not been diagnosed with moderate or severe intellectual disability. As part of this screening interview, parents also completed a standardized rating scale that provided pre-intervention data on the presence and severity of EF and attention deficits associated with ADHD (see Appendix B).

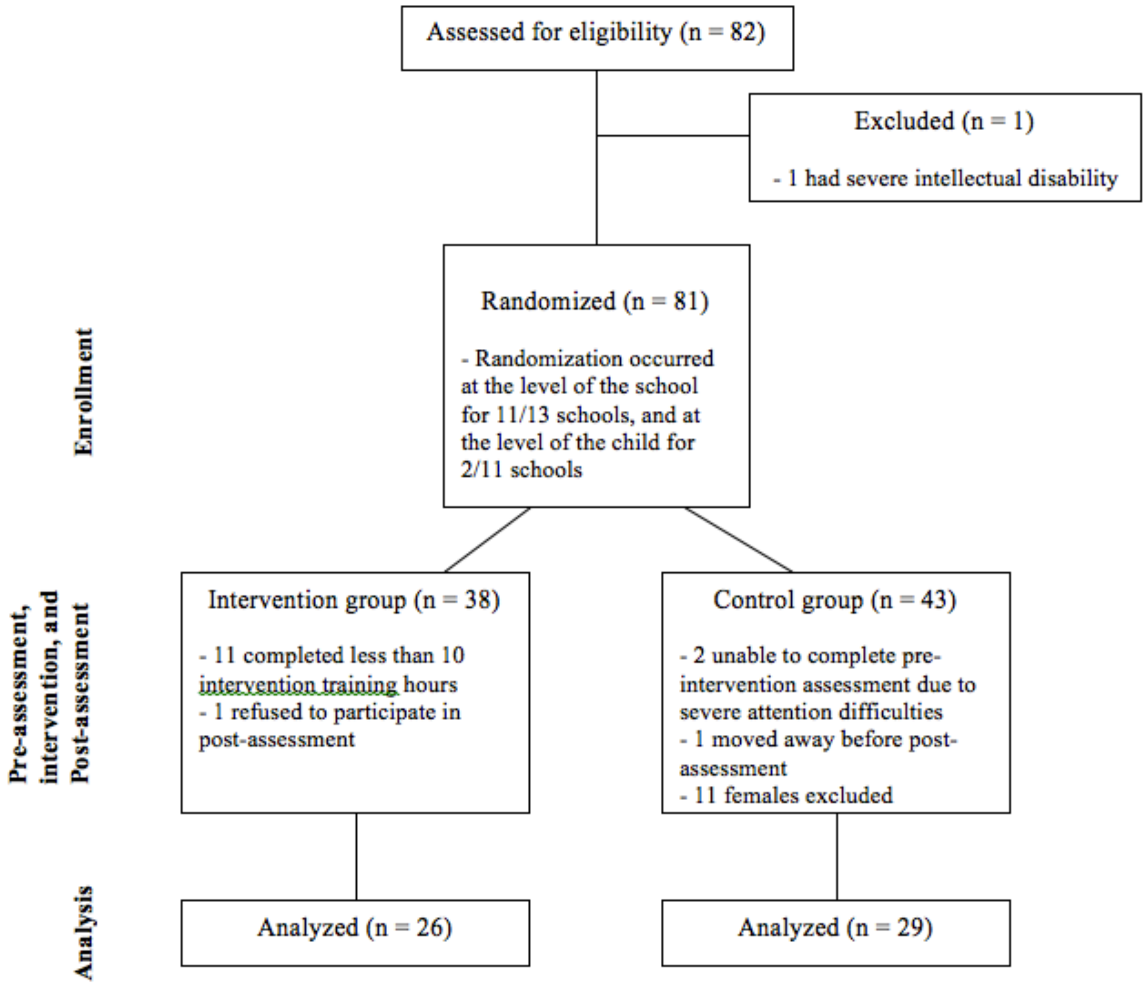
Initially, 82 children assented and their parents consented to participate in this study. Of these 82 children, 66 met study inclusion criteria and completed the minimum requirement of 10 intervention training hours. The remaining sample included 40 children in the control group (11 girls, 29 boys) and 26 children (0 girls, 26 boys) in the intervention group. Despite attempts at random assignment of child participants to the intervention and control groups, gender composition differed significantly, with no girls in the intervention group. Researchers have argued that including a covariate that correlates with the independent variable (i.e., group) to counter a pre-existing difference between groups is inappropriate and problematic, as meaningful variance from the independent variable is removed, which compromises or even invalidates the interpretation of the relationship between the remaining residual variance and the original independent variable (Miller & Chapman, 2001). Given that the pre-existing gender difference between groups could cause interpretive problems, the 11 female control children were excluded from analyses.

In total, 55 male children were included in the statistical analyses. This included 29 children in the control group with a mean age of 8.38 years (range 6.40 – 11.91 years), and 26 children in the intervention group with a mean age of 8.35 years (range 6.06 – 12.75 years).

According to parent ratings on the SNAP-IV, 55% of all children scored above the cut-off on the Inattention subscale, 67% scored above the cut-off on the Hyperactivity/Impulsivity subscale, and 55% scored above the cut-off on the Combined subscale. A total of 75% of children exhibited clinically significant impairment on at least one of the SNAP-IV subscales. Based on parent ratings on the Comprehensive Executive Functioning Index (CEFI), 15% of all children scored above the cut-off on the Attention subscale, 35% on the Emotion Regulation subscale, 23% on the Self-Monitoring subscale, and 37% on the Working Memory subscale. Overall, 57% of children exhibited clinically significant impairment on at least one of the parent report CEFI subscales. Teacher ratings on the CEFI indicated that 19% of all children scored above the cut-off on the Attention subscale, 26% on the Emotion Regulation subscale, 16% on the Self-Monitoring subscale, and 16% on the Working Memory subscale. Overall, 51% of children exhibited clinically significant impairment on at least one of the teacher report CEFI subscales. See Table 1 for details on SNAP-IV and CEFI subscale scores separated by group.

Figure 1

*Flow of Participants through the Study*




## Assessment Measures

### Screening and demographic telephone interview for parents/guardians.

During the pre-intervention interview, each child's parent or guardian was asked 18 questions that form the ADHD Inattention, Hyperactivity/Impulsivity, and Combined subscales on the SNAP-IV Scale (Swanson, 1992; Swanson, Lerner, March, & Gresham, 1999). These questions were used to assess the frequency and severity of EF and attention problems that are commonly associated with ADHD. Cut-off criteria are provided to identify children with clinically significant cognitive deficits (i.e., scores above the 95$^{th}$ percentile; Gaub & Carlson, 1997; Pliszka, Carlson, & Swanson, 1999).

**Executive functioning.**

To evaluate behaviours associated with EF, parents and teachers completed the Attention, Emotion Regulation, Self-Monitoring, and Working Memory subscales from the CEFI prior to the intervention (Naglieri & Goldstein, 2013). Normative data is available to convert raw scores into standard scores for individuals aged 5 through 18 years. Internal reliability for the CEFI subscales administered in the present study ranges from .87 to .93 for parent report and .92 to .96 for teacher report, and test-retest reliability ranges from .74 to .91 (Naglieri & Goldstein, 2013).

**Intellectual function.**

The Kaufman Brief Intelligence Test, Second Edition (KBIT-2) was used as a measure of general intellectual function (Kaufman & Kaufman, 2004). The test consists of two verbal subtests and one nonverbal subtest, and yields verbal, nonverbal, and full scale intellectual quotient (FSIQ) standardized scores based on the child's age.

Normative data is available to convert raw scores into standard scores for individuals ages 4 through 90. Internal consistency ranges from 0.86 to 0.94 for the overall verbal score, 0.78 to 0.93 for the nonverbal score, and 0.89 to 0.96 for the FSIQ composite score. Test-retest reliability is 0.91 for the overall verbal score, 0.83 for the nonverbal score, and 0.90 for the FSIQ score.

**Self-concept.**

Self-concept was assessed with one of two measures, depending on the age of the child. The Pictorial Scale of Perceived Competence and Social Acceptance for Young Children (PSPCSA) is a standardized self-report pictorial questionnaire for children ages 4 to 7 years. The questionnaire includes 24 items to assess perceived competence in four domains: cognitive competence, physical competence, peer acceptance, and maternal acceptance (Harter & Pike, 1983, 1984). Separate versions of the instrument are available for two age groupings, Preschool/Kindergarten (ages 4-5) and Grades 1-2 (ages 6-7).

Items are represented pictorially as paired opposites to facilitate use of the measure with preliterate children. For each item, the examiner read aloud two statements while pointing to the corresponding picture (e.g., the child on the left is good at puzzles and the child on the right is not good at puzzles). For each item, the child indicated which picture described him/herself better, and then decided whether that picture was “a lot like me” or “a little bit like me.” Items are scored from 1 (indicative of low self-concept) to 4 (indicative of high self-concept). The four self-evaluative domains each contain six items, such that domain total raw scores range from 6 to 24 points.

The PSPCSA is the most widely used and psychometrically acceptable measure of self-concept and -esteem for young children (French & Mantzicopoulos, 2007). Relative to other scales, the PSPCSA includes fewer questions, items appropriate to the developmental level of 4- to 7-year-old children, the exclusion of a global self-concept scale, a pictorial format, a four point response scale that allows for a greater range of responses (as compared to dichotomous responses), and an individual administration procedure that allows the examiner to clarify the meaning of an item for the child and the child’s response (Harter & Pike, 1984). Normative data is provided to convert raw scores into z-scores for children in Preschool to Grade 2 (Harter & Pike, 1984). Research indicates adequate reliability and validity of the PSPCSA. Specifically, factor analytic studies involving large samples of typically developing children and economically disadvantaged children ages 4 to 7 support the two-factor model of the PSPCSA (Garrison, Earls, & Kindlon, 1983; Harter & Pike, 1983, 1984; Mantzicopoulos, French, & Mailer, 2004). Internal consistency for self-concept domains range from 0.66 to 0.85 for preschool children, 0.52 to 0.81 for kindergarteners, 0.50 to 0.78 for Grade 1 students, and 0.62 to 0.83 for Grade 2 students (Harter & Pike, 1984). Test-retest reliability ranges from 0.48 to 0.76 across the self-concept domains (Cadieux, 1996; Harter & Pike, 1984).

The PSPCSA has been used in research involving children with learning disabilities (Cadieux, 1996; Holguin & Sherrill, 2007), speech disorders (Hertsberg & Zebrowski, 2016), sickle cell disease (Lemanek, Horwitz, & Ohene-Frempong, 1994), Down syndrome (Campos, Ferreira, & Gaspar, 2008), and cerebral palsy (Scholtes, Vermeer, & Meek, 2002), and with children from various cultural backgrounds (i.e., Portuguese, French Canadian, Lebanese, Czech, and Korean; Cadieux, 1996; Campos et al., 2008; Chae & Ceci, 2005; Čurdová, Vermeer, & Válková, 2001; Hassan, 1999).

The Self Perception Profile for Children (SPPC) is a standardized self-report questionnaire for children ages 8 to 13 years. The questionnaire contains 36 items to assess perceived competence in five domains: scholastic competence, social acceptance, athletic competence, physical appearance, and behavioural conduct, as well as one scale to assess overall self-worth (Harter, 1982). Items are formulated as paired opposite statements - the child is first asked to decide which statement describes him/herself better, and then decide whether that statement is “sort of true for me” or “really true for me.” Items are scored from 1 (indicative of low self-concept) to 4 (indicative of high self-concept). Total raw scores for each domain reflect the sum of six items and range from 6 to 24 points. Normative data is provided to convert raw scores into z-scores for children in Grades 3 to 8 (Harter, 2012a). The SPPC demonstrates adequate reliability and validity (Granleese & Joseph, 1994; Harter, 2012a; Muris, Meesters, & Fijen, 2003; Shevlin, Adamson, & Collins, 2003).

**Working memory.**

The Listening Recall subtest from the Working Memory Test Battery for Children (WMTB-C) was used as a measure of verbal auditory working memory capacity (Pickering & Gathercole, 2001). In this task, the child listens to a series of sentences. At the end of each sentence, the child decides whether the sentence is true or false (e.g., rabbits have ears – "true," bananas can fly – "false"), and then at the end of the block of sentences the child recalls the last word of each sentence in correct order ("ears, fly"). The number of sentences in each block increases until the child can no longer accurately recall the sequence of final words. The total number of correct trials is summed. Normative data is provided to convert raw scores into standard scores for children ages 4 to 15 years. Test-retest reliability ranges from 0.38 to 0.83 (Pickering & Gathercole, 2001).

**Sustained attention.**

The Code Transmission subtest of the Test of Everyday Attention for Children (TEA-Ch) was used as a measure of sustained auditory attention (Manly, Robertson, Anderson, & Nimmo-Smith, 1999). The child monitors a stream of orally presented digits (presented at a rate of one digit every 2 seconds) for the occurrence of a particular target sequence (e.g., 5 5) and then says aloud the digit that occurred immediately before the target sequence. Following a practice sequence to ensure comprehension, 40 targets are presented during the 12-minute task. The total number of correct responses is summed. Normative data is provided to convert raw scores into standard scores for children ages 6 to 16 years. Test-retest reliability for this subtest is 0.78.

**Intrinsic motivation.**

The Scale of Intrinsic versus Extrinsic Orientation in the Classroom (SIEO) is a self-report measure of children's orientation towards learning and mastery in the classroom (Harter, 1981). For the present study, an abbreviated version of the scale was used, comprised of the two items with the highest factor loadings from each of the three motivation subscales (Harter, 1981). The motivation subscales, defined by intrinsic versus extrinsic motivational orientations, included: 1) preference for challenge (i.e., desire for challenging vs. easy tasks); 2) curiosity (i.e., focus is on personal curiosity/interest vs. pleasing the teacher/getting a good grade); and 3) independent mastery (i.e., desire for independent mastery vs. dependence on the teacher for guidance and direction). Items are formulated as paired opposite statements - the child decides which statement describes him/herself better and whether this statement is "sort of true" or "really true." Items are scored from 1 (indicative of maximum extrinsic motivation) to 4 (indicative of maximum intrinsic motivation). As the scale was originally intended for children in Grades 3 to 9, the items were modified slightly and piloted with a 6 year old to ensure that younger children were able to comprehend the items.

