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Reprint of "Deficits of hot executive function in developmental coordination disorder: Sensitivity to positive social cues" ☆

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ABSTRACT

Recent research shows that children with motor coordination problems (or developmental coordination disorder – DCD) show deficits in not only cool executive function (EF), but also hot EF. We aimed to determine whether this deficit of hot EF is due to heightened sensitivity to rewarding stimuli, specifically, or to a general deficit of cognitive control, like inhibition. Using two versions of a go/no-go task, one with neutral facial expressions and the other with happy and fearful faces, we compared 12 children with DCD with 28 typically-developing children, aged 7–12 years. Like earlier studies, children responded faster to happy faces. Both groups showed comparable accuracy in response to go targets, and also had similar commission errors, except when the no-go stimulus was a happy face. Importantly, the DCD group made significantly more commission errors to happy faces failing to suppress their response on more than half of the no-go trials. These results suggest a heightened sensitivity to emotionally significant distractors in DCD; this type of impulsivity may undermine self-regulation in DCD, with possible implications for adaptive function and emotional well-being. We argue that the interaction of cognitive control and emotion processing networks may be disrupted in DCD or delayed in development.

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1. Introduction

Neurodevelopmental disruptions in one aspect of functioning (e.g., motor) can have far-reaching consequences beyond the primary domain (Leonard & Hill, 2014). In the particular case of poor motor coordination in children (or developmental coordination disorder—DCD), aspects of psychosocial functioning, cognition, and academic performance can also be disrupted (Zwicker, Harris, & Klassen, 2012). In this paper we explore issues of cognition in DCD using an experimental approach, specifically the nature of *executive function* (EF) in these children.

Under DSM-V, DCD is conceptualized as a neurodevelopmental disorder that is marked by motor coordination problems that negatively affect one's daily living activities and/or academic achievement (Zwicker, Missiuna, Harris, & Boyd, 2012), and is generally diagnosed in 5–6% of school-aged children (APA, 2013). The disorder is a distinct diagnostic entity, but often co-occurs with other conditions like Attention Deficit/Hyperactivity Disorder (ADHD) and Specific Language Impairment (SLI) (APA, 2013; DSM-V). Importantly, DCD has been linked to underlying difficulties in not only motor control (Wilson, Ruddock, Smits-Engelsman, Polatajko, & Blank, 2013), but also psycho-social adjustment (e.g., poor self-worth, self-esteem, feelings of loneliness, depression and anxiety, as well as externalizing problems) and cognitive control (Cairney, Rigoli, & Piek, 2013; Cummins, Piek, & Dyck, 2005; Schmahmann & Caplan, 2006; Skinner & Piek, 2001; Zwicker, Missiuna, Harris, & Boyd, 2012). More specifically, the recent review of Wilson et al. (2013) shows a quite pervasive pattern of dysfunction across (predictive) motor control, all major aspects of EF (i.e., inhibition, working memory (WM) and executive attention—Diamond, 2013), and the self-regulation of movement (e.g., Sangster Jokic & Whitebread, 2011). What remains unclear is the role of affect in the expression of these deficits, or indeed, whether certain types of problems exist only when the child's emotional investment in the task is heightened.

1.1. Cool and hot EF

EF is an umbrella term that refers to a set of neurocognitive processes involved in conscious and effortful control of thought, emotion, and behavior. Broadly, it can be divided into cool and hot EF. Cool EF is mainly subserved by lateral prefrontal cortex (L-PFC), enlisted when one deals with abstract and decontextualized stimuli. In contrast, hot EF is linked to ventromedial prefrontal cortex (VM-PFC), active in many real-life situations that are characterized by high affective involvement; here, one needs to consider or reappraise the emotional/motivational significance of stimuli and refrain from impulsive actions (Zelazo & Muller, 2011).

EF has been traditionally assessed using 'cool' tasks (e.g., WM, inhibition, and set-shifting), which include decontextualized stimuli (Miyake et al., 2000; Zelazo & Carlson, 2012). There is strong evidence of cool EF deficits in DCD. The recent meta-analysis by Wilson et al. (2013) showed very large effect sizes ($d > 1$) on tasks that assess WM, inhibitory control, and executive attention. The stimuli in cool EF tasks, however, often bear little resemblance to everyday situations where one interacts with emotionally and motivationally meaningful stimuli. By comparison, measures of hot EF aim to mimic aspects of real-life decision-making through use of reward and losses, as in delay of gratification and gambling tasks (e.g., Iowa Gambling Task (IGT); Bechara, Damasio, Damasio, & Anderson, 1994).

The studies that compared the performance of typically-developing (TD) children and adolescents on hot and cool EF tasks report that cool EF may mature earlier since adult-like levels of performance are reached later for hot EF. This fits with the view that VM-PFC or its connections might follow a protracted trajectory of development relative to more dorsal aspects of PFC (Hooper, Luciana, Conklin, & Yarger, 2004; Prencipe et al., 2011). However, it has also been suggested that regions associated with hot EF (i.e., orbitofrontal cortex) may develop earlier than those recruited in 'cool' tasks of EF (e.g., DL-PFC) (Orzhekhovskaya, 1981). The fact is that the neurocognitive networks involved in hot and cool EF overlap and form part of a larger interactive functional system. As such, it remains challenging to design 'pure' measures of each of the major two domain of EF (Hongwanishkul, Happaney, Lee, & Zelazo, 2005). Deficits of hot EF, for instance, have been linked to inadequate response inhibition which results in reduced modulation of what is otherwise a relatively mature affective system