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Hot executive function in children with Developmental Coordination Disorder: Evidence for heightened sensitivity to immediate reward

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ABSTRACT

Deficits of cool executive function (EF) have been shown in children with motor problems (or Developmental Coordination Disorder – DCD), but little is known of hot EF in this group. Given some evidence of poor self-regulation in DCD, we predicted poorer performance on a measure of hot EF, the Hungry Donkey Task (HDT), relative to typically developing (TD) children. Participants were 14 children with DCD and 22 TD children aged between 6.5 and 12 years. The DCD group performed significantly worse than the TD group on a 100-trial version of the HDT, making more selections from disadvantageous options and less from advantageous ones. Within-group analyses showed that children with DCD had faster responses to disadvantageous options than to advantageous. These results suggest high sensitivity to immediate reward in DCD. This sensitivity may reflect a more generalized deficit in the ability to resist the rewarding aspects of emotionally significant stimuli.

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1. Introduction

Developmental Coordination Disorder (DCD) is a neurodevelopmental disorder characterized by problems with motor coordination and skill acquisition that significantly disrupt the daily living activities and/or academic achievement of children (APA, 2013; DSM-V). The clinical diagnosis of DCD is motor coordination significantly lower than expected from chronological age and intellectual ability, and also not due to a pervasive developmental delay or medical conditions such as cerebral palsy or muscular dystrophy. DCD is not a trivial disorder. It affects about 5–6% of school-aged children and is associated with a range of psychosocial and behavioural problems, such as low academic achievement, poor social interaction, poor self-concept, and higher incidence of psychological disorders (Missiuna, Moll, King, Stewart, & McDonald, 2008; Rigoli, Piek, & Kane, 2012). Numerous studies exist of the underlying motor control and learning issues that may explain the disorder, but very few unifying accounts have been put forward. However, a recent quantitative review of the literature by Wilson, Ruddock, Smits-Engelsman, Polatajko, and Blank (2013), compared the performances of children with DCD and typically developing (TD) children on behavioural measures, and revealed that deficits in DCD tend to coalesce around several aspects of control, including predictive control, ability to develop stable coordination patterns, and executive function (EF), the last of these the focus of the present study.

1.1. Executive function deficits in DCD

Given that the control of action is supported by a complex and interactive network of neural structures, motor coordination problems are likely to be constrained by not only motor processes but also cognitive and affective ones (Alloway, 2007; Rigoli, Piek, Kane, & Oosterlaan, 2012a; Rigoli, Piek, Kane, & Oosterlaan, 2012b), for example visual attention and EF (Dewey, Kaplan, Crawford, & Wilson, 2002; Green, Baird, & Sugden, 2006), consistent with both modern information processing theory and recent advances in the cognitive neuroscience of action. For example, in Sergeant's (2000) cognitive-energetic model, EF refers to the complex array of neurocognitive processes that support the conscious and goal-directed control of thought, emotion, and action (Zelazo & Carlson, 2012). In this model, cognitive control and motor behaviour are intertwined. From the perspective of interactive specialization (Johnson & Munakata, 2005), cognition and action become increasingly coupled over the course of development. Initially distinct systems interact according to the timescales of neural maturation and the moderating effect of experience. From this perspective, there are two prime hypotheses about EF deficits in DCD. The first is that the biological process by which specific neurocognitive and neuromotor systems mature is impaired, and the second is that the emerging neural systems are not stimulated (via appropriate learning experiences) in a way that promotes coupling between specialized sub-systems (e.g., the modulating effect of frontal planning on more primitive limbic structures that resolve stimulus reward).

Studies of clinical populations, such as children with DCD (Piek, Dyck, Francis, & Conwell, 2007) or ADHD (Barkley, 1997; Sergeant, 2000), and non-clinical TD children (Pennequin, Sorel, & Fontaine, 2010) support the interactive relation between cognition and action. We see ample indication that poor coordination, such as in children with DCD, is associated with deficits in EF. Wilson et al. (2013) identified very large effect sizes across core domains of EF, including working memory (WM) ($d = 1.07$, averaged over visuospatial and verbal), inhibitory control (1.03), and executive attention, which includes deficits in set-shifting and planning (1.46). Most striking was degree of generalized executive dysfunction (operationalized by performance deficits on different EF tasks), in excess of that reported in children with ADHD (Piek, Dyck, et al., 2007).

1.2. Are deficits of EF in DCD confined to 'cool' EF?

The executive functions studied in children with DCD are generally grouped under the label 'cool' EF. Cool EF is associated with lateral prefrontal cortex (L-PFC) and is required in situations characterized by abstract, decontextualized stimuli with no affective or motivational component (Zelazo & Carlson, 2012). Recent research has broadened the conceptualization of EF to include neurocognitive processes