The Teacher's Rating Scale of Child's Orientation (TRSCO) is a teacher-report measure of a child's intrinsic versus extrinsic orientation toward learning and mastery in the classroom (Harter, 1981). In parallel to the abbreviation of the SIEO, an abbreviated version of the TRSCO was used, comprised of the two items with the highest factor loadings from each of the three subscales pertaining to motivation. Motivation subscales, question format, and response choices were the same as the SIEO.

**State motivation.**

State motivation questions were constructed based on a literature review of assessment methods used in previous research (Bryanton et al., 2006; Choi & Medalia, 2010; Jaeggi et al., 2011, 2014; Nutley et al., 2011; Prins et al., 2011; Sjö et al., 2010). The number of answers indicative of state motivation for the CQ intervention was summed.

1) Did you like playing Caribbean Quest games today? (yes = 1 point)
2) Would you tell your friend to play Caribbean Quest games? (yes = 1 point)
3) Did you think Caribbean Quest was too hard? (no = 1 point)
4) Did you think Caribbean Quest was fun? (yes = 1 point)
5) Do you want to play Caribbean Quest games again? (yes = 1 point)
6) Did you think Caribbean Quest was boring? (no = 1 point)

## Procedure

Child participants of the active intervention and control groups completed pre- and post-intervention assessments that were conducted in one-to-one sessions by the principal investigator and trained research assistants. The assessments took place in one of three locations, at local public schools on weekends, at a laboratory at the University of Victoria on weekends, or for children unable to be tested on the weekend, in a quiet room at the child's school during regular school hours. Pre-assessments lasted approximately 120 minutes (including a 15 minute break in the middle) and involved a measure of general intelligence and outcome measures. Post-assessments began following the completion of the intervention for the experimental group and after an equivalent period of time on the waitlist for the control group (*M* = 8.43; range 4.71 – 14.00 weeks). The post-intervention assessments lasted approximately 75 minutes and consisted only of the outcome measures. Following each assessment, the child was invited to choose a prize from a selection of small toys and compensated with $5.

Parents and teachers were asked to complete questionnaires pre- and post-intervention. Parents were compensated with $10 and teachers with a $5 gift card to a coffee shop for each set of questionnaires completed. The study was approved by the Human Research Ethics Board of the University of Victoria, as well as School Districts 62 and 64. Funding for this research was obtained from NeuroDevNet and the Social Sciences and Humanities Research Council.

**Intervention: Caribbean Quest.**

The CQ intervention was designed and programmed as a joint funded research project between the Departments of Psychology and Computer Science at the University of Victoria. The CQ program is comprised of five independent tasks designed to strengthen aspects of EF and attention through mass practice (Kerns et al., 2016). The five tasks are hierarchically structured, meaning that each level within a task is more difficult than the level before. For the three attention training games, a minimum 90% accuracy score (i.e., percent of correct responses) is required to advance through the hierarchy of tasks. Progression through the hierarchy of levels in the two WM games is dependent upon achieving a specific number of trials correct. In addition, WM task difficulty is adjusted every two trials based on the child's performance such that the child is consistently working at or above maximum WM capacity.

Briefly, the three attention training games were: 1) Submarine, which involved attending to a series of fish swimming by portholes and selecting the correct fish; 2) Squidditch, which required scanning a display of marine animals to determine the presence or absence of a particular animal; and 3) Wave, which involved remembering and collecting items according to a pre-specified rule while avoiding distracters. The two WM training games were: 1) Scuba, which required remembering a sequence of items to collect in order from a coral reef; and 2) Pirates Deli, which involved remembering and recalling a series of food items to make a sandwich. For more details about the intervention see Kerns et al. (2016).

To enhance motivation and engagement with the training materials, children earn points for correct responses that accumulate across tasks. In addition, children are rewarded with a variety of fun games that are interspersed between training tasks. In these brief games, children accumulate "sand dollars" that are used to purchase trophies from the "CQ trophy store."

Prior to delivery of the intervention, EAs completed a series of online training modules to learn information relevant to the intervention. The modules were organized into the following topics: 1) cognitive training and neuroplasticity; 2) EF and attention deficits in children; 3) EF and metacognition; 4) performance scaffolding, techniques to generalize skills to other settings, positive behaviour supports, and goal setting; 5) cognitive and metacognitive strategies and self-regulatory scripts; and 6) CQ intervention and delivery. Training was provided through a combination of videos, podcast type audio recordings, links to articles and websites, downloadable written materials, discussion forums, and individual consultation. Multiple-choice quizzes were embedded within each module to ensure adequate mastery of content. Progression through the web-based content was self-paced to allow EAs to learn at a time, place, and rate of their convenience. On average, the training took approximately three hours to complete. Upon completion of the training and quizzes, EAs were compensated with $127 and a Professional Development Certificate.

During intervention training sessions, EAs provided support to children in their game play, encouraging them through difficult tasks, helping them to monitor their performance, and scaffolding their use of cognitive and metacognitive strategies. To select strategies, EAs and children utilized a five step self-regulatory script, which involved: 1) identifying the issue in performance; 2) identifying the reason for the issue; 3) selecting and implementing a strategy; 4) evaluating the outcome of the strategy; and 5) celebrating success if the strategy improved performance or repeating steps 2 to 4 if the strategy did not improve performance.

Cognitive and metacognitive strategies were used to promote children's success in their game play. Specifically, strategies were implemented to enhance memory (e.g., rehearsal, chunking, and visualization), attention (e.g., self-control, good listening, and movement breaks), and self-awareness of task difficulty and performance monitoring. The level of support that EAs provided gradually diminished over the duration of the intervention, as children required less scaffolding and support to succeed, learned to self-monitor performance, and spontaneously applied strategies to improve performance. As children varied greatly in their areas of cognitive and metacognitive strength and weakness and the effectiveness of a given strategy targeting the same issue varied between children, an individualized approach to scaffolding performance and utilizing strategies was necessary. As such, the intervention approach was flexible rather than "standardized" and EAs offered appropriate support and strategies based on the individual child's need and task performance.

EAs were also responsible for completing a record of intervention progress (i.e., "CQ Tracking Sheet") for each training session. On these sheets, EAs recorded: 1) date and session length; 2) training game, level, and score; 3) type and outcome of any cognitive or metacognitive strategy used; and 4) type of reward, if any, provided for that session (i.e., none, tangible reward such as a small toy, social reward such as engaging in a preferred activity or engaging with a preferred adult or peer, and/or verbal praise). Finally, EAs also recorded the child's answers to the six state motivation questions immediately after the first and last five training sessions. EA incentive to track intervention progress was provided via a raffle ticket to win an iPad mini if all tracking sheets were completed.

The intervention was delivered via computer to one or two children at a time during the regular school day. Utilizing a 1:2 delivery format was offered as an option to reduce demands on limited EA staff and school resources, and enable children who were not receiving EA services or were receiving shared EA services to be paired with other children in the school who received individual or shared EA support, such that more children could participate in the intervention. Schools and EAs were informed that the ideal intervention delivery model was four 30-minute training sessions per week, with training equally divided between each of the five cognitive tasks. Regardless of whether this schedule was possible, all participants completed a minimum of 10 training hours. Additional information for intervention delivery is provided in the results section below.

Throughout the intervention, the principal investigator and research assistants with CQ intervention experience were available to EAs to answer questions, troubleshoot problems, support the use of cognitive and metacognitive strategies, and ensure intervention fidelity. Within the first three weeks of beginning the intervention, the principal investigator visited all schools at least once to meet with and observe each EA working with a child. EAs were also contacted biweekly via email to obtain updates and offer additional support.

**Waitlist control group.**

Children randomized to the control group were asked to continue with any existing treatment(s) but not to commence any new treatments during the wait period. All children from the waitlist control group received the CQ intervention after the experimental group had completed the intervention and all children had completed the post-assessment.

# Results

## Statistical Analyses

Results are discussed in five parts. First, comparison between the control and intervention groups, as well as training information specific to the intervention group, is presented. Second, results pertaining to the efficacy of the intervention in terms of improving self-concept, WM, and attention are discussed. Third, findings pertaining to the relationship between motivation and training gains on the self-concept questionnaire and neuropsychological measures of WM and attention are provided. Fourth, results related to the relationship between rewards and training gains on outcome measures are presented. Fifth, results investigating the relationship between amount of training and training gains are discussed. Sixth, findings related to the relationship between age, motivation, and self-concept are discussed. Seventh, results investigating the level of state motivation across training sessions are presented.

Analyses used SPSS statistical package 23.0. An alpha significance level of .05 (two-way) was used for all statistical tests unless otherwise indicated. As per recommendations by Tabachnick and Fidell (2007), Box's test of equality of covariance matrices, a highly sensitive measure, was ignored unless the observed $p < .001$. When an underlying assumption of a statistical test was not met, the details of the violation and rationale for using the test (or alternate procedures) were provided.

## Part 1: Group Characteristics and Training Information

Group comparison of continuous variables (i.e., age, KBIT-2 FSIQ, SNAP-IV subscales, and CEFI subscales) utilized independent samples *t* test. For group comparisons of nominal variables (i.e., presence of ADHD, presence of ASD, presence of other medical or mental health disorder, presence of comorbid diagnoses, and use of ADHD medication), Pearson $\chi^2$ was used. Group comparison for the ordinal variable (i.e., income) used the Mann Whitley U test.

Table 1 shows details on demographic variables separated by group. The control group consisted of 29 children with a mean age of 8.38 years (range 6.40 – 11.91 years). The intervention group consisted of 26 children with a mean age of 8.35 years (range 6.06 – 12.75 years). Age, general intelligence, diagnosis of ADHD, ASD, or “other” (i.e., LD, anxiety disorder, mild intellectual disability, Tourette’s disorder, and ODD), comorbid diagnostic status, use of ADHD medication, parent ratings on the SNAP-IV and CEFI subscales, teacher ratings on the CEFI subscales, and family income did not differ significantly between groups. Although parent ratings on the SNAP-IV did not differ significantly between groups, there was a higher frequency of children classified as impaired on the Inattention and Combined subscales. Similarly, there were no between group differences on the parent or teacher CEFI subscales, but a higher frequency of children were classified as impaired on all of the parent-report subscales and on the teacher-report Attention and Emotion regulation subscales. Overall, this suggests children in the intervention group were exhibiting more difficulties with EF and attention, albeit at a non-significant level.

In the control group, nine children were diagnosed with ADHD, five children with ASD, three children with LD, two children with anxiety disorder, and one child each with mild intellectual disability, Tourette’s disorder, and ODD. A total of 13 children did not have any formal diagnosis. On the SNAP-IV, 52% of children were classified as impaired on the Inattention subscale, 72% on the Hyperactivity/Impulsivity subscale, and 48% on the Combined subscale. On the CEFI parent report, 7% were classified as impaired on the Attention subscale, 22% on the Emotion regulation subscale, 14% on the Self-monitoring subscale, and 33% on the Working memory subscale. Based on CEFI teacher report, 16% were classified as impaired on the Attention subscale, 25% on the Emotion regulation subscale, 25% on the Self-monitoring subscale, and 17% on the Working memory subscale. Five children in the control group were receiving speech and language services within the school setting, six children were receiving occupational therapy, 15 children were receiving learning assistance, and nine children were receiving counselling services.

In the intervention group, 10 children were diagnosed with ADHD, six children with ASD, two children with mild intellectual disability, one child with LD, four children with anxiety disorder, and three children with ODD. A total of seven children did not have any formal diagnosis. On the SNAP-IV, 58% of children were classified as impaired on the Inattention subscale, 62% on the Hyperactivity/Impulsivity subscale, and 62% on the Combined subscale. On the CEFI parent report, 24% were classified as impaired on the Attention subscale, 48% on the Emotion regulation subscale, 32% on the Self-monitoring subscale, and 40% on the Working memory subscale. Based on CEFI teacher report, 22% were classified as impaired on the Attention subscale, 26% on the Emotion regulation subscale, 10% on the Self-monitoring subscale, and 17% on the Working memory subscale. Five children in the intervention group were receiving speech and language services, six children were receiving occupational therapy, 16 children were receiving learning assistance, and four children were receiving counselling services in the school.

Table 1

*Participant Demographic Information*

| Demographic variables | Control group N = 29 | Intervention group N = 26 | *p* |
|---|---|---|---|
| Age in years (M [SD]) | 8.38 [1.50] | 8.35 [1.86] | .951 |
| KBIT-2 FSIQ (M [SD]; range) | 91.66 [12.90]<br>67-119 | 99.15 [20.15]<br>57-138 | .103 |
| Diagnosis (N) | ADHD = 9<br>ASD = 5<br>Other = 7<br>Comorbid = 8 | ADHD = 10<br>ASD = 6<br>Other = 9<br>Comorbid = 7 | .563<br>.589<br>.393<br>.956 |
| ADHD medication (N) | 7 | 4 | .418 |
| SNAP-IV I (M [SD])<br>(N above 95% cut-off score) | 1.72 [0.54]<br>15 | 1.88 [0.70]<br>15 | .320 |
| SNAP-IV H/I (M [SD])<br>(N above 95% cut-off score) | 1.66 [0.69]<br>21 | 1.80 [0.75]<br>16 | .493 |
| SNAP-IV C (M [SD])<br>(N above 95% cut-off score) | 1.68 [0.54]<br>14 | 1.84 [0.62]<br>16 | .307 |
| CEFI A – PR (M [SD])<br>(N above 95% cut-off score) | 83.48 [8.59]<br>2 | 83.40 [12.43]<br>6 | .978 |
| CEFI ER – PR (M [SD])<br>(N above 95% cut-off score) | 84.81 [14.94]<br>6 | 79.88 [14.30]<br>12 | .230 |
| CEFI SM – PR (M [SD])<br>(N above 95% cut-off score) | 85.04 [11.50]<br>4 | 83.08 [14.06]<br>8 | .580 |
| CEFI WM – PR (M [SD])<br>(N above 95% cut-off score) | 83.85 [13.22]<br>9 | 80.88 [14.45]<br>10 | .442 |
| CEFI A – TR (M [SD])<br>(N above 95% | 82.37 [8.21]<br>3 | 82.96 [9.46]<br>5 | .833 |

| | | | |
|---|---|---|---|
| cut-off score) | | | |
| CEFI ER – TR (M [SD]) (N above 95% cut-off score) | 82.10 [12.71]<br>5 | 82.04 [12.76]<br>6 | .988 |
| CEFI SM – TR (M [SD]) (N above 95% cut-off score) | 81.95 [7.10]<br>5 | 86.95 [6.96]<br>2 | .280 |
| CEFI WM – TR (M [SD]) (N above 95% cut-off score) | 83.22 [9.80]<br>3 | 85.68 [13.35]<br>4 | .519 |
| Income per year (N)[a] | Below $25,000 = 4<br>$25,000-$49,999 = 7<br>$50,000-$100,000 = 9<br>Over $100,000 = 8<br>Median = $50,000-$100,000 | Below $25,000 = 3<br>$25,000-$49,999 = 6<br>$50,000-$100,000 = 13<br>Over $100,000 = 4<br>Median = $50,000-$100,000 | .778 |

Note: ADHD = Attention-Deficit/Hyperactivity Disorder; ASD = Autism Spectrum Disorder; Other = learning disorder, anxiety disorder, mild intellectual disability, Tourette's disorder, and oppositional defiance disorder; KBIT-2 = Kaufman Brief Intelligence Test, Second Edition; SNAP-IV I = Inattention subscale; SNAP-IV H/I = Hyperactivity/Impulsivity subscale; SNAP-IV C = Combined subscale; CEFI A = Attention subscale; CEFI ER = Emotion regulation subscale; CEFI SM = Self-monitoring subscale; CEFI WM = Working memory subscale; PR = parent report; TR = teacher report; [a] One parent of a control participant declined to answer.

