



**Mental Capital and Wellbeing:  
Making the most of ourselves in the 21st century**

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Self-Regulation and Executive Function:  
What Can Teachers and Schools Do?**

Mark T. Greenberg, Ph.D.  
Human Development and Family Studies Department  
Pennsylvania State University

Brittany L. Rhoades, M.S.  
Human Development and Family Studies Department  
Pennsylvania State University

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## Summary

**The importance of executive functions in children's everyday social-emotional, behavioural, and academic success is undeniable. The ability to flexibly manage one's attention and impulsivity and to plan ahead in the service of an established goal are crucial to young children's overall wellbeing. Development in these skills occurs in parallel with growth in the prefrontal cortex, resulting in improved volitional, higher order cognitive and behavioural processes. Evidence of the prolonged developmental period of the prefrontal cortex and its neural plasticity suggests there are significant opportunities for environmental influence. Recently, a number of curricula and training programmes to promote self-regulation have been developed, some of which have been shown to improve executive function skills and behavioural competence. This research offers preliminary evidence that active promotion of social-emotional and behavioural competence may lead to increases in neurocognitive abilities, and in turn, could greatly influence the long-term prevention of academic and social difficulties.**

### 1. Importance of self-regulation

The development of effective self-regulation provides children with the crucial foundation needed to be effective in their social and cognitive interactions with an ever-expanding social world (Shonkoff and Phillips, 2000). Successful interactions with parents, teachers and peers depend on children's abilities to direct, maintain and focus their attention, manage their impulsivity, regulate their behaviour and emotions, plan ahead and demonstrate cognitive flexibility in order to solve a problem. Executive function (EF) is an umbrella term that has been used to describe the cognitive processes that underlie the skills described above.

Carlson (2005, p.595) defines EF as: 'higher order, self-regulatory, cognitive processes that aid in the monitoring and control of thought and action'. EF is a multidimensional construct reflecting a number of component skills that primarily develop in numerous areas of the prefrontal cortex. EF is comprised of a number of related, but distinguishable components, including working memory, inhibitory control, attention flexibility, and planning (Carlson, 2005; Hughes et al., 1998a; Pennington, 1997; Pennington and Ozonoff, 1996; Welsh et al., 1991). Taken together, EF skills enable flexible, coordinated, cognitive and affective decision-making that is critical in most ongoing behaviour.

During the past decade there has been an enormous expansion of knowledge regarding both the development of EF skills as well the growth and differentiation of the pre-frontal area of the brain. Findings indicate that rudimentary forms of EF emerge by the end of the first year of life and continue to develop until at least early adulthood (Dempster and Corkhill, 1999; Diamond, 1991; Welsh and Pennington, 1988).

### 2. Role of EF in children's healthy development

A growing body of research suggests that EF skills play an important role in children's social, cognitive, and behavioural wellbeing. Recent studies have shown predictive relationships between EF skills and a variety of outcomes. For example, effortful/inhibitory control in early childhood has been longitudinally related to better emotion regulation, fewer behavioural problems, and greater compliance with adults later in middle childhood (Kochanska and Knaack, 2003; Kochanska et al., 2000; Kochanska et al., 2001). Similarly, measures of inhibitory control at six and eight years of age predicted parental and self-ratings of conduct and aggression problems during adolescence (Olson et al., 1999).

Children's ability to direct and maintain their attention (attentional control), as rated by teachers and parents, is predictive of higher social competence in elementary school age children (Eisenberg et al., 1995) and negatively related to problem behaviours (Eisenberg et al., 1996). First-grade children exhibiting higher rates of aggression also show more difficulties in shifting their attention during interactions with peers compared to those who are low in aggression (Wilson, 2003). Evidence indicates that attentional control is an important strategy in the regulation of negative affect and, therefore, has important implications for the development of socially and emotionally competent behaviours (Belsky et al., 2001; Gilliom et al., 2002).

EF skills that play a role in the development of social-emotional competence are also integral to other important developmental tasks in early childhood, including school readiness and academic achievement (Blair, 2002; van der Sluis et al., 2004). First, in learning new information, children are often required to shift their attention from one mental set to another in order that learning may occur. Second, their working memory span may be particularly important for reading ability as it involves monitoring and coding incoming information necessary for reading comprehension such that old, irrelevant information is replaced by current, relevant information. Third, much learning involves inhibitory control in which one deactivates (inhibits) an obsolete mental set in favour of a new one. Thus, it is not surprising that research has found that both working memory and inhibitory control contribute to the prediction of early math skills (Espy, 2004), as well as to early reading ability (Bull and Scerif, 2001; Shah and Greenberg, 2007).

