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The effects of focused attention on inhibition and state regulation in children with and without attention deficit hyperactivity disorder ☆

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ABSTRACT

This study investigated the effects of response rate and attention focusing on performance of ADHD, clinical-control (CRNA) and non-clinical control children in response inhibition tasks. All children completed the "Go–NoGo" task, a computer-based task of attention and impulsivity. Focused attention on this task was manipulated using a priming arrow, and reaction time and accuracy served as dependent variables. Results indicated that children with ADHD and children in the CRNA group performed more poorly than children in the Control group. Results failed to support the assertion that state regulation or inhibition is a unique deficit in children with ADHD. Evidence was found to suggest that clinical samples have difficulty with response regulation and visual orienting skills. The presence of cognitive deficits in all clinical group children suggests that more research is needed to more clearly delineate differences between childhood psychopathologies and that treatments for cognitive deficits should benefit various groups of children including but not limited to those with ADHD.

1. Introduction

According to the American Psychiatric Association (APA), Attention Deficit Hyperactivity Disorder (ADHD) can be conceptualised as a continual pattern of age-inappropriate inattention and/or hyperactivity/impulsivity (APA, 2000). There is accumulating evidence suggesting that ADHD might arise from abnormalities in the frontal lobes, the prefrontal cortex, and their networks with other brain regions (e.g., Boucugnani & Jones, 1989; Casey et al., 1997; for a review see Hale, Hariri, & McCackren, 2000; Swanson, Castellanos, Murias, LaHoste, & Kennedy, 1998). Moreover, there are remarkable similarities between individuals with frontal lobe injuries and those with ADHD (Welsh, 2002). In particular, both populations demonstrate difficulties with a variety of executive functions (Pennington & Ozonoff, 1996).

Executive functioning is a term that is generally used to refer to a variety of "supervisory" cognitive abilities that permit self-control (Lyon & Krasnegor, 1996). Empirical evidence has shown that several components of executive functioning can be reliably identified, and that a number of these abilities are impaired in children and adolescents with ADHD (e.g., Barkley, 1997c; Barkley, Edwards, Laneri, Fletcher, & Metevia, 2001; Klorman et al., 1999; Overtoom et al., 2002; Pennington & Ozonoff, 1996). Accordingly, several models of ADHD now include the impairment of executive abilities within their framework.

Furthermore, there is an impressive amount of evidence to suggest that executive functions do not arise concomitantly during human development, but rather, in a sequential fashion (e.g., Becker, Isaac, & Hynd, 1987; Luciana, & Nelson, 1999; Passler, Isaac, & Hynd, 1985; Welsh, 2002; Welsh, Pennington, & Groisser, 1991). Some research has also indicated that age-related changes in

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executive function abilities exist in children with ADHD as well as in non-clinical samples, with increased age being positively correlated with improved performance (Weyandt & Willis, 1994). In particular, the executive ability of inhibitory control shows age-related improvements in both ADHD and non-clinical samples (Stevens, Quittner, Zuckerman, & Moore, 2002).

The current study was meant to determine the degree to which impaired response inhibition, an executive ability that has been emphasized in ADHD literature, is influenced by attentional factors in children ranging in age from 5 to 9 years. This study was designed specifically to address discrepancies in theoretical accounts of ADHD, specifically whether response inhibition is a primary deficit associated with ADHD (a behavioural disinhibition account, e.g., Barkley (1997a,b) and Quay (1988) or, at best, only one component of a more complex and generalized disorder (Sergeant, 2005; Sonuga-Barke, 2005; Swanson et al., 1998).

Although the term "disinhibition" has been operationally defined in a variety of ways in past research, all of the definitions have one underlying principle in common: the failure to withhold responding (Barkley, 1997a,b; Sergeant, Oosterlaan, & van der Meere, 1999). According to Barkley, response disinhibition is a unique feature of ADHD that is at the top of an executive function hierarchy, and all of the deficits associated with ADHD can be considered secondary to that of response disinhibition. Inhibition of behaviour must be the first self-regulatory event to take place, given that it provides a delay in time during which an individual can decide whether to respond to an event or stimulus, and subsequently employ other self-regulatory actions. Thus, children with ADHD often display a disorder characterized by impaired executive functions, self-control, and goal-directed behaviour.