Table 2 presents information pertaining to the delivery of the CQ intervention. On average, children in the intervention group completed 3.79 sessions and 1.91 hours of training per week. Number of sessions per week and total length of intervention varied due to EA and child absences, field trips, school assemblies, and holidays. In addition, younger children and children with more severe attention difficulties were more likely to complete shorter (and thus more frequent) training sessions.

Table 2

*CQ Training Information*

| Training information | N | M | SD | Range |
|---|---|---|---|---|
| Total hours of training | 26 | 12.03 | 0.97 | 10.08 – 14.50 |
| Number of sessions | 26 | 23.85 | 2.89 | 19.00 – 30.00 |
| Total weeks of training | 26 | 6.29 | 0.68 | 4.14 – 7.14 |

A total of 18 EAs delivered the intervention to children. On average, the EAs were 46.10 years of age (range 29 – 62 years). In terms of education and training, 27% had a bachelor's degree, 6% had a master's degree, 12% had an associate's degree, 27% had completed an education assistant program, 6% had completed a community support worker program, and 15% had completed additional coursework or workshops.

The CQ intervention was delivered to 18 children in a 1:1 (EA:child) format and to eight children in a 1:2 format. Group comparisons utilizing the independent samples *t* test did not reveal any significant differences between children who received the intervention in a 1:1 versus a 1:2 delivery model in terms of age, general intelligence, parent ratings on the SNAP-IV and CEFI subscales, teacher ratings on the CEFI subscales, hours of training, and number of training sessions (all *p*'s >.200). However, children who received the intervention in pairs completed significantly fewer weeks of training ($M = 5.77$, $SD = 0.71$) than children who received the intervention individually [$M = 6.52$, $SD = 0.53$; $t(24) = 2.988$, $p = .006$].

Table 3 provides details on training frequency for the CQ training games. Each of the five games were played relatively equally across training sessions, with Squidditch played the least frequently (in approximately 65% of all sessions) and Wave played the most frequently (in approximately 81% of sessions). On average, children completed 67% of the levels in the WM games (75% of the Deli levels; 59% of the Scuba levels) and 64% of the levels in the attention games (72% of the Wave levels; 56% of the Submarine levels; 65% of the Squidditch levels).

Table 3

*Training Information by CQ Game*

| CQ training games | N | M | SD | Range |
|---|---|---|---|---|
| Deli (8 levels) | | | | |
| Training frequency | 26 | 77.28% | 16.44 | 41.38 – 100 |
| Highest level | 26 | 6.00 | 1.55 | 1 – 8 |
| Scuba (8 levels) | | | | |
| Training frequency | 26 | 69.25% | 24.49 | 21.05 – 100 |
| Highest level | 26 | 4.54 | 2.06 | 1 – 8 |
| Wave (30 levels) | | | | |
| Training frequency | 26 | 81.03% | 15.05 | 41.38 – 100 |
| Highest level | 26 | 21.69 | 8.15 | 1 – 30 |
| Submarine (18 levels) | | | | |
| Training frequency | 26 | 75.33% | 17.46 | 43.33 – 100 |
| Highest level | 26 | 10.58 | 4.78 | 2 – 18 |
| Squidditch (13 levels) | | | | |
| Training frequency | 26 | 65.10% | 22.12 | 24.00 – 100 |
| Highest level | 26 | 8.46 | 3.52 | 2 – 13 |

Note: Training frequency = number of sessions during which the game was played / total number of sessions.

Table 4 provides information on strategy frequency by type. On average, each child utilized 49.38 training strategies during the CQ intervention. The majority of strategies were applied during WM training games (Scuba, 31.31%; Deli, 23.52%) compared to the attention training games (Wave, 16.67%; Squidditch, 14.41%; Submarine, 14.10%). The two most frequently utilized strategies were memory strategies (rehearsal, 28.12%; visualization, 15.73%), followed by attention strategies (movement, 13.71%; good listening, 9.81%).

Table 4

*Strategy Frequency by Type*

| Type of strategy | N | Frequency |
|---|---|---|
| Memory strategies | | |
| Rehearsal | 26 | 28.12% |
| Visualization | 26 | 15.73% |
| Elaboration | 26 | 8.41% |

| | | |
|---|---|---|
| Tracing | 26 | 6.00% |
| Chunking | 26 | 5.06% |
| Substituting/paraphrasing | 26 | 1.87% |
| Attention strategies | | |
| Movement | 26 | 13.71% |
| Good listening | 26 | 9.81% |
| Self control | 26 | 3.50% |
| Self-awareness and monitoring | 26 | 7.79% |

Table 5 provides information on reward frequency by type. On average, each child received 1.24 rewards per training session, for a total of 29.58 rewards throughout the intervention. Children were most frequently rewarded with verbal praise during or after a training session (approximately 80% of training sessions), followed by a tangible reward (e.g., small toy, food item, or sticker), no reward, and a social reward (e.g., arm wrestle with chosen adult, playing an iPad game, playing with Lego, or free time). For more than one-third of training sessions (approximately 38%), children received two or more types of reward.

Table 5

*Reward Frequency by Type*

| Type of reward | N | Frequency |
|---|---|---|
| Social | 26 | 6.69% |
| Tangible | 26 | 35.46% |
| Verbal | 26 | 80.21% |
| None | 26 | 15.15% |

**Part 2: CQ Intervention Efficacy – Self-Concept, WM, and Attention**

A set of mixed factorial ANOVAs was performed on the self-concept scores with the within subject factor of time (pre- and post-test) and between subject factor of group (intervention and control). See Table 7 for means and standard deviations of pre- and post-intervention scores on outcome measures by group. At baseline, there were no significant differences between groups on measures of self-concept, WM, and attention (all *p* values >0.05).

Using Cognitive/Scholastic self-concept as the dependent variable, Levene's test was significant for the post-test scores ($p = .026$), indicating that the assumption of homogeneity of variance was violated and the variances between groups were significantly different from one another. Rather than using transformed scores which limit statistical interpretation, Tabachnick and Fidell (2007) recommend using a more stringent α of .025 for moderate violations of Levene’s test. Using the adjusted α level, there was not a significant difference in Cognitive/Scholastic self-concept as a function of group [$F(1,48) = 0.71$, $p = .405$] or between pre- and post-test [$F(1,48) = 3.04$, $p = .088$], nor was the interaction significant [$F(1,48) = 2.30$, $p = .136$]. For Peer/Social self-concept, there was no significant difference as a function of time [$F(1,48) = 0.11$, $p = .741$] or group [$F(1,48) = 1.81$, $p = .185$], nor was the interaction significant [$F(1,48) = 1.15$, $p = .288$].

The self-concept research previously summarized above indicates developmental differences in the formation and evaluation of self-evaluations for children less than eight years of age as compared to children aged eight years and older. Briefly, younger children lack the ability to integrate self-concept domains into an overall concept of their worth as a person, use less comparative standards to judge their abilities, and rely more on social feedback relative to objective feedback (Harter & Pike, 1984; Stipek & Mac Iver, 1989). These factors are reflected in the measures employed in the present study, with the PSPCSA having fewer items, developmentally appropriate content in terms of items and domains, and a greater focus on categories of self-description and age-related differences in self-conceptions as compared to the SPPC.

Hence, a set of mixed factorial ANOVAs was conducted using Cognitive/Scholastic and Peer/Social self-concept scores as separate dependent variables for children less than eight years of age and children aged eight years and older. Table 6 provides details on demographic variables according to younger and older groups of children. The younger group consisted of 25 children (13 control; 12 intervention) with a mean age of 7.06 years (range 6.06 – 7.99 years). The older group also consisted of 25 children (13 control; 12 intervention) with a mean age of 9.81 years (range 8.18 – 12.75 years). Intelligence, parent ratings on the SNAP-IV subscales, and teacher ratings on the CEFI subscales did not differ significantly between groups (all $p$'s > .083). Parent ratings on the CEFI Attention and Emotion Regulation subscales also did not differ significantly between groups. However, parents rated the younger children ($M$ = 78.68, $SD$ = 11.10) as significantly more impaired than older children ($M$ = 88.54, $SD$ = 12.84) on the Self-Monitoring subscale [$t(47) = 2.880$, $p = .006$]. Parents also rated the younger children ($M$ = 77.20, $SD$ = 11.93) as significantly more impaired than older children ($M$ = 87.25, $SD$ = 14.17) on the Working Memory subscale [$t(47) = 2.690$, $p = .010$]. Frequency of social, tangible, verbal, and no rewards did not differ between groups (all $p$'s > .130). In addition, there were no significant differences between younger and older children on training variables, including total training time, number of training sessions, weeks of training, and delivery format (all $p$'s > .292).

Table 6

*Participant Demographic Information by Age Group*

| Demographic | Children <8 years | Children >8 years | *p* |
|---|---|---|---|

| variables | N = 25 | N = 25 | |
|---|---|---|---|
| Age in years (M [SD]) | 7.06 [0.57] | 9.81 [1.19] | - |
| KBIT-2 FSIQ (M [SD]) | 95.00 [15.77] | 96.20 [19.78] | .814 |
| SNAP-IV I (M [SD]) | 1.77 [0.57] | 1.87 [0.71] | .580 |
| SNAP-IV H/I (M [SD]) | 1.67 [0.69] | 1.81 [0.73] | .503 |
| SNAP-IV C (M [SD]) | 1.72 [0.57] | 1.83 [0.61] | .537 |
| CEFI A – PR (M [SD]) | 80.68 [8.96] | 86.00 [11.99] | .084 |
| CEFI ER – PR (M [SD]) | 78.96 [13.87] | 84.78 [14.28] | .159 |
| CEFI SM – PR (M [SD]) | 78.68 [11.10] | 88.54 [12.84] | .006 |
| CEFI WM – PR (M [SD]) | 77.20 [11.93] | 87.25 [14.17] | .010 |
| CEFI A – TR (M [SD]) | 81.71 [9.23] | 82.95 [8.88] | .679 |
| CEFI ER – TR (M [SD]) | 78.94 [12.66] | 82.86 [11.36] | .322 |
| CEFI SM – TR (M [SD]) | 85.19 [7.81] | 84.30 [7.18] | .725 |
| CEFI WM – TR (M [SD]) | 81.18 [10.15] | 86.35 [12.41] | .179 |
| Frequency of social reward | 5.59 [12.43] | 8.23 [15.67] | .646 |
| Frequency of tangible reward | 27.22 [29.58] | 45.79 [29.70] | .131 |
| Frequency of verbal reward | 80.05 [24.69] | 79.79 [22.36] | .978 |
| Frequency of no reward | 16.18 [19.30] | 14.37 [18.57] | .813 |
| Total hours of training | 12.02 [1.05] | 12.03 [0.97] | .983 |
| Number of sessions | 24.50 [3.29] | 23.23 [2.59] | .293 |
| Total weeks of training | 6.32 [0.90] | 6.29 [0.45] | .900 |

Note: KBIT-2 = Kaufman Brief Intelligence Test, Second Edition; SNAP-IV I = Inattention subscale; SNAP-IV H/I = Hyperactivity/Impulsivity subscale; SNAP-IV C = Combined subscale; CEFI A = Attention subscale; CEFI ER = Emotion regulation subscale; CEFI SM = Self-monitoring subscale; CEFI WM = Working memory subscale; PR = parent report; TR = teacher report.

For the younger group of children, Levene's test was significant for post-test scores on Cognitive/Scholastic self-concept ($p$ = .029), and thus a more stringent α of .025 was adopted (Tabachnick & Fidell, 2007). Using the adjusted α level, the interaction between group and time was significant [$F$(1,23) = 6.81, $p$ = .016], with the intervention group showing significant gains in Cognitive/Scholastic self-concept [$t$(11) = -2.34, $p$ = .037] but not the control group [$t$(12) = 0.92, $p$ = .376]. There was no main effect of time [$F$(1,23) = 3.28, $p$ = .083] or group [$F$(1,23) = 0.16, $p$ = .695]. For Peer/Social self-concept, the interaction was significant [$F$(1,23) = 5.90, $p$ = .023], indicating that the intervention group made significant gains [$t$(12) = -2.50, $p$ = .030], whereas the control group did not [$t$(12) = 0.76, $p$ = .465]. There was not a significant difference in self-concept as a function of group [$F$(1,23) = 0.16, $p$ = .689] or time [$F$(1,23) = 2.15, $p$ = .156].

For the older group of children, Cognitive/Scholastic self-concept did not significantly differ as a function of time [$F$(1,23) = 0.67, $p$ = .422] or group [$F$(1,23) = 1.24, $p$ = .276], and the interaction was not significant [$F$(1,23) = 0.65, $p$ = .430]. For Peer/Social self-concept, there was not a significant difference between the two times [$F$(1,23) = 0.54, $p$ = .469] or as a function of group [$F$(1,23) = 2.33, $p$ = .140], nor was the interaction significant [$F$(1,23) = 0.34, $p$ = .563].