### **3. EF deficits and maladaptation**

The majority of research examining the link between EF and children's behaviour has focused on child and adolescent populations that show difficulties in the areas of attention deficit hyperactivity disorder (ADHD), conduct problems or antisocial behaviour. In one meta-analysis examining the link between EF deficits and antisocial behaviour, antisocial groups performed more than a half standard deviation below normal comparison groups on a group of six validated EF tasks (Morgan and Lilienfeld, 2000).

Research has also consistently shown that children with ADHD have significant deficits in inhibitory control when compared to normally developing children (Charman et al., 2001; Pennington and Ozonoff, 1996; Sonuga-Barke et al., 2002). Preschool children at risk for ADHD are more likely to fail a variety of EF tasks – i.e. planning, working memory, inhibition, attentional flexibility (Hughes et al., 1998b). They also report that EF skills are negatively related to antisocial behaviour and positively related to prosocial behaviour in peer interactions (Hughes et al., 2000). Diamond (2005) asserts that ADHD and ADD (without hyperactivity) are distinct disorders characterised by specific EF deficits. The core deficit of ADD is working memory, whereas the core deficit of ADHD is impulsivity.

Recent research has developed innovative assessments of EF in young children and shown its relationship to early problem behaviours (Cole et al., 1993; Hughes et al., 1998b; Hughes et al., 2000; Kusche et al., 1993; Seguin and Zelazo, 2005). Although many factors influence the development of persistent physical aggression, one factor that may explain a portion of this persistence is EF deficits (Seguin and Zelazo, 2005). For example, children with healthy development can be distinguished from those exhibiting anxious, externalising, and comorbid symptoms by the level of EF functioning in middle childhood (Kusche et al., 1993).

Further, after accounting for IQ and academic competence, EF difficulties at school entrance are predictive of increases in both externalising and internalising behaviours across the next few years of school (Nigg et al., 1998; Riggs and Greenberg, 2004a). In all, these findings provide convincing evidence of a link between EF deficits and various behaviour problems during childhood.

#### **4. EF and the prefrontal cortex**

Interest in EF as an important developmental construct largely began as a result of brain damage studies which consistently found a family of inter-related deficits associated with prefrontal cortex (PFC) damage. These studies found that patients with PFC damage exhibited problems with inhibition, planning, and socially appropriate behaviours (Rankin, 2007). The PFC plays a significant role in these processes and is associated with performance on common EF tasks that require switching and active maintenance and inhibition (Diamond, 2005). Moreover, research shows that development in the PFC coincides with increasing coordination of goal-directed behaviours and increases in behavioural control and self-regulation (Diamond, 2005).

Whereas the limbic system is responsible for automatic, instinctual emotion processing, the PFC is responsible for secondary emotion processing and cognitive control. As children mature, the pathway from the limbic system to the frontal cortex strengthens, which allows the PFC to serve a regulatory role in interpreting emotional information and responding with subsequent actions. Development in the PFC promotes vertical control, which is illustrated by the higher-order cognitive processes of the PFC overriding the lower-level, automatic limbic system reactivity (Lieberman et al., 2007). Dramatic growth in the PFC and vertical control begin in early childhood, but the PFC is not fully developed until early adulthood (Casey et al., 2005).

During childhood and into adolescence, the PFC is rapidly developing in accordance with genetically influenced processes. However, there remains great plasticity in neural development and organisation (Riggs et al., 2004b). The PFC takes the longest of all brain regions to reach full maturity. As a consequence, there are significant opportunities for environmental influence in its development. Preventive interventions that focus on promoting strategies to assist children in their behaviour and emotional control are likely to impact the strength of the neurological pathways that develop in the PFC, which allow for the self-regulated behaviours needed to succeed in all areas of their life.

#### **5. Role of EF in preventive intervention programmes**

During the past decade there has been progress in developing curricula and training programmes to promote self-regulation. In addition, a few programmes have focused specifically on developing EF skills. Those focused on developing self-regulation fall under the general domain of social and emotional learning (SEL) programmes (Greenberg et al., 2003). These often focus on promoting a combination of skills including self-control, emotional awareness, and communication and problem-solving skills. They often also include a specific focus on skills for making and maintaining friendships.