Research supporting Barkley's theoretical framework includes findings that ADHD children demonstrated significant impairments in inhibitory control compared to a control sample (Stevens et al., 2002) and evidence that a response inhibition deficit in children with ADHD is independent of age, IQ, reading, or other disruptive behaviour difficulties (Nigg, 2001). A review by Pennington and Ozonoff (1996) reports a consistent pattern of deficits on executive function tasks for children with ADHD. In particular, children with ADHD showed difficulties in inhibiting inappropriate responding. Although children in other clinical populations also displayed executive function deficits, an inhibition deficit was not found to be as prominent in these children (Pennington & Ozonoff, 1996).

Some have questioned whether the disinhibition explanation explains all of the existing data associated with the disorder (e.g., Jennings, van der Molen, Pelham, Debski, & Hoza, 1997; Oosterlaan & Sergeant, 1998; Purvis & Tannock, 2000). Of particular concern is whether inhibition deficits are unique to ADHD samples. In a metaanalysis, Oosterlann, Logan, and Sergeant (1998) provided evidence to suggest that a response inhibition deficit is prominent in children with ADHD but is not unique to ADHD populations. Inhibition deficits are frequently unable to distinguish between ADHD, Conduct Disordered (CD), and comorbid ADHD/CD samples. Likewise, in a thorough review by Nigg (2001) the author maintained that although children with ADHD display more disinhibitory behaviour than their typical counterparts, the claim that an inhibition deficit is the core and causal deficit of ADHD is questionable. In their review, Sergeant, Geurts, and Oosterlaan (2002) also concluded that measures typically associated with inhibition result in lower scores for children with a variety of diagnoses (e.g., Oppositional Deviant Disorder, Conduct Disorder), suggesting that inhibition is a difficulty present in, but not limited to children with ADHD.

More specifically, Swanson et al. (1998) and Sergeant (2005) hold that inhibition is a symptom of neurological and cognitive impairments that cause ADHD, rather than a core deficit of the disorder, and propose that within each domain of the disorder (inattention, hyperactivity, impulsivity), there are deficits associated with specific cognitive processes (e.g., executive control, alerting/arousal, attention), that are the result of abnormalities in assorted brain regions. Thus, ADHD is viewed as a "polytypic syndrome" that is caused by multiple biologically-based difficulties, rather than a disorder caused primarily by a response inhibition deficit. Evidence in support of this includes research suggesting that not all children with ADHD present with a consistent pattern of executive functioning deficits (Biederman et al., 2004; Nigg, Blaskey, Stawicki, & Sachek, 2004).

Another way to address whether there are unique deficits to ADHD is to look for different patterns of behaviour across situations that require varying degrees of attentional control. One technique that has been used to manipulate attentional control involves modifying the context of inhibition tasks by varying event rate (i.e., the speed at which information is presented to the participant). Research investigating the effects of manipulating event rate has found that children with ADHD differ from typical children only under certain event rate conditions (van der Meere, 1995; van der Meere & Stemerdink, 1999). Because inhibition models of ADHD would predict deficits under all conditions, a new model of ADHD, the Cognitive Energetic Model, was proposed to explain these results (Sergeant, 2000, 2005; Sergeant et al., 1999; van der Meere & Stemerdink, 1999).

van der Meere and Stemerdink (1999), proposed that the problems experienced by children with ADHD are, at least in part, determined by their lower ability to regulate their level of arousal which predisposes these children to being under/over activated, resulting in a lack of impulse control. According to the Cognitive Energetic Model, if inhibition deficits are primary in explaining the problems associated with ADHD, disinhibitory responding should occur independent of the event rate associated with information presentation. However, if state regulation plays a role in inhibitory responding then performance of children with ADHD should be influenced by event rate changes (Sergeant, 2000, 2005; Sergeant et al., 1999; van der Meere and Stemerdink, 1999). That is, ADHD children's lower abilities to internally regulate their state in response to changing presentation rates means that they, in contrast to non-ADHD individuals, will be affected by the presentation rate of stimuli.

In an attempt to examine the state regulation hypothesis, van der Meere, Stemerdink, and Gunning (1995, 1999) employed a modified version of a Go–NoGo test which involves the presentation of a series of stimuli that require a response on most trial (Go trials). On a small number of trials, however, the participant is presented with a signal that tells him/her to not respond on the subsequent trial (NoGo trial). It is believed that NoGo trials require response inhibition. In the modified version of this task the presentation rate of the stimuli was manipulated to include slow, medium, and fast rates. Van der Meere et al. proposed that children exposed to a fast presentation rate would become hyperaroused (resulting in rapid and erroneous responses) and children exposed to a slow presentation rate would become hypoaroused (resulting in slow and erroneous responses). These results were