To test for group differences in cognitive scores on measures of WM and sustained attention, a set of mixed factorial ANOVAs was performed (see Table 7). Using the Listening Recall scores from the WMTB-C as the dependent variable, Levene's test was significant for pre- ($p$ = .013) and post- ($p$ = .038) test scores, and thus a more stringent α of .01 was adopted (Tabachnick & Fidell, 2007). At this threshold, there was a significant main effect of time for Listening Recall scores [$F(1,50) = 17.92$, $p < .001$], indicating significantly higher post-test scores ($M = 10.03$) compared to pre-test scores ($M = 8.36$). No significant effect was found for group [$F(1,50) = 0.16$, $p = .691$] or between group and time [$F(1,50) = 0.03$, $p = .860$]. Using the Code Transmission scores from the TEA-Ch as the dependent variable, there was no significant main effect for time [$F(1,43) = 2.68$, $p = .109$] or group [$F(1,43) = 0.09$, $p = .765$], and the interaction between group and time was not significant [$F(1,43) = 0.85$, $p = .363$].

Of note, these findings were rerun with KBIT-2 FSIQ scores and randomization approach (i.e., assignation to intervention or control group at the level of the student or school) as covariates. The pattern of results remained the same for all analyses, suggesting that differences in intelligence and randomization approach did not affect the outcomes.

Table 7

*Pre- and Post-Intervention Scores on Outcome Measures by Group*

| | Control group | | | Intervention group | | | $p^a$ |
|---|---|---|---|---|---|---|---|
| Measures | N | Pre | Post | N | Pre | Post | |
| Self-concept | | | | | | | |
| Cognitive/scholastic (All ages; z-score) | 25 | -0.82 (1.88) | -0.79 (2.07) | 25 | -1.47 (2.00) | -0.97 (1.18) | .136 |
| Peer/social (All ages; z-score) | 25 | -0.24 (1.16) | -0.34 (1.32) | 25 | -0.84 (1.41) | -0.66 (1.30) | .288 |
| Cognitive/scholastic (< 8 years of age; raw score) | 13 | 18.85 (4.98) | 18.46 (5.43) | 12 | 16.50 (4.01) | 18.75 (4.56) | .016 |
| Peer/social (< 8 years of age; raw score) | 13 | 18.62 (5.65) | 18.08 (3.33) | 12 | 16.58 (5.04) | 18.75 (4.07) | .023 |
| Cognitive/scholastic (> 8 years of age; raw score) | 12 | 15.57 (4.02) | 16.92 (4.91) | 13 | 14.15 (5.41) | 14.15 (3.53) | .430 |
| Peer/social (> 8 years of age; raw score) | 12 | 16.58 (4.34) | 16.33 (5.66) | 13 | 14.77 (5.13) | 13.69 (3.99) | .563 |
| Listening recall | 28 | 88.32 | 96.36 | 24 | 88.71 | 96.83 | .860 |

| | | | | | | |
|---|---|---|---|---|---|---|
| (Standard score) | | (16.68) | (17.02) | | (23.34) | (23.64) | |
| Code transmission | 24 | 86.88 | 89.38 | 21 | 75.81 | 82.58 | .363 |
| (Standard score) | | (14.80) | (18.49) | | (19.50) | (19.36) | |

Note: Values indicate means (and standard deviations). Self-concept raw scores range from 6-24 points. [a] Interaction effect between group and time.

**Part 3: Relations among Motivation and Training Gains on Measures of Self-Concept, WM, and Attention**

Hierarchical linear regression analyses were performed to investigate the effect of motivation on self-concept, WM, and attention outcome measures for children in the intervention group. For each model, the pre-test or baseline scores for the outcome measures were entered first as covariates, followed by the measure of motivation as the independent variable of interest. Pre-test intrinsic motivation scores were used in analyses, as children's self- [$t(24) = 0.88$, $p = .385$] and teacher- [$t(15) = -1.07$, $p = .301$] reported intrinsic motivation did not change significantly from pre- to post-test. In addition, the sum of state motivation scores across the first five training sessions was used ($M = 26.19$; $SD = 4.90$; range = 9-30). Table 8 shows unstandardized and standardized coefficients, $R^2$ and $R^2$ change, $F$ and $F$ change, and $p$ statistics for the regression analyses.

First, hierarchical regressions of motivation onto self-concept were performed to determine the proportion of variance in change explained by motivation. Results indicated that child self-reported intrinsic motivation accounted for a significant proportion of variance in the change in Peer/Social self-concept ($F$ change = 5.17, $p$ = .033, $R^2$ change = .101), but not Cognitive/Scholastic self-concept ($F$ change = 0.35, $p$ = .559, $R^2$ change = .007). Teacher report of child intrinsic motivation, however, did not account for a significant proportion of variance in change in Cognitive/Scholastic ($F$

change = 1.06, $p = .317$, $R^2$ change = .023) or Peer/Social self-concept ($F$ change = 1.13, $p = .302$, $R^2$ change = .028). State motivation also did not account for a significant proportion of the variance in change in Cognitive/Scholastic ($F$ change = 2.16, $p = .156$, $R^2$ change = .038) or Peer/Social self-concept ($F$ change = 0.22, $p = .640$, $R^2$ change = .005).

Given developmental differences in self-evaluations for children less than eight years of age compared to children aged eight years and older, separate regression analyses of age onto self-concept were performed. Analyses indicated that motivation did not account for a significant proportion of variance in change in self-concept in younger or older age groups.

Second, regression analyses of motivation onto neuropsychological measures were performed. Results indicated that child self-reported intrinsic motivation accounted for a significant proportion of variance in change in Code Transmission scores ($F$ change = 5.18, $p = .035$, $R^2$ change = .160), but not Listening Recall scores ($F$ change = 0.20, $p = .658$, $R^2$ change = .002). Teacher report of child intrinsic motivation did not account for a significant proportion of variance in change in scores in Listening Recall ($F$ change = 1.87, $p = .187$, $R^2$ change = .019) or Code Transmission scores ($F$ change = 0.63, $p = .442$, $R^2$ change = .029). Child state motivation also did not account for a significant proportion of variance in change in Listening Recall ($F$ change = 0.26, $p = .617$, $R^2$ change = .003) or Code Transmission scores ($F$ change = 0.12, $p = .737$, $R^2$ change = .005).

Table 8

*Motivation Effects on Outcome Measures*

| | N | | *b* | β | $R^2$ | *F* | *p* |
|---|---|---|---|---|---|---|---|
| Self-concept | | | | | | | |
| Cognitive/scholastic | 25 | Pre-test | 0.45 | .76 | .578 | 31.53 | <.001 |
| | | Int mot – CR | 0.02 | .09 | Δ .007 | Δ 0.35 | .559 |
| | 22 | Pre-test | 0.46 | .75 | .568 | 26.34 | <.001 |
| | | Int mot – TR | 0.05 | .17 | Δ .023 | Δ 1.06 | .317 |
| | 25 | Pre-test | 0.45 | .76 | .578 | 31.53 | <.001 |
| | | State mot | -0.05 | -.20 | Δ .038 | Δ 2.16 | .156 |
| Peer/social | 25 | Pre-test | 0.63 | .69 | .471 | 20.50 | <.001 |
| | | Int mot – CR | -0.10 | -.32 | Δ .101 | Δ 5.17 | .033 |
| | 22 | Pre-test | 0.61 | .70 | .493 | 19.44 | <.001 |
| | | Int mot – TR | -0.05 | -.17 | Δ .028 | Δ 1.13 | .302 |
| | 25 | Pre-test | 0.63 | .69 | .471 | 20.50 | <.001 |
| | | State mot | -0.20 | -.08 | Δ .005 | Δ 0.22 | .640 |
| Listening recall | 24 | Pre-test | 0.83 | .88 | .778 | 77.08 | <.001 |
| | | Int mot – CR | 0.07 | .05 | Δ .002 | Δ 0.20 | .658 |
| | 22 | Pre-test | 0.83 | .89 | .785 | 72.98 | <.001 |
| | | Int mot – TR | 0.20 | .16 | Δ .019 | Δ 1.87 | .187 |
| | 24 | Pre-test | 0.83 | .88 | .778 | 77.08 | <.001 |
| | | State mot | 0.06 | .05 | Δ .003 | Δ 0.26 | .617 |
| Code transmission | 21 | Pre-test | 0.52 | .53 | .283 | 7.49 | .013 |
| | | Int mot – CR | 0.60 | .40 | Δ .160 | Δ 5.18 | .035 |
| | 18 | Pre-test | 0.52 | .53 | .281 | 6.25 | .024 |
| | | Int mot – TR | 0.29 | .18 | Δ .029 | Δ 0.63 | .442 |
| | 21 | Pre-test | 0.52 | .53 | .283 | 7.49 | .013 |
| | | State mot | 0.10 | .07 | Δ .005 | Δ 0.12 | .737 |

Note: Int mot – CR = Intrinsic motivation, child report; Int mot – TR = Intrinsic motivation, teacher report; State mot = State motivation; *b* = unstandardized coefficient; β = standardized beta coefficient; $R^2$ = percent of explained variance accounted for; *F* = *F* to change results; *p* = probability value for the *F*-test.

**Part 4: Relations among Rewards and Training Gains on Measures of Self-Concept, WM, and Attention**

Hierarchical linear regression analyses were performed to assess the effect of tangible and verbal rewards on self-concept, WM, and attention outcomes for children in the intervention group. Given the infrequent use of no rewards and social rewards, the impact of these variables was not assessed. Pre-test or baseline scores for the outcome measures were entered into the model first as covariates, followed by the frequency of reward as the independent variable of interest. Table 9 shows unstandardized and standardized coefficients, $R^2$ and $R^2$ change, $F$ and $F$ change, and $p$ statistics for the regression analyses.

First, hierarchical regressions of reward onto self-concept were performed to determine the proportion of variance in change explained by reward. Results indicated that the use of tangible rewards did not account for a significant proportion of variance in the change in Cognitive/Scholastic ($F$ change = 0.35, $p$ = .563, $R^2$ change = .01) or Peer/Social self-concept ($F$ change = 1.86, $p$ = .186, $R^2$ change = .04). Verbal rewards also did not account for a significant proportion of variance in change in Cognitive/Scholastic ($F$ change = 0.10, $p$ = .755, $R^2$ change = .002) or Peer/Social self-concept ($F$ change = 1.43, $p$ = .244, $R^2$ change = .032).

Second, regression analyses of reward onto neuropsychological measures were performed. Results indicated that the use of tangible rewards did not account for a significant proportion of variance in change in scores in Listening Recall ($F$ change = 2.08, $p$ = .164, $R^2$ change = .020) or Code Transmission scores ($F$ change = 0.00, $p$ = .979, $R^2$ change = .000). Verbal rewards accounted for a significant proportion of variance in change in Code Transmission ($F$ change = 7.38, $p$ = .014, $R^2$ change = .209), but not Listening Recall scores ($F$ change = 1.87, $p$ = .186, $R^2$ change = .018).

Table 9

*Reward Effects on Outcome Measures*

| | N | | $b$ | β | $R^2$ | $F$ | $p$ |
|---|---|---|---|---|---|---|---|
| Self-concept | | | | | | | |
| Cognitive/scholastic | 25 | Pre-test | 0.45 | .76 | .578 | 31.53 | <.001 |
| | | Tangible | <0.01 | -.08 | Δ .007 | Δ 0.35 | .563 |
| | 25 | Pre-test | 0.45 | .76 | .578 | 31.53 | <.001 |
| | | Verbal | <0.01 | -.04 | Δ .002 | Δ 0.10 | .755 |
| Peer/social | 25 | Pre-test | 0.63 | .69 | .471 | 20.50 | <.001 |
| | | Tangible | -0.10 | -.20 | Δ .041 | Δ 1.86 | .186 |
| | 25 | Pre-test | 0.63 | .69 | .471 | 20.50 | <.001 |
| | | Verbal | 0.65 | .70 | Δ .032 | Δ 1.43 | .244 |
| Listening recall | 24 | Pre-test | 0.83 | .88 | .778 | 77.08 | <.001 |
| | | Tangible | 0.02 | .14 | Δ .020 | Δ 2.08 | .164 |
| | 24 | Pre-test | 0.83 | .88 | .778 | 77.08 | <.001 |
| | | Verbal | -0.03 | -.14 | Δ .018 | Δ 1.87 | .186 |
| Code transmission | 21 | Pre-test | 0.52 | .53 | .283 | 7.49 | .013 |
| | | Tangible | <0.01 | -.01 | Δ <.001 | Δ <0.01 | .979 |
| | 21 | Pre-test | 0.52 | .53 | .283 | 7.49 | .024 |
| | | Verbal | 0.14 | .48 | Δ .209 | Δ 7.38 | .014 |

Note: $b$ = unstandardized coefficient; β = standardized beta coefficient; $R^2$ = percent of explained variance accounted for; $F$ = $F$ to change results; $p$ = probability value for the $F$-test.

**Part 5: Relations among Training Time and Training Gains on Measures of Self-Concept, WM, and Attention**

Hierarchical linear regression analyses were performed to investigate the effect of training time (i.e., total training hours, number of training sessions, and weeks of training) on changes in self-concept, WM, and attention for children in the intervention group. For each model, the pre-test or baseline scores for the outcome measures were entered first as covariates, followed by the amount of training time as the independent variable of interest. Table 10 shows unstandardized and standardized coefficients, $R^2$ and $R^2$ change, $F$ and $F$ change, and $p$ statistics for the regression analyses.

First, hierarchical regressions of training time onto self-concept were performed to determine the proportion of variance in change explained by motivation. Results indicated that total training hours did not account for a significant proportion of variance in the change in Cognitive/Scholastic (*F* change = 0.46, $p = .507$, $R^2$ change = .009) or Peer/Social self-concept (*F* change = 0.72, $p = .404$, $R^2$ change = .017). Total number of sessions did not account for a significant proportion of variance in change in Cognitive/Scholastic (*F* change = 0.06, $p = .816$, $R^2$ change = .001) or Peer/Social self-concept (*F* change = 0.54, $p = .472$, $R^2$ change = .013). Total weeks of training did not account for a significant proportion of variance in change in Cognitive/Scholastic (*F* change = 0.34, $p = .563$, $R^2$ change = .006) or Peer/Social self-concept (*F* change = 0.12, $p = .735$, $R^2$ change = .003).

