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Review article

Cognitive training as a resolution for early executive function difficulties in children with intellectual disabilities

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ABSTRACT

Core executive functions (EF) such as attention, and working memory have been strongly associated with academic achievement, language development and behavioral stability. In the case of children who are vulnerable to cognitive and learning problems because of an underlying intellectual disability, EF difficulties will likely exacerbate an already compromised cognitive system. The current review examines cognitive training programs that aim to improve EF, specifically focusing on the potential of this type of intervention for children who have intellectual disabilities. We conclude that despite considerable discrepancies regarding reported intervention effects, these inconsistencies can be attributed to flaws in both program and study design. We discuss the steps needed to address these limitations and to facilitate the advancement of non-pharmaceutical interventions for children with intellectual disabilities.

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1. Introduction

Concentrating on a task, switching attention between tasks, or inhibiting impulsive responding are critical components in the development of cognitive control. Collectively known as executive functions (EF) these skills emerge early in life and their development becomes progressively more robust from the preschool years onwards (Steele, Karmiloff-Smith, Cornish, & Scerif, 2012; Zhan et al., 2011). The importance of EFs are highlighted by recent studies demonstrating that these skills are more strongly associated with school readiness than IQ (Blair & Peters Razza, 2007), serve as predictors of literacy and numeracy scores in preschool through high school (Clark, Pritchard, & Woodward, 2010; Clark, Sheffield, Wiebe, & Espy, 2013), facilitate social inclusion and peer relationships (Gomes & Livesey, 2008), and play an important role in maintaining mental health across the lifespan (Diamond, 2012; Meyer et al., 2004). Disruption to these essential processes can lead to increased levels of distractibility, impulsivity, forgetfulness and poor focus. In the case of children who are especially vulnerable to learning impairments, because of an underlying intellectual disability (e.g. Autism, Down syndrome), EF difficulties will likely exacerbate an already compromised cognitive system. The developing child's ability to interact with the world around them is significantly impacted, reducing their capacity to engage in educational programs and increasing their already heightened risk of long-term behavioral and emotional problems (Einfeld et al., 2006; Hofer et al., 2009).

Treatment options for improving EF in individuals with intellectual disabilities (ID) are sparse and largely target only behavioral features such as inattention and hyperactivity. As a result psychostimulant medication comprises the most common treatment option, and although short term effects of drugs such as methylphenidate and amphetamine are well documented (e.g. Swanson, Baler, & Volkow, 2011), less is known about the long term impacts of prolonged use. Findings also indicate that children with ID are less likely to show therapeutic benefits and have increased vulnerability to the negative side effects of psychostimulants than typically developing (TD) children (Aman, Farmer, Hollway, & Arnold, 2008). In light of the shortfalls of current interventions, recent investigations have suggested that cognitive training may provide an adjunct to pharmaceutical interventions and a riposte to the concept that cognitive impairments are permanent. An increasing number of studies have explored the impact of EF training in TD children, including those within the general intellectual range of the TD population, such as children with Attention Deficit Hyperactivity Disorder (ADHD), and have reported promising effects on early working memory (Alloway, Bibile, & Lau, 2013; Thorell, Lindqvist, Bergman Nutley, Bohlin, & Klingberg, 2009) and attentional control skills (Rueda, Rothbart, McCandliss, Saccomanno, & Posner, 2005). Given the high prevalence of cognitive difficulties in children with ID, coupled with the significant lack of suitable interventions, an extensive investigation of how cognitive training can strengthen core EF skills in individuals with limitations in intellectual functioning is warranted.

In this narrative review, we examine current cognitive training programs, specifically those that target core EF, such as attention and working memory. Our primary aim is to assess existing cognitive training studies in the context of children with ID in order to gauge the potential benefits this intervention may offer in terms of cognitive and behavioral improvements for those with limited cognitive abilities. Although several narrative and meta-analytic reviews have assessed the effect of cognitive training in TD children and children with ADHD (Klingberg, 2010; Melby-Lervag & Hulme, 2013; Morrison & Chein, 2011; Shipstead, Hicks, & Engle, 2012; Shipstead, Redick, & Engle, 2012), to our knowledge this is the first review to examine the potential application of cognitive training in children with ID.

2. Executive functions: target training domains

2.1. Attention

The attention system is complex and multifaceted, and as such interacts with several cognitive domains (Posner & Petersen, 1990). Despite previous conflict regarding the definition of attention there is now widespread agreement that there are three separable cognitive components (Fan, McCandliss, Fossella, Flombaum, & Posner, 2005; Posner & Petersen, 1990) that are in place by as young as 6 years of age (Manly et al., 2001). These processes are *selective attention*, i.e. the ability to selectively attend to aspects of the environment; this network is operated by parietal structures connected with frontal eye fields and the superior colliculus. *Sustained attention* i.e. the ability to sustain attention on a task over time and maintain a high state of sensitivity to incoming information; this involves the parietal cortex, right frontal cortex and locus coeruleus. And lastly *executive attention*, the ability to control attention on a fixed goal while ignoring conflicting information; this process involves the left and right frontal areas as well as the anterior cingulate cortex.

All three attentional processes operate through a series of distinct yet complementary neural circuits, and undergo dramatic postnatal development in line with the maturation of each of the associated neural structures (Ruff & Rothbart, 1996). Due to the significant overlap between the attentional networks, disruption to one network is likely to have a

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