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Do motor ability and handwriting kinematic measures predict organizational ability among children with Developmental Coordination Disorders?

Sara Rosenblum *

The Laboratory of Complex Human Activity and Participation (CHAP), Department of Occupational Therapy, Faculty of Social Welfare and Health Sciences, University of Haifa, Haifa, Israel

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ABSTRACT

Background and aim: Children with Developmental Coordination Disorders (DCD) exhibit deficient daily performance concealed in their perception–action mechanism. The aim of this study was to analyze behavior organization of children with DCD, in varied tasks that require generating and monitoring mental representations related to space and time inputs/requirements, for achieving better insight about their perception–action mechanism.
Method: Participants included 42 children aged 7–10, half of whom were defined with DCD and half were typically developing (TD). The children were matched for age, gender and school. They were evaluated using the Movement–ABC and performed three handwriting tasks on an electronic tablet that is part of a computerized system (ComPET – Computerized Penmanship Evaluation Tool). In addition, their teachers completed the Questionnaire for Assessing Students' Organizational Abilities-Teachers (QASOA-T) to assess the children's daily organizational ability.
Results: Significant group differences (DCD versus controls) were found for all handwriting kinematic measures across the three handwriting tasks and for the children's organizational abilities. Motor ability predicted a considerable percentage of the variance of the kinematic handwriting measures (30–37%), as well as a high percentage of the variance of their organizational abilities (67%).

* Address: Department of Occupational Therapy, University of Haifa, Haifa 3498838, Israel. Tel.: +972 4 8240474; fax: +972 4 8249753.
E-mail address: rosens@research.haifa.ac.il

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The coefficient of variance of the pen tilt added an additional 3% to the prediction of their organizational abilities.
Conclusions: The results of this study exhibited deficient ability among children with DCD in organizing their behavior in varied real-world tasks requiring generation and monitoring representation related to space and time. The significance of the results to understanding the performance mechanism and implication to the clinical field are discussed.

1. Introduction

Developmental coordination disorder (DCD), labeled in the past as 'clumsiness', is one of the most common *hidden disabilities* affecting school-aged children. DCD is characterized by motor impairment that interferes with the child's activities of daily living and academic achievements (Blank, Smits-Engelsman, Polotajko, & Wilson, 2012; Cairney, Hay, Faught, Flouris, & Klentrou, 2007; Wann, 2007). Prevalence ranges from 1.4% to 19% among school aged children, depending on the definition used and the methods applied in their evaluation (Kadesjo & Gillberg, 1999; Lingam, Hunt, Golding, Jongmans, & Emond, 2009). The diagnosis of children with DCD leans mainly on the characteristics of their actions such as dressing, feeding, self-care, playing and writing (May-Benson, Ingolia, & Koomar, 2002).

Fuster's perception–action theory indicates that actions are specified from abstract plans to concrete responses (Fuster, 2004). Among children with DCD there is evidence of disturbance in the *cognitive control* which allows selection of actions that are consistent with the child's goals and context (Badre, 2008; Zwicker, Missiuna, Harris, & Boyd, 2010).

Previous findings of deficiency in two main domains related to cognitive control of children with DCD served as the background for this study. The first is their deficient *action representation* (Wilson, Maruff, Ives, & Currie, 2001; Gabbard & Bobbio, 2011) and the second is their deficient executive control (e.g., Alloway & Archibald, 2008). Deficits were found among children with DCD in generating accurate visuospatial representations of intended actions, monitoring and utilizing them (Lingam et al., 2009; Meltzer, 2007; Wilson et al., 2001; Wilson et al., 2004). Action representation can be viewed as a component of a predictive system including a neural process that is simulated through motor imagery which is the dynamic behavior of the body in relation to the environment (Bourgeois & Coello, 2009; Choudhury, Charman, Bird, & Blakemore, 2007; Gabbard & Bobbio, 2011).

Beside the supporting findings of the action representation hypothesis, several authors linked children's with DCD performance features to their insufficient executive control (e.g. Alizadeh & Zahedipour, 2005; Alloway & Archibald, 2008). Executive control encompasses high-level cognitive functions such as setting and managing goals, planning, inhibition and dealing with diverse elements, shifting among cognitive and affective sets, *organization*, working memory and metacognition (Ylvisaker & Feeney, 2002). Organization of behavior is a manifestation of the perceptual-motor cycle as it requires obtaining, conceptualizing, representing and integration of various space and time dimensions (Blanche & Praham, 2001). Spatial and temporal measures may also reflect the action representation process as successful action is evaluated by them (Gorelick, Blank, Shechtman, Irani, & Basri, 2007).

In light of the neuro-occupation theory (Lazzarini, 2004), detailed knowledge from actual daily activities' performance may shed light on the neural process involved in representation and control of actions (Badre, 2008). This theory is in line with the call for use of standardized *ecologically valid* evaluation tools that encompass real-world activities which indeed reflect the individual's daily function abilities (Burgess et al., 2006; Lawrence et al., 2004).

Based on previous results of varied aspects of daily function among children and adults with DCD (e.g., Rosenblum, Aloni, & Josman, 2010; Rosenblum & Livneh-Zirinski, 2008), the purpose of the