Second, regression analyses of training time onto neuropsychological measures were performed. Results indicated that training hours did not account for a significant proportion of variance in change in Listening Recall (*F* change = 1.10, $p = .309$, $R^2$ change = .011) or Code Transmission (*F* change = 0.23, $p = .637$, $R^2$ change = .009). Number of training sessions also did not account for a significant proportion of variance in change in Listening Recall (*F* change = 0.01, $p = .928$, $R^2$ change = <.001) or Code Transmission (*F* change = 0.10, $p = .761$, $R^2$ change = .004). Finally, total weeks of training did not account for a significant proportion of variance in change in Listening Recall (*F* change = 0.05, $p = .830$, $R^2$ change = <.001) or Code Transmission (*F* change = <0.01, $p = .962$, $R^2$ change = <.001).

Table 10

*Effects of Training Time on Outcome Measures*

| | N | *b* | β | $R^2$ | *F* | *p* |
|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| <u>Self-concept</u> | | | | | | | |
| Cognitive/scholastic | 25 | Pre-test | 0.45 | .76 | .578 | 31.53 | <.001 |
| | | Hours | <0.01 | -.09 | Δ .009 | Δ 0.46 | .507 |
| | 25 | Pre-test | 0.45 | .76 | .578 | 31.53 | <.001 |
| | | Sessions | -0.01 | -.03 | Δ .001 | Δ 0.06 | .816 |
| | 25 | Pre-test | 0.45 | .76 | .578 | 31.53 | <.001 |
| | | Weeks | -0.14 | -.08 | Δ .006 | Δ 0.34 | .563 |
| Peer/social | 25 | Pre-test | 0.63 | .69 | .471 | 20.50 | <.001 |
| | | Hours | -0.18 | -.14 | Δ .017 | Δ 0.72 | .404 |
| | 25 | Pre-test | 0.63 | .69 | .471 | 20.50 | <.001 |
| | | Sessions | -0.05 | .12 | Δ .013 | Δ 0.54 | .472 |
| | 25 | Pre-test | 0.63 | .69 | .471 | 20.50 | <.001 |
| | | Weeks | 0.10 | .05 | Δ .003 | Δ 0.12 | .735 |
| <u>Listening recall</u> | 24 | Pre-test | 0.83 | .88 | .778 | 77.08 | <.001 |
| | | Hours | -0.63 | -.11 | Δ .011 | Δ 1.09 | .309 |
| | 24 | Pre-test | 0.83 | .88 | .778 | 77.08 | <.001 |
| | | Sessions | -0.19 | -.01 | Δ <.001 | Δ 0.01 | .928 |
| | 24 | Pre-test | 0.83 | .88 | .778 | 77.08 | <.001 |
| | | Weeks | 0.17 | .02 | Δ <.001 | Δ 0.05 | . 830 |
| <u>Code transmission</u> | 21 | Pre-test | 0.52 | .53 | .283 | 7.49 | .013 |
| | | Hours | 0.72 | .10 | Δ .009 | Δ 0.23 | .637 |
| | 21 | Pre-test | 0.52 | .53 | .283 | 7.49 | .013 |
| | | Sessions | 0.17 | .06 | Δ .004 | Δ 0.10 | .761 |
| | 21 | Pre-test | 0.52 | .53 | .283 | 7.49 | .013 |
| | | Weeks | -0.10 | -.01 | Δ <.001 | Δ <0.00 | .962 |

Note: *b* = unstandardized coefficient; β = standardized beta coefficient; $R^2$ = percent of explained variance accounted for; *F* = *F* to change results; *p* = probability value for the *F*-test.

**Part 6: Relations among Age, Motivation, and Self-Concept**

Relations among age, motivation, and self-concept are presented in Table 11. Correlations between age and measures of motivation and self-concept tended to be small. Contrary to expectations, age was not significantly correlated to any measure of motivation or self-concept. Most notable are strong positive correlations between: 1) child self- and teacher-reported intrinsic motivation; 2) Cognitive/Scholastic self-concept and child-reported intrinsic motivation; and 3) Cognitive/Scholastic and Peer/Social self-concepts.

Table 11

*Correlations between Age, Motivation, and Self-Concept*

| | Age | Int mot – CR | Int mot – TR | State mot | Cog/sch SC | Peer/soc SC |
|---|---|---|---|---|---|---|
| Int mot – CR | .12 | 1.00 | | | | |
| Int mot – TR | .14 | .35* | 1.00 | | | |
| State mot | -.15 | -.19 | -.04 | 1.00 | | |
| Cog/sch SC | -.15 | .41** | .29 | .10 | 1.00 | |
| Peer/soc SC | -.20 | .09 | -.18 | .28 | .36** | 1.00 |

Note: Int mot – CR = Intrinsic motivation, child report; Int mot – TR = Intrinsic motivation, teacher report; State mot = State motivation; Cog/sch SC = Cognitive/scholastic self-concept; Peer/soc SC = Peer/social self-concept; * $p < .05$; ** $p < .01$

To examine developmental trends in motivation, regression analyses of age onto intrinsic and state motivation were performed. Contrary to expectations, age did not account for a significant proportion of variance in any of the motivation measures [Child self-reported intrinsic motivation: $F(1,52) = 0.80$, $p = .376$, $R^2 = .015$; Teacher-reported child intrinsic motivation: $F(1,46) = 0.92$, $p = .343$, $R^2 = .020$; State motivation: $F(1,24) = 0.53$, $p = .472$, $R^2 = .022$].

A different pattern of results was found for state motivation when separate analyses were performed for younger and older children (i.e., children less than eight years of age and children aged eight years and older). State motivation was positively correlated to age for the younger group of children ($r = .65$, $p = .008$) and negatively correlated to age for the older group of children ($r = -.70$, $p = .004$). Age accounted for a significant proportion of variance in state motivation for both younger [$F(1,11) = 7.90$, $p = .017$, $R^2 = .418$] and older children [$F(1,11) = 10.60$, $p = .008$, $R^2 = .491$]. Specifically, for the younger children, there was a predicted increase in state motivation of 5.16 points for every additional year of age, whereas there was a predicted decrease in state motivation of 2.99 points for every additional year of age for the older children. Age did not account for a significant proportion of variance in child self- or teacher-reported intrinsic motivation for either age group.

To examine developmental trends in self-concept, regressions of age onto self-concept were performed. Age did not account for a significant proportion of variance in Cognitive/Scholastic [$F(1,48) = 1.14$, $p = .292$, $R^2 = .023$] or Peer/Social self-concept [$F(1,48) = 2.00$, $p = .164$, $R^2 = .040$].

Again, separate regressions were performed for younger and older children (i.e., children less than eight years of age and children aged eight years and older). For the younger children, the proportion of variance in Cognitive/Scholastic self-concept accounted for by age was significant [$F(1,23) = 11.67$, $p = .002$, $R^2 = .337$], indicating a predicted increase in Cognitive/Scholastic self-concept of 5.40 points for every additional year of age. The variance in Cognitive/Scholastic self-concept accounted for by age was not significant for the older children [$F(1,23) = 0.08$, $p = .781$, $R^2 = .003$]. For Peer/Social self-concept, the proportion of variance accounted for by age was not significant for younger [$F(1,23) = 1.98$, $p = .173$, $R^2 = .079$] or older children [$F(1,23) = 0.87$, $p = .361$, $R^2 = .036$].

Regression analyses of self-concept onto motivation were performed. Cognitive/Scholastic self-concept accounted for a significant proportion of variance in self-reported child intrinsic motivation [$F(1,48) = 9.84$, $p = .003$, $R^2 = .170$], in which there was a predicted increase in motivation of .85 points for every additional point on self-concept. Cognitive/Scholastic self-concept did not account for a significant proportion of variance in teacher-reported child intrinsic motivation [$F(1,41) = 3.64$, $p =$

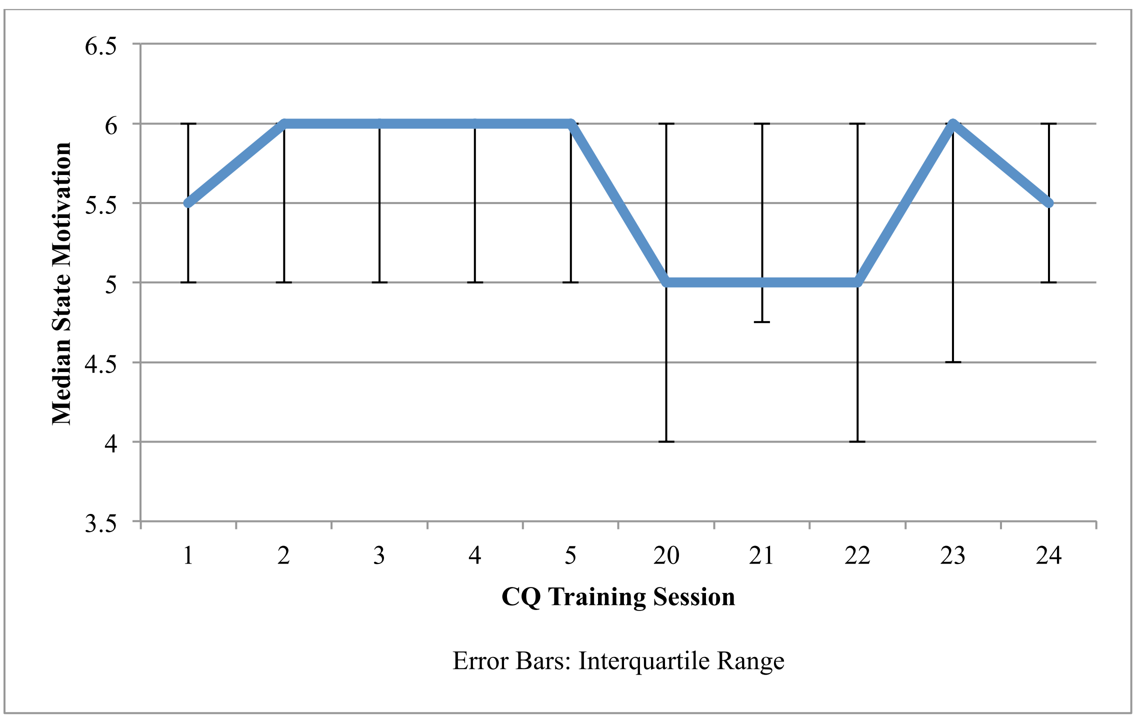
.064, $R^2$ = .081] or state motivation [$F$(1,23) = 0.22, $p$ = .647, $R^2$ = .009]. Peer/Social self-concept did not account for a significant proportion of variance in child self-reported intrinsic motivation [$F$(1,48) = 0.40, $p$ = .532, $R^2$ = .008], teacher-reported child intrinsic motivation [$F$(1,41) = 1.29, $p$ = .262, $R^2$ = .031], or state motivation [$F$(1,23) = 1.93, $p$ = .178, $R^2$ = .077]. The same pattern emerged when regressions of self-concept onto motivation were performed separately for younger and older children.

**Part 7: State Motivation across CQ Training Sessions**

Child reported state motivation across CQ intervention training sessions were generally at or near ceiling levels as depicted in Figure 2. Scores ranged from 0 to 6.

Figure 2

*Ratings of State Motivation Ratings across CQ Sessions*



State motivation ratings were not normally distributed as assessed by Shapiro-Wilk's test ($p \leq .005$). Thus, the Friedman test was used to compare state motivation across training sessions. Results indicate that state motivation did not change significantly across training sessions [$\chi^2(9) = 13.55$, $p = .139$]. The same pattern emerged when Friedman tests were performed separately to compare state motivation across training sessions for younger and older children.

# Discussion

The current study examined the impact of an EF and attention intervention program, CQ (aimed at improving EF and attention in children with deficits in these cognitive skill areas) on children's self-concept. Trained EAs provided 1:1 or 1:2 scaffold support to children during intervention sessions, helping them to evaluate their performance and utilize cognitive and metacognitive strategies to improve performance. On average, children completed 12 hours of intervention training, typically attending four 30-minute sessions per week for six weeks.

The results of the current study provided partial support for the first hypothesis, which held that children who participated in the CQ intervention would significantly improve self-concept, WM, and attention compared to control group children. Specifically, results indicated that boys less than eight years of age in the intervention group evidenced significant gains on a self-report measure of self-concept, as reflected by significantly higher scores on the Cognitive/Scholastic and Peer/Social self-concept subscales, relative to the control group.

First, for self-ratings on the Cognitive/Scholastic scale, the younger group of children rated their competency to perform cognitive tasks (e.g., solving puzzles, counting, and knowing the alphabet) and scholastic skills (e.g., reading, writing, and math) as significantly improved following their participation in the CQ intervention. Although the CQ intervention did not directly address these particular cognitive and academic skills, children were taught to evaluate and monitor their performance on the computerized EF and attention tasks, to deduce when and why performance was weak, and to implement cognitive and metacognitive strategies to improve performance. Hence, one possibility is that Cognitive/Scholastic self-concept increased because the strategies and skills that children learned and mastered over the course of the CQ intervention were successfully applied to other challenging tasks, activities, and situations, including those referred to on the self-concept questionnaire. Alternatively, participation in the CQ intervention could have led to increased self-perceived competence and self-evaluations for performance on the training tasks, and these competency beliefs may have generalized to children's self-perceived abilities for other cognitive and scholastic tasks.

In addition, Schunk (2003) and Schraw (1998) directly link four types of educational teaching practices (i.e., modeling procedures, provision of progress feedback, direct instruction on goal-setting, and direct instruction on self-evaluation methods) to enhanced self-competency beliefs *and* academic achievement. These instructional methods are used throughout the delivery of the CQ intervention, with EA interventionists modeling the use of strategies and self-regulatory scripts, tracking and reviewing game play performance with children, and teaching children how to set and achieve appropriate goals. The importance and emphasis placed on the use of these teaching methods throughout CQ delivery may also contribute to children's gains in Cognitive/Scholastic self-concept.