One such programme, Promoting Alternative Thinking Strategies Curriculum (PATHS), has focused on SEL skills, but it has a theoretical model based on contemporary models of neuroscience (Kusche and Greenberg, 2006). In a series of randomised clinical trials with children from ages six to 10, PATHS has been shown to improve socially competent behaviour and self-regulation, as well as to reduce both aggressive and internalising behaviours by both teacher and peer report. In a recent report, findings showed that PATHS also increased inhibitory control and working memory in children aged nine to 11 and that these changes in EF skills mediated changes one year later in improved behaviour as rated by teachers. Thus, a direct connection was made between improvement in self-regulatory cognitive skills and behavioural adjustment in an experimental model.

More recent findings from a randomised trial in US Head Start Programs for low-income American children utilised a preschool version of PATHS (Domitrovich et al., 2005). Results indicate not only improvements in behavioural adjustment, but also significant changes in a measure of working memory (Bierman et al., 2007).

A second study of a preschool intervention model based on Vygotskyian ideas about the importance of play called 'Tools of the Mind' (Diamond et al., 2007) has also shown changes in both working memory and inhibitory control using computer-based measures of EF.

In addition to these broader classroom curriculum models that integrate SEL and EF models, there have been a number of more limited, clinic- or laboratory-based interventions that explicitly focus on improving EF skills using computer-based training. One model utilised a five-session programme for 4- and 6-year-old children that was specifically designed to strengthen the executive attention system. Results for 4-year-olds indicated improvements in a non-verbal measure of intelligence, but little effect on the executive attention system; findings for 6-year-olds indicated an effect on attentional control but no effect on non-verbal intelligence (Rueda et al., 2005). No effects of training were found on parent-reported temperament.

A second training study with preschoolers indicated that a brief series of three training sessions could significantly improve 3- and 4-year-olds' inhibitory control in a laboratory EF task (Dowsett and Livesey, 2000). A third intervention study focused on improving working memory with computer-based training in 7- to 12-year-olds who had significant problems in attention (ADHD). Results indicated not only improvement in working memory, but also short-term improvements in behaviour as rated by parents.

The initial success of these models should not be surprising considering the solid basis of research which indicates that children's environmental experiences have the potential to influence the structure and function of the brain (Shonkoff and Phillips, 2000).

Although there has been considerable interest in promoting self-regulation to improve behaviour, little attention has been paid to how focused teaching regarding these EF skills may be related directly to learning processes and academic achievement. One programme that implicitly focused on EF skills and mediated learning is Instrumental Enrichment (Feuerstein, 1980). Mediated learning involves the use of an adult guide who helps the child to focus, select, intensify, direct, and verbally monitor their experience and thus alter the child's cognitive structure. Although this model has been extensively studied, there are no known randomised trials of its effects on children in which self-regulatory outcomes have been assessed. A similar model focused on cognitive modifiability (Tzuriel, 1999) has shown promising effects on cognitive development, but the researchers did not specifically assess either EF or self-regulatory skills.

As a result of these innovations, researchers in human development are increasingly recognising the importance of incorporating theoretical models of neurocognitive functioning in the development and evaluation of educational and prevention programmes (Greenberg, 2006; Greenberg et al., 2007). Numerous evidence-based preventive and educational interventions have been designed to improve skills such as emotion regulation and problem-solving (Greenberg et al., 2003), but few have examined their effects on attention or EF. Although some were not designed specifically to enhance EF skills directly, it is possible that they influence EF abilities *indirectly* by targeting attention, verbal self-regulation, and problem-solving skills.

## **6. Future directions**

The above evidence suggests potential benefits in promoting skills such as conscious strategies for self-control, attention, concentration, and problem-solving – all of which may ultimately aid in the development of children's neurocognitive capabilities. In turn, the strengthening of neurocognitive abilities has the potential to further decrease children's problem behaviours. Future research requires more complete tests of models of change that incorporate neurocognitive development as well as more direct measures of brain activity (Blair, 2002) in order to test these possibilities.

To accomplish this change in schooling would require research not only on outcomes of curricular interventions, but a deeper understanding of the cultural context of schooling. Such a change requires a clear understanding of what innovations in training and ongoing support are required for effective outcomes. This requires further understanding of how to highlight the goals of self-regulation in the context of educational policy and to alter both the rhetoric and everyday behaviour of local educational leaders.

By actively promoting social-emotional and behavioural competence at a time in children's lives that their neurocognitive abilities are rapidly developing and are most influenced by environmental input, participation in preventive interventions might lead to commensurate increases in neurocognitive abilities. These, in turn, could greatly influence the long-term prevention of academic and social difficulties.

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