Moreover, EAs provided scaffold support to children during training sessions, guiding children's goal-directed activity by offering age-appropriate problem-solving strategies to facilitate successful experiences of problem-based learning. This two-step process involved the provision of escalating levels of verbal and nonverbal assistance until the level of scaffold was sufficient to support the child's developmental needs, followed by gradually fading the scaffolding over time as the child became more proficient and required less support. From a neurodevelopmental standpoint, scaffolding results in changes in brain function by developing and strengthening existing, new, and alternative neural circuits to achieve a particular cognitive goal (Park & Reuter-Lorenz, 2012). Consistent with this conceptualization, several studies conclude that scaffolding in childhood is predictive of later EF development and performance (Bernier, Carlson, & Whipple, 2010; Bibok, Carpendale, & Müller, 2009; Hammond, Müller, Carpendale, Bibok, & Liebermann-Finestone, 2012; Hughes & Ensor, 2009; Landry, Miller-Loncar, Smith, & Swank, 2002). Thus, the cognitive and metacognitive scaffolding provided throughout the CQ intervention may have facilitated cognitive and emotional development and allowed children to acquire skills that improved their self-perceived performance abilities for cognitive and scholastic tasks.

Although the exact cause of the change is uncertain, the finding is consistent with research demonstrating that reliance on effective cognitive and metacognitive strategies is associated with higher academic and learning self-competency and -efficacy beliefs (Greene, Miller, Crowson, Duke, & Akey, 2004; Pajares, 2002; Pintrich, 1999). Furthermore, children's self-competency beliefs motivate their use of strategies and self-regulatory methods (Zimmerman & Martinez-Pons, 1990), suggesting that children with higher self-concept will employ the learned strategies even more frequently. Ultimately, this may lead to additional gains in perceived competency and usage of strategies.

Second, post-assessment ratings on the Peer/Social self-concept scale indicated that following participation in the CQ intervention, the younger group of boys perceived themselves to have more friends (e.g., have friends on the playground), be more socially included (e.g., others sit next to you), and experience more prosocial behaviours from others (e.g., others share their toys with you). Improved dynamics within social interactions and relationships may lead to further self-concept gains by decreasing the negativity of children's self-evaluations and the discrepancy between self and peers in social comparisons, both of which influence self-concept. Improved social functioning would be especially valuable for children with EF and attention deficits who exhibit significant and long-term social impairments (Diamantopoulou et al., 2007; Wehmeier, Schacht, & Barkley, 2010), and may circumvent or mitigate secondary disabilities associated with poor social functioning, such as substance abuse, mental health problems, lower educational and vocational achievement, criminal behaviour, and antisocial behaviour (Greene et al., 1999; Kully-Martens, Denys, Treit, Tamana, & Rasmussen, 2012; Mannuzza & Klein, 2000).

There may be multiple processes through which perceived social functioning increased post-intervention. One possibility is that use of *cognitive strategies* throughout the intervention directly impacted younger children's social functioning. Children with EF and attention deficits, such as ADHD, are especially vulnerable to social rejection and negative peer status as a result of having difficulty sustaining attention to peer interactions and activities, not listening to others, deficits in conversation (e.g., interrupting others and abrupt conversation shifts), and high rates of intrusive and disruptive behaviour (de Boo & Prins, 2007; Nixon, 2001). Cognitive strategies, in particular those targeting attention skills, enable children to better direct and sustain their attention during play activity with peers, shift attention to manage emotional reactivity and negative affectivity, and adjust their attentional focus to align with social norms or goals (Eisenberg, Valiente, & Eggum, 2010; Fox & Calkins, 2003; Rueda, Checa, &

Rothbart, 2010). Indeed, these critical social skills predict peer popularity and prosocial behaviour (Eisenberg, Smith, & Spinrad, 2011; Wilson, 2003). Although research in this area is scant, two studies found that children with TBI demonstrated social behaviour improvements following cognitive remediation training for WM and attention (Catroppa et al., 2015; Galbiati et al., 2009).

In addition, the scaffolded provision of *metacognitive strategies* throughout the CQ training sessions, including strategies for self-awareness, self-monitoring, self-control, and emotional and behavioural regulation (e.g., impulsivity and frustration management), may have increased younger children's self-regulatory abilities and thereby improved the quality of their social interactions, relationships, and overall functioning. For example, children who employ metacognitive practices in social situations to monitor and control their emotion and behaviour are able to find socially adaptive ways to cope with frustration or other negative emotions and utilize social feedback to modify inappropriate or intrusive behaviours. These children also display more cooperative social behaviours, exhibit appropriate levels of assertiveness, and are better liked by their peers (Berger, 2011; Eisenberg, Pidada, & Liew, 2001; Gilliom, Shaw, Beck, Schonberg, & Lukon, 2002). Notably, children's use of regulation strategies predicts later social competence as rated by teachers and peers (Denham et al., 2003), and children with multiple self-regulatory strategies display more socially adaptive behaviours than those with only one strategy (Thompson & Calkins, 1996). Hence, both cognitive *and* metacognitive skills developed during CQ game play may uniquely contribute to improved social competence and functioning, as reflected in younger children's ratings of social self-concept.

Another hypothesis that may explain the increase in social self-concept relates to the positive attention, support, and encouragement demonstrated by the EA to the child(ren) during the delivery of the CQ intervention, which may have had beneficial effects on other aspects of the child's social functioning. Consistent with this hypothesis, evidence-based reviews of cognitive rehabilitation research noted less favourable results when control treatments included a psychosocial component, suggesting that the psychosocial element inherent in much of the cognitive training research is a potent element of intervention (Cicerone et al., 2000; Sitzer, Twamley, & Jeste, 2006). Indeed, the quality of the relationship between a child and school staff is related to the child's social development, competence, and peer popularity (Baker, 2006; Klem & Connell, 2004; Malecki & Demaray, 2003; Roorda, Koomen, Spilt, & Oort, 2011). Previous studies that utilized a school-based delivery model to implement a cognitive and metacognitive intervention reported incidental improvements in the quality of the relationship between the interventionist (i.e., EA or teacher) and child (Kerns et al., 2016; Sjö et al., 2010). In the present study, EA interventionists anecdotally noted improvements in EA-child relations through participation in the CQ intervention, which may have promoted children's social functioning.

Moreover, the observed concurrent gains in Cognitive/Scholastic and Peer/Social self-concept is consistent with research indicating that academic and social competencies are partially dependent constructs (Malecki & Elliot, 2002; Welsh, Parke, Widaman, & O'Neil, 2001). In addition to overlapping cognitive (e.g., attention, goal setting, and listening) and metacognitive self-regulatory skills that are necessary for success in both academic and social domains (Brigman & Campbell, 2003; Patrick, 1997), the reciprocal relationship is believed to be the result of reinforced self-competency beliefs during the application of a cognitive or metacognitive strategy. For example, when a child implements a cognitive strategy in conjunction with a metacognitive strategy to monitor and evaluate their performance, self-perceived progress serves to reinforce self-efficacy beliefs, motivation, and continued use of strategies in academic and social domains (Schunk, 1996).

In contrast, self-concept in children aged eight years and older did not differ between intervention and control groups. From a developmental perspective, the significant improvement for the younger boys in the CQ intervention and the lack of significant improvement for the older boys suggests that a combined cognitive and metacognitive intervention may be most likely to effect change to self-concept prior to the age of eight. Accumulating evidence suggests that self-concept decreases with each successive year for children ages five to 17 (Fredricks & Eccles, 2002; Jacobs et al., 2002; Marsh et al., 1998; Wigfield et al., 1997) due to factors such as increased recognition of the importance of ability and achievement, use of normative or social comparative grading, and (negative) feedback at school (Fredricks & Eccles, 2002; Robins & Trzesniewski, 2005). This suggests that children's self-concept may be more modifiable early on in school years, before the negative self-concept trajectory has become firmly entrenched, as self-concepts develop early in childhood and show increasing stability over time (Eder & Mangelsdorf, 1997; Trzesniewski et al., 2003).

It is important to note that the age-related differences in cognitive and language abilities between younger and older children necessitated the use of two different self-concept assessment measures (Harter & Pike, 1984; Harter, 2012b). Both self-concept measures were developed by the same author using a domain-specific approach to conceptualize and assess self-concept, with the scale for younger children (i.e., 4-7 year olds) described as a developmentally appropriate downward extension of the self-concept measure for older children (i.e., 8-13 year olds). The two measures contain overlapping subscales of self-concept, with each subscale comprised of six items. Compared to the self-concept measure for older children, the younger children's measure relies on a pictorial format rather than a written questionnaire, does not contain a subscale assessing global self-worth, and includes modified item content to assess skills relevant to 4 to 7-year-old children (Harter & Pike, 1984). Although this study focused on two overlapping domains of self-concept for younger and older children (i.e., Cognitive/Scholastic and Peer/Social self-concept), it is possible that self-concept gains only evidenced by the younger children reflect differences in the psychometric properties of the assessment tools rather than true differences in self-concept between groups.

In general, self-concept scores for all children in this study tended to be below average (pre-intervention Cognitive/Scholastic self-concept $M = -1.15$; pre-intervention Peer/Social self-concept $M = -0.54$), supporting the conclusion that children with deficits in EF and attention have lower self-concept (e.g., Houck et al., 2011). It is noteworthy that self-concept scores for children diagnosed with ADHD (pre-intervention Cognitive/Scholastic self-concept $M = -1.07$; pre-intervention Peer/Social self-concept $M = -0.25$) were not significantly different than self-concept scores for children with EF and attention deficits without a diagnosis of ADHD (pre-intervention Cognitive/Scholastic self-concept $M = -1.20$; pre-intervention Peer/Social self-concept $M = -0.72$). Thus, interventions that increase self-concepts and therefore mitigate the far-reaching adverse effects of low self-concept are imperative, particularly in the context of young children with deficits in EF and attention regardless of diagnostic etiology.

As previously discussed, several longitudinal studies have established that childhood self-concept is predictive of consequential outcomes in adolescence and adulthood, including factors related to educational and occupational achievement, mental and physical health, engagement in risky behaviours (e.g., criminal activity), and cumulative number of adjustment problems, even after controlling for potential confounding variables such as intelligence, gender, socioeconomic status, and childhood academic, social, and mental functioning (Donnellan et al., 2005; Mann et al., 2004; Trzesniewski et al., 2006). Thus, self-concept is not only indicative of current and future functioning, but is itself "a causal force in determining future outcomes" (Trzesniewski et al., 2006, p. 387). Review of self-concept intervention studies indicates that children's and adolescent's self-concept can be improved through treatment, in addition to yielding positive concomitant changes in other areas of adjustment, including behaviours (e.g., cooperation and sharing), mental health (e.g., anxiety and depression), academic ability (e.g., grades and performance on standardized academic tests), and social functioning (e.g., sociometric status and social preference; de Bruyn & van den Boom, 2005; Haney & Durlak, 1998). In that children with higher self-concept are better prepared and able to make balanced decisions and healthy choices throughout life (Dalgas-Pelish, 2006), increasing self-concept in childhood may positively influence the developmental trajectory across the lifespan (Trzesniewski et al., 2006). This is especially true for children with EF and attention deficits, as these children are more likely to exhibit lower self-concept than typically developing children, and thus are likely to be at greater risk of negative life outcomes (Barber et al., 2005; Williamson et al., 2008).

Research has also investigated differences in self-concept between female and male children. For example, studies involving students in later elementary, middle, and high school indicate that females endorse higher self-concept in areas such as music, language arts/reading, and behavioural conduct, whereas boys tend to rate self-concept higher in areas such as sports, math, athletic competence, physical appearance, and global self-worth (Eccles, Wigfield, Harold, & Blumenfeld, 1993; Fredricks & Eccles, 2002; Jacobs et al., 2002; Muris et al., 2003; Wigfield et al., 1997). These differences have been interpreted as reflecting the influence of gender-role stereotypes on self-concept. With regard to the academic and social self-concept subscales on the SPPC measure used with the older children in the present study, gender differences have *not* been found (e.g., Gacek, Pilecka, & Fusińska-Korpik, 2014; Harter, 2012a). In contrast, with regard to students in preschool and early elementary school, there are no differences between female and male children on *any* of the PSPCSA subscales (Hertsberg & Zebrowski, 2016; Jambunathan & Hurlbut, 2000; Mantzicopoulos, 2004, 2006; Mobley, Harless, & Miller, 1996; Strein & Simonson, 1999), suggesting that gender-role stereotypes may not yet be impacting self-concept. Although only boys were included in the present study, prior research would suggest that girls would not have scored differently than boys on the self-concept subscales at pre-test. However, a meta-analysis of self-concept interventions revealed that children with externalizing behaviours demonstrate significantly greater improvements in self-concept than children with internalizing symptoms or mixed symptomatology (Haney & Durlak, 1998). Since girls have a lower prevalence of externalizing behaviours as compared to boys (Biederman et al., 1999, 2002), it is conceivable that girls may derive less benefit to self-concept from a cognitive training intervention. Future cognitive training studies should explore the relationship between gender, presence of internalizing and externalizing symptoms, and changes in self-concept to disentangle these effects.

In addition, children in the intervention group did not make statistically significant gains on the neuropsychological measures of WM and sustained attention. However, results did indicate trends of increased scores in the intervention group compared with the control group, with the intervention group gaining 1.71 and 2.52 raw score points on the WM and sustained attention task, respectively, and the control group demonstrating smaller increases (1.57 and 0.7, respectively). There are several possible reasons for these non-significant findings.

First, significant intra- and inter-variability in the scores, compounded by a relatively small sample size, may have obscured true changes. Second, although pre-test intelligence scores did not significantly differ between groups, KBIT-2 FSIQ scores were higher and more variable for the children in the intervention group ($M$ = 99.15; $SD$ = 20.15) as compared to the control group ($M$ = 91.66; $SD$ = 12.90). In addition, approximately half of pre-intervention scores on the sustained attention and WM task were within the average range or above (Code transmission: 50% of scores in the control group and 54% of scores in the intervention group were in the average range or above; Listening recall: 38% of scores in the control group and 43% of scores in the intervention group were in the average range or above). According to the compensation account of individual differences in training-related performance gains, higher performing individuals will benefit less from cognitive interventions because there is less room for improvement (Dahlin, 2011; Jaeggi, Buschkuehl, Jonides, & Perrig, 2008; Karbach & Unger, 2014). Thus, the relatively high intelligence and neuropsychological test scores may have restricted the amount of training-related gains for children in the intervention group, contributing to the lack of significant findings on neuropsychological outcome measures.

Third, this study utilized a community-referred sample, relying on school staff to identify children for intervention participation based on guidelines specifying disorders that typically involve EF and attention difficulties and common behavioural and emotional manifestations of these deficits in everyday life. However, according to parent ratings on the SNAP-IV, 14 of the 55 children (25%) in the final sample did not exhibit clinically significant EF or attention difficulties associated with ADHD. In addition, 23 out of 53 children (43%) did not exhibit clinically significant deficits based on parent CEFI ratings on the EF and attention subscales, and 21 out of 43 children (49%) did not exhibit clinically significant deficits according to teacher CEFI reports. Thus, these children may not have had difficulty or had only mild difficulty in the areas targeted by the intervention. These children would be less likely to show cognitive changes, in keeping with findings that training derived benefits are greater among children with more severe symptomatology (Diamond, 2013; Lim et al., 2012; Rabiner, Murray, Skinner, & Malone, 2010).

Fourth, and perhaps most important, the CQ tasks may not have targeted the same aspects of WM and sustained attention as were assessed by outcome measures. Specifically, on the two WM training games, children completed a combined average of

10.54 out of 16 levels. Of these levels, only one level presented auditory stimuli and only two levels involved “working” memory (i.e., manipulation of information in mind rather than simple recall). Unfortunately, the remaining levels that most children did not have sufficient time to complete all targeted auditory “working” memory. Hence, the pre-post measure of auditory WM may have been poorly suited to detect change given that children primarily practiced visual short-term memory recall tasks. Likewise, the sustained attention training games on the CQ target visual attention only, and progressively increase from one minute to six minutes in length. Based on the average level completed, children sustained their attention to tasks that were five minutes long. In contrast, the chosen outcome measure assesses auditory sustained attention over the course of 12 minutes. Although children may have improved in their ability to sustain attention to visual information for a shorter duration of time, they may not have made improvements in their ability to sustain attention to auditory information over a longer duration. Thus, a visual recall span task and five minute visual sustained attention task may have more directly assessed cognitive training gains.

The second hypothesis of the study was that children in the CQ intervention group with higher intrinsic and state motivation would evidence larger changes in self-concept (i.e., Cognitive/Scholastic and Peer/Social self-concept) and on neuropsychological measures of WM and attention. This hypothesis was based on intervention research suggesting that higher motivation facilitates intervention derived gains. Consistent with this literature, child-reported intrinsic motivation accounted for 10.1% of the variance in the change in Peer/Social self-concept and 16.0% of the variance in the change in sustained attention scores. This suggests that intrinsic motivation plays an important role in facilitating cognitive and metacognitive intervention gains, and that individual differences in motivation may enhance or limit the effectiveness of training.

Motivation has been conceptualized as a limited resource that is particularly important when considering self-regulation; motivation to self-regulate is essential for engaging in self-regulatory practices and self-regulation is necessary to stop motivational urges from dictating behaviour (Bandura, 2001; Baumeister & Vohs, 2007). The importance of motivation for effective intervention has been widely acknowledged and investigated in the educational psychology field, where studies have demonstrated the superiority of academic interventions that incorporate motivational principles (e.g., realistic goal-setting) in maximizing immediate and long-term intervention derived outcomes (Guthrie, Mcrae, & Klauda, 2007; Souvignier & Moklesgerami, 2006). Similarly, results from the current study suggest that intrinsic motivation facilitates training derived gains in cognitive and metacognitive interventions. Future cognitive training research should include a formal assessment of motivation to identify intrinsic motivational components that affect the extent of training derived gains, which may reduce or resolve discrepant findings within cognitive intervention literature. Researchers should also begin to consider how motivational factors could be manipulated in the context of cognitive remediation to make training more effective. Addressing motivational factors may be especially crucial for younger children and children with disorders associated with motivation impairments (e.g., ADHD).

On the other hand, teacher perceptions of children's intrinsic motivation did not account for a significant proportion of variance in change on any outcome measures, despite a significant correlation between child self-report and teacher-report of intrinsic motivation. This suggests that unique aspects of child-reported intrinsic motivation, rather than aspects that are shared with the teacher-report measure, account for variance in change. As well, it may be that self-report provides a more valid assessment of intrinsic motivation. Child self-report measures of intrinsic motivation tend to be more strongly correlated with objective indices of academic achievement than teacher-report measures (Gottfried, 1990; Lepper et al., 2005), and teacher ratings are more similar to child ratings by the end of the school year as compared to at the beginning of the year (Stipek, Givvin, Salmon, & Macgyvers, 1998). In general, interrater agreement is lower when ratings pertain to unobservable (i.e., internal) events and states of children (De Los Reyes & Kazdin, 2005). These factors may explain the observed differences between measures of intrinsic motivation in accounting for variance in change on outcome measures.

The finding that child reported state motivation did not predict change on any outcome measures contradicts results from Jaeggi and colleagues (Jaeggi et al., 2011, 2014). However, in the current study state motivation scores were consistently at or near ceiling levels across the duration of the CQ intervention. The restricted variability in scores may have resulted in low predictive validity. Another interpretation pertains to the 11 children who did not complete the minimum requirement of 10 intervention hours and thus were not included in the statistical analyses. To the best of the author's knowledge, these children were unable to satisfy the 10-hour training requirement due to factors such as delayed intervention start time, technical issues, and school absences, though it is plausible that these factors were confounded by low state motivation. For example, one cognitive intervention study found that adult participants who completed a WM training intervention (i.e., approximately 8 hours of training) reported significantly higher levels of engagement during training sessions as compared to participants who dropped out of the study (Jaeggi et al., 2014). However, in the present study state motivation did not differ significantly between children who completed 10 or more training hours and those who completed less than 10 hours. Moreover, in contrast to the cognitive intervention approach adopted by Jaeggi and colleagues (2014), whereby individuals trained on computerized tasks in isolation, the current study combined computerized training with one-on-one or one-on-two support from an EA. The supervision, encouragement, and attention provided by EAs may have increased state motivation. Similarly, Sjö and colleagues concluded that the supervision provided by the teacher who delivered a cognitive intervention to children had a positive effect on sustaining children's motivation throughout the training period (Sjö et al., 2010).

Previous research has demonstrated that the provision of tangible rewards has a negative impact on children's state motivation, especially when rewards are tangible, expected, and dependent on task engagement or completion (Cameron et al., 2001; Deci et al., 1999, 2001). In the present study, tangible rewards were provided following 35% of training sessions and state motivation remained consistently high throughout the intervention. Although EAs were not instructed when, why, or how frequently to provide rewards, this may suggest that tangible rewards were unexpected and independent of training engagement or completion. Moreover, if EAs provided tangible rewards when children met specific performance standards and goals, this may have actually helped to sustain children's state motivation (Cameron et al., 2001). In future cognitive training studies, it would be prudent to track the reason for the provision of each tangible reward in conjunction with children's state motivation to determine the impact of rewards on motivation, as well as any potential impact on the effectiveness of cognitive intervention.

When the relationship between frequency of reward (by type) and change on outcome measures was explored, only the frequency of verbal rewards accounted for a significant proportion (i.e., 20.9%) of the variance in the change in sustained attention scores. This finding is consistent with prior research indicating that verbal reinforcement improves children's task performance and behavioural compliance (Feldman & Klein, 2003; Henderlong & Lepper, 2002), especially when the verbal reinforcement is specific and emphasizes strategy or effort (Corpus & Lepper, 2007). In the context of cognitive training with children, verbal reinforcement may be valuable in providing children with information about effective problem-solving strategies, fostering adaptive reactions in challenging situations, and enhancing self-efficacy beliefs.

The third hypothesis investigated the relationship between motivation and age. Age was expected to be positively related to state motivation for the CQ intervention because of factors related to self-regulation and cognition development, including being able to persist with difficult and repetitive training activities, maintain focus during training sessions, and understand the value of training (Bandura, 1993; Eccles & Wigfield, 2002; Hidi & Harackiewicz, 2000). Regression results were not significant when the entire sample was included; however, age significantly predicted state motivation to reveal opposing patterns when analyses were separated for younger and older age groups. Specifically, prior to the age of eight years, state motivation was predicted to increase 5.16 points for each additional year of age, whereas there was a predicted decrease of 2.99 points for each additional year of age for children older than eight years of age. It was noteworthy that state motivation scores between these two age groups did not significantly differ. However, based on anecdotal feedback received during consultations and school visits, younger children and their EAs were more likely to report that the CQ games were perceived to be frustrating and too challenging, middle-aged children and their EAs were most likely to report that the games were perceived to be "cool," and older children and their EAs most commonly reported that the games were perceived to be "childish" and "too young." These perceptions of the CQ intervention, which appear to be age-related, may have differentially impacted the relationship between children's state motivation and age.

Based on previous literature, intrinsic motivation was expected to decrease with age. Results from the present study did not support this hypothesis, and age was not significantly related to self- or teacher-reported child intrinsic motivation. From visual inspection of the mean raw scores, child-reported intrinsic motivation increased each year from age six to nine and decreased each year after age nine ($M$ at age six = 13.91; $M$ at age seven = 14.33; $M$ at age eight = 15.63; $M$ at age nine = 16.60; $M$ at age 10 = 13.30; $M$ at age 11 = 11). The same pattern emerged when mean scores by grade and teacher-reported mean scores were examined, though there was no significant difference in intrinsic motivation for children under the age of 10 compared to children over the age of 10. The initial rise and subsequent decline of motivation generally supports the view that intrinsic motivation increases over the course of the first three years of elementary school (Broussard & Garrison, 2004), and then begins a continual gradual decline (Corpus et al., 2009; Lepper et al., 2005; Otis et al., 2005). Interestingly, the anticipated decline in intrinsic motivation occurred one year later for children with EF and attention deficits as compared to unselected samples of children. To the author's knowledge, this is the first study to investigate the relation of age to intrinsic motivation in children with EF and attention deficits. This may indicate that children with EF and attention deficits are slower to recognize the significance of performance evaluations and shift from task oriented (i.e., goals to develop ability) to performance driven goals (i.e., goals to demonstrate ability or avoid demonstrating lack of ability), which are believed to be two of the main factors that contribute to the gradual erosion of intrinsic motivation in children (Gottfried et al., 2001; Lepper et al., 2005). Although the reason for the delayed decline is unclear, it may offer a larger window of opportunity for these children to learn and strengthen cognitive and metacognitive skills. Thus, interventions targeting children with EF and attention deficits prior to age 10 (or Grade 5), before intrinsic motivation for learning begins to decline, may be of greater benefit.

The fourth hypothesis predicted that age would be negatively related to self-concept, in keeping with research documenting a progressive yearly decline in self-concept for children ages five to 17 years (Fredricks & Eccles, 2002; Jacobs et al., 2002; Marsh et al., 1998; Wigfield et al., 1997). Initially, age did not account for a significant proportion of variance in self-concept when the entire sample was included. When regression analyses were separated into two age groups (i.e., boys less than eight years of age and boys aged eight years and older), age explained a significant proportion of variance in Cognitive/Scholastic self-concept for the younger children (26.5%). However, results indicate a predicted *increase* in Cognitive/Scholastic self-concept of 2.22 points for every additional year of age. This predicted increase in Cognitive/Scholastic self-concept for young children with EF and attention deficits contradicts the majority of literature that documents a consistent decline in self-concept for unselected samples of children (Fredricks & Eccles, 2002; Jacobs et al., 2002; Marsh et al., 1998; Wigfield et al., 1997). Similar to the delayed onset of the decline in intrinsic motivation, children with EF and attention deficits may be slower to make use of appropriate social comparisons, recognize the importance of abilities and achievements over effort, and perceive competitiveness in school, sport, and recreational activities (Fredricks & Eccles, 2002; Robins & Trzesniewski, 2005), therefore delaying the negative impact of these factors on self-concept.

From visual inspection of the mean scores, Cognitive/Scholastic self-concept increased from age six to seven, decreased from age seven to eight, increased from age eight to nine, decreased from age nine to 10, and increased from age 10 to 11. The same pattern emerged when mean Z-scores and Peer/Social self-concept scores were examined. There are two possible explanations for these unexpected findings. First, these fluctuations in self-concept over time may indicate that self-concept in children with EF and attention deficits is less stable during childhood as compared to unselected samples of children (Trzesniewski et al., 2003). Lower self-concept stability is presumed to occur during periods of significant environmental and/or maturational change that may test and alter a child's self-perceptions (Alsaker & Olweus, 1992). Indeed, early to middle childhood is a period marked by rapid developmental and maturational changes, shifting expectations at home and school, and the formation of increasingly complex relationships; EF and attention deficits may heighten the frequency or intensity of these changes and cause self-evaluations to fluctuate. Interventions that target the time period during which self-concept stability is low may induce the greatest change, as self-evaluations and efficacy beliefs may be especially malleable (Trzesniewski et al., 2003).

Given the small sample sizes in the current study, especially when scores were separated into one-year age groups, the year-to-year variations in self-concept could reflect factors other than age. For example, internalizing symptomatology, presence and severity of ADHD, co-occurring aggression, and attribution style affect self-concept (Edbom, Granlund, Lichtenstein, & Larsson, 2008; Houck et al., 2011; McQuade, Hoza, Murray-Close, Waschbusch, & Owens, 2011; Treuting & Hinshaw, 2001). Although not all of these influential factors were measured, younger and older groups of children were similar in terms of the frequency of internalizing disorder (2 younger children; 4 older children) and ADHD diagnoses (9 younger children; 10 older children), and symptom severity according to SNAP-IV ratings of inattention (1.74 and 1.86, respectively) and hyperactivity/impulsivity (1.70 and 1.76, respectively). However, these factors may have differed across one-year age groups and affected self-concept. Further complicating the relationship between age and self-concept for children with EF and attention deficits are inconsistent findings across studies. With regard to ADHD, some evidence indicates self-concept scores are lower in these children as compared to children without ADHD (Barber et al., 2005; Ialongo, Lopez, Horn, Pascoe, & Greenberg, 1994), yet other studies report no differences in self-concept (Bussing, Zima, & Perwien, 2000; Ohan & Johnston, 2002). Although some researchers argue that discrepancies across studies are the result of differences in sample characteristics, as well as measurement, methodological, and statistical approaches (Owens et al., 2007), these conflicting results may in fact reflect fluctuations in self-concept and self-concept instability during childhood.

Consistent with the fifth hypothesis, which held that children's self-concept would predict level of motivation, Cognitive/Scholastic self-concept explained a significant percentage of the variance in self-reported child intrinsic motivation. This hypothesis was based on previous research that suggests intrinsic motivation and academic self-concept are reciprocally related (Pajares & Graham, 1999; Zsolnai, 2002). For example, children with positive self-evaluations invest more effort in tasks, are driven by mastery oriented goals (i.e., concerned with developing competence and skills), take on difficult tasks that are viewed as more interesting, and persist for longer, even when challenges are encountered (Baumeister et al., 2003; Souvignier & Moklesgerami, 2006; Zimmerman, 2000). These hallmark behaviours of children with higher self-competency beliefs capture the defining components of an intrinsic motivational orientation, including preference for challenging tasks, learning driven by interest, and striving for competence and mastery (Gottfried et al., 2001). On the other hand, motivation can be explained by one's beliefs about how well they can do the activity and the perceived value of the activity (i.e., usefulness and importance; Wigfield & Eccles, 1992; Wigfield, 1994), and positive self-concept evaluations are strengthened when one engages in behaviours associated with intrinsic motivation (Schunk, 1996). Hence, positive self-concept leads to behaviours consistent with an intrinsic motivational orientation, and an intrinsic motivational orientation supports positive self-concept.

The bidirectional nature of the relationship between self-concept and motivation suggests that an increase in self-concept will yield an increase in motivation and vice versa. Hence, the younger children in the intervention group may evidence reciprocal increases in intrinsic motivation as their competency beliefs lead them to invest more effort in tasks, form mastery oriented goals, engage in more challenging tasks, and persist for longer when faced with difficulties. In support of the expectation that these children will demonstrate a complementary increase in motivation, previous research has found that changes in children's competency beliefs predicted changes in interest level, one of the key motivational determinants, over the course of a semester in high school (Mac Iver, Stipek, & Daniels, 1991). Taking this one step further, children may attach more value to the activities that they perceive themselves to perform well because of processes associated with classical conditioning (i.e., the positive emotional reaction experienced post-activity will become attached to the activity) and also because raising the value attached to an activity that is performed well is an adaptive way to maintain a positive sense of self-concept (Eccles & Wigfield, 2002). Thus, the increased competence-related beliefs endorsed post-intervention for the younger group of boys should not only raise their intrinsic motivation for learning, but also their beliefs about the value and importance of cognitive and scholastic activities. For children with EF and attention deficits, this may be of particular benefit, because these children tend to display a disengaged attitude towards learning and are less likely to report that they enjoy learning (Carlson et al., 2002; Hoza, Pelham, Waschbusch, Kipp, & Owens, 2001; Hoza, Waschbusch, Pelham, Molina, & Milich, 2000).

The final hypothesis investigated state motivation over the course of multiple training sessions. Results indicate that there were no differences in state motivation across the duration of the CQ intervention. However, child reported state motivation scores were consistently at or near ceiling levels, indicating high state motivation with minimal variability among the scores. This suggests that the vast majority of children were motivated to engage in the CQ intervention.

The state motivation questions were constructed based on a literature review of current assessment methods, with particular attention to the three cognitive training studies that measured state motivation. In the first study, children, parents, and trainers were asked to rate post-intervention how eager the child had been to start training sessions (Sjö et al., 2010). In another study, parents completed a post-intervention questionnaire, on which they rated how motivating, challenging, unvarying, and fun the cognitive training had been for their child (Nutley et al., 2011). Finally, in the third study, children answered a series of 10 questions post-intervention to assess training interest and enjoyment, perceived training difficulty, and perceived competence on training tasks (Jaeggi et al., 2011). Hence, the current study adopted a similar approach to previous studies and asked children a series of six yes/no questions to assess state motivation. However, children were asked the series of questions a total of 10 times (i.e., immediately following the first and last five training sessions). To the author's knowledge, this is the first cognitive remediation study to investigate state motivation across the duration of an intervention. In that children's state motivation for the CQ intervention appeared consistently high, more sensitive methods to detect changes in state motivation may be useful to better assess the potential impact of state motivation on training outcomes.

There are several limitations to this study that require consideration. First, the study involved relatively small groups of participants, and included children with and without various mental health diagnoses, as well as children with ADHD of all subtypes.

Although the sample could have been restricted to children with non-comorbid ADHD, the external validity of findings would have been limited given that approximately 75% of school age children have ADHD with psychiatric comorbidity (Wilens et al., 2002). Ideally, it would have been useful to recruit larger numbers of participants to examine differences across groups with and without specific diagnoses.

In addition, as a community based research study, school staff identified children with EF and attention deficits they felt should participate in the intervention. Although guidelines were provided to school staff to assist with the identification of children with EF and attention deficits, parent SNAP-IV and CEFI ratings, teacher CEFI ratings, and pre-test scores on neuropsychological outcome measures indicated that some children in the final sample did not exhibit clinical levels of EF or attention difficulties. This method of recruitment also led to the identification of significantly fewer girls than boys. In contrast to boys with ADHD, girls have a higher prevalence of inattentive symptoms and comorbid internalizing disorders over symptoms of hyperactivity and impulsivity and comorbid disruptive behaviour and learning disorders (Biederman et al., 1999, 2002). In addition, girls with ADHD engage in higher rates of verbal aggression, whereas boys engage in more rule-breaking behaviours. Taken altogether, symptoms of inattention, internalizing disorders, and verbal aggression are more covert than symptoms of hyperactivity and impulsivity, disruptive behaviour, learning disorders, and rule-breaking behaviours, and school staff may have been unable to detect these more covert indicators of EF and attention deficits.

In addition to significantly fewer girls identified for participation in the study, the four girls that were initially recruited to the intervention group did not complete the minimum requirement of 10 training hours. This may be critically important, as gender has been implicated in children's use of computers. Research suggests that boys hold more positive attitudes and self-efficacy beliefs toward computers, play more computer games, and enjoy using computers more than girls (McKenney & Voogt, 2010; Reinen & Plomp, 1997; Vekiri & Chronaki, 2008). Thus, it is possible that gender differentially influenced children's perceptions of the CQ intervention, which caused girls to drop out of the CQ intervention and gender discrepancies between groups.

Finally, training EAs to deliver and tailor the intervention to the individual child's needs and performance, as opposed to providing a highly structured, manualized intervention training protocol, may have affected treatment fidelity and interpretations regarding the efficacy of CQ intervention. As well, variation among the EAs in terms of their ability to effectively deliver the intervention likely affected the extent of gains made by children.

Overall, the gender discrepancy and ecologically valid delivery approach to cognitive intervention may have limited the interpretation and generalization of present results. There are several important directions for future research, including assessing the efficacy of the CQ intervention in samples of female children with EF and attention deficits, identifying internal and external factors that affect a child's ability to successfully complete a cognitive intervention, and monitoring the consistency of intervention delivery.

In summary, the CQ intervention demonstrated positive results in that younger boys, identified by school staff as having significant deficits in EF and attention, experienced significant gains in cognitive and social domains of self-concept. The improvements in self-concept, and the notably high levels of state training motivation across the duration of the intervention, despite the heterogeneity in diagnosis, supports the external validity of the CQ intervention. The predictive value of intrinsic motivation for changes on outcome measures highlights the necessity of assessing motivation and examining the impact of motivation on intervention derived gains. In addition, findings suggest that boys with EF and attention deficits demonstrate increasing motivation and low self-concept stability during the first few years in elementary school, which may provide a window of opportunity for cognitive intervention to produce greater change. It will be important to further study the effects of the CQ intervention with female children and within larger diagnostic groups, as well as to investigate the extent to which beneficial effects may transfer to children's everyday life at school and home.

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# Appendix A: Child Participant Eligibility Guidelines

In order to be eligible for the study, a child must:

a) Be between 5 and 12 years of age AND
b) Exhibit difficulties with EF and/or attention.

A child is ineligible for the study if he or she:

a) Has a diagnosis of moderate or severe intellectual disability (i.e., IQ < 55 standard points) OR
b) Is unable to communicate verbally.

The following conditions typically involve EF and attention difficulties:

- Attention-deficit hyperactivity disorder
- Autism spectrum disorder
- Fetal alcohol spectrum disorder
- Mental health disorders (e.g., conduct disorder, oppositional defiant disorder, obsessive-compulsive disorder, Tourette syndrome)
- Learning and language disorders
- Brain damage (e.g., spina bifida, hydrocephalus, cerebral palsy, and epilepsy)
- Central nervous system cancer and cancer treatments

The following symptoms typically indicate EF and attention difficulties:

- Difficulty listening and paying attention
- Easily distracted
- Loses a train of thought when interrupted
- Needs to be told the directions many times
- Knows something at one time but forgets the same day or the next day
- Unable to think about or do more than one thing at a time
- Difficulty remembering directions, taking notes or understanding something that has just been explained
- Frequently says, "I forgot what I was going to say"
- Poor organization (e.g., loses track of information and things, and loses or misplaces things)
- Does things either quickly and messily or slowly and incompletely
- Impulsiveness (e.g., blurts things out, does unsafe things without thinking it through, or has trouble following rules consistently)
- Self-regulation struggles
  - Difficulty attaining, maintaining and changing level of arousal appropriately for a task or situation
  - Difficulty controlling emotions
  - Difficulty formulating a goal, monitoring goal-progress, and adjusting behaviours
  - Difficulty managing social interactions

  - Lack awareness of personal strengths and weaknesses, as well as strategies to tackle day-to-day challenges of academic tasks
- Poor emotional control (e.g., trouble accepting negative feedback, overreacts to little injustices, or struggles to finish a task when something upsets them)
- Difficulty getting started on a task
- Overwhelmed when trying to break tasks into smaller, more manageable chunks
- Poor time estimation and time management skills
- Difficulty changing plans or strategies, even when it’s clear that the plan or strategy isn’t working
- Easily frustrated
- Difficulty switching gears from one activity to another
- Difficulty making decisions
- Doesn’t always have the words to explain something
- Needs help processing what something feels/sounds/looks like

# Appendix B: Parent Screening and Demographic Interview

1. Name of parent/guardian

2. Your relationship to child (e.g., biological parent, adoptive parent, step-parent, foster parent, biological grandparent)

3. Contact information (phone, email)

4. Name of child

5. Child's age/birthdate (must be between 5-12 years of age)

6. Child's gender

7. Child's race/ethnicity: Aboriginal/First Nation/Native American; Asian; Black/African American; Hispanic/Latino; White; Other

8. What category best matches your family's total gross annual household income?
    - Less than $25,000
    - $25,000 to $49,999
    - $50,000 to 99,999
    - $100,000 or more

9. Child's school

10. Child's grade

11. Confirm child does not meet exclusionary criteria: moderate or severe intellectual disability (i.e., IQ < 55 standard points) or unable to communicate verbally

12. Does your child receive any services at school, such as speech and language, occupational therapy, learning assistance, counseling? What service(s)? When did this service start? How long has this service been received for?

13. Does your child have a formal diagnosis of any medical or mental health disorders made by a qualified health care practitioner? Who made this diagnosis? When was this diagnosis made? Are you scheduled or on a waiting list for any diagnostic service?

14. Does child take any medications and, if so, which ones and for how long?

15. Does your child have a diagnosis of a learning disability or disorder or difficulty? Are you scheduled or on a waiting list for any diagnostic service for LD?

16. Does your child have ADHD? If so, what subtype - inattentive, hyperactive-impulsive, or combined? Are you scheduled or on a waiting list for any diagnostic service for ADHD?

17. SNAP-IV Parent Rating Scale - Inattention and Hyperactivity-Impulsivity Scales

| **For each item, select only one box that best describes your child.** | **Not at all (0)** | **Just a little (1)** | **Quite a bit (2)** | **Very much (3)** |
|---|---|---|---|---|
| 1. Often fails to give close attention to details or makes careless mistakes in schoolwork, work, or other activities | | | | |
| 2. Often has difficulty sustaining attention in tasks or play activities | | | | |
| 3. Often does not seem to listen when spoken to directly | | | | |
| 4. Often does not follow through on instructions and fails to finish schoolwork, chores, or duties | | | | |
| 5. Often has difficulty organizing tasks and activities | | | | |
| 6. Often avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort (e.g., schoolwork or homework) | | | | |
| 7. Often loses things necessary for tasks or activities (e.g., toys, school assignments, pencils, books, or tools) | | | | |
| 8. Often is distracted by extraneous stimuli | | | | |
| 9. Often is forgetful in daily activities | | | | |
| 10. Often fidgets with hands or feet or squirms in seat | | | | |
| 11. Often leaves seat in classroom or in other situations in which remaining seated is expected | | | | |
| 12. Often runs about or climbs excessively in situations in which it is inappropriate | | | | |
| 13. Often has difficulty playing or engaging in leisure activities quietly | | | | |
| 14. Often is "on the go" or often acts as if "driven by a motor" | | | | |
| 15. Often talks excessively | | | | |
| 16. Often blurts out answers before questions have been completed | | | | |
| 17. Often has difficulty awaiting turn | | | | |
| 18. Often interrupts or intrudes on others (e.g., butts into conversations/games) | | | | |
| | **Sum of items** | **Average rating** | **Parent 5% cut-off** | **≥ cut-off?** |
| **Average score for ADHD-Inattention (sum of** | | | **1.78** | |

| | | | | |
|---|---|---|---|---|
| **items 1-9/ # of items)** | | | | |
| **Average score for ADHD-Hyperactivity-Impulsivity (sum of items 10-18/ # of items)** | | | **1.44** | |
| **Average score for ADHD-Combined (sum of items 1-18/ # of items)** | | | **1.67** | |

18. Does your child have any behavioural difficulties?

19. Does your child have any emotional difficulties?

20. What are your current areas of concern pertaining to your child?

21. What do you see as your child's strengths? What is he/she really good at? What do they enjoy?