



Full Length Article

Visual perceptual and handwriting skills in children with Developmental Coordination Disorder



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ABSTRACT

Objective: Children with Developmental Coordination Disorder demonstrate a lack of automaticity in handwriting as measured by pauses during writing. Deficits in visual perception have been proposed in the literature as underlying mechanisms of handwriting difficulties in children with DCD. The aim of this study was to examine whether correlations exist between measures of visual perception and visual motor integration with measures of the handwriting product and process in children with DCD.

Method: The performance of twenty-eight 8–14 year-old children who met the DSM-5 criteria for DCD was compared with 28 typically developing (TD) age and gender-matched controls. The children completed the Developmental Test of Visual Motor Integration (VMI) and the Test of Visual Perceptual Skills (TVPS). Group comparisons were made, correlations were conducted between the visual perceptual measures and handwriting measures and the sensitivity and specificity examined.

Results: The DCD group performed below the TD group on the VMI and TVPS. There were no significant correlations between the VMI or TVPS and any of the handwriting measures in the DCD group. In addition, both tests demonstrated low sensitivity.

Conclusion: Clinicians should exercise caution in using visual perceptual measures to inform them about handwriting skill in children with DCD.

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1. Introduction

Difficulties with the skill of handwriting is cited as one of the most common reasons for the referral of school aged children to paediatric occupational therapy services worldwide (Doyle & Goyen, 1997; Feder, Majnemer, & Synnes, 2000). One group in particular who are known for their difficulties in this area is children with Developmental Coordination Disorder (DCD). These children present with motor coordination difficulties unexplained by a general medical condition, intellectual disability or neurological impairment (American Psychiatric Association (APA), 2013). They fail to develop age appropriate motor coordination skills, with significant difficulties in manual dexterity, ball skills and/or balance (Zoja, Barnett, Wilson, & Hill, 2006). The motor difficulties are commonly accompanied by a range of psychological and social difficulties including low self-esteem, anxiety and depression (Lingham et al., 2012; Missiuna, Moll, King, King, & Law, 2007; Poulsen, Johnson, & Ziviani, 2011). As a result of their coordination deficits meaningful participation in activities of daily living, leisure and play

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are affected (APA, 2013; Polatajko & Mandich, 2004). In particular, the task of handwriting is significantly impacted which is reflected in its inclusion in the formal diagnostic criteria for the disorder (American Psychiatric Association (APA), 2013). Given the high incidence of handwriting difficulties among children with DCD there is a need for a robust evidence base to inform effective assessment and intervention. Although previous work has focused on the assessment of handwriting difficulties in children, including those with DCD (Bo et al., 2014; Volman, van Schendel, & Jongmans, 2006), there remains a debate over the exact nature of their handwriting difficulties. For example, assumptions have been made about the underlying mechanisms which relate to coordination ability and/or difficulties with visual perception (Rosenblum & Livneh-Zirinski, 2008; Volman et al., 2006). However the extent to which visual perceptual ability actually relates to difficulties with handwriting has rarely been investigated and research has traditionally focused on the handwriting product (overall speed and legibility) rather than the process (real-time movement of the pen and time spent pausing) (Volman et al., 2006).

In recent years a knowledge base surrounding the underlying mechanisms of handwriting performance in children with DCD has emerged with the use of digitizing writing tablets. This has enabled researchers to examine not only the product but also the on-line process of handwriting in children with DCD. Specialized software and high speed recording of the position of the pen tip has provided detailed descriptions of spatial and temporal features of handwriting (Jolly & Gentaz, 2014; Prunty, Barnett, Wilmut, & Plumb, 2013; Rosenblum & Livneh-Zirinski, 2008). Prunty and colleagues (Prunty, Barnett, Wilmut, & Plumb, 2014; Prunty et al., 2013) used this approach to examine the handwriting product and process of 28 children with DCD by completing the Detailed Assessment of Speed of Handwriting (DASH) (Barnett, Henderson, Scheib, & Schulz, 2007) on a writing tablet. They found that while children with DCD produced fewer words per minute during the DASH handwriting tasks, this was not attributed to slow movement of the pen but rather a result of excessive 'pausing' during writing (Prunty et al., 2013, 2014). This 'pausing phenomenon' in the handwriting of children with DCD was initially revealed by Rosenblum and Livneh-Zirinski (2008) in Israel, where children with DCD were found to spend considerably more time than controls with the pen in the air. Since then, further studies have characterised these pauses in greater detail and found that children with DCD are more likely to pause for longer periods of time (over 10 s) and pause more frequently within words (suggesting a lack of automaticity) (Prunty et al., 2014). Rosenblum and Livneh-Zirinski (2008) proposed that the inability to retrieve the correct letter form from memory; and/or to visualise the letters prior to forming them might contribute to poor performance in this population. However, neither of these possible explanations were examined by Rosenblum and Livneh-Zirinski (2008) and it remains unclear whether deficits in these areas relate to handwriting performance in children with DCD.

The deficits proposed by Rosenblum and Livneh-Zirinski (2008) are often considered in paediatric occupational therapy practice under the umbrella of 'visual perceptual' skills. For many clinicians these are viewed as skills that underlie everyday functional performance and are therefore a key focus for assessment and intervention. This 'bottom-up', or information processing approach (Blank, Smits-Engelsman, Polatajko, & Wilson, 2012) is frequently embedded in paediatric occupational therapy (OT) practice. In relation to handwriting assessment, tests of visual perception and visual motor-integration have been reported as the most commonly used tests among paediatric OTs worldwide (Burtner, McMain, & Crowe, 2002; Feder et al., 2000; Roger, Brown, & Brown, 2005). Although not designed to assess handwriting performance, the Beery-Buktenica Developmental Test of Visual Motor Integration (VMI: Beery & Beery, 2004) and the Test of Visual Perceptual Skills (TVPS: Gardner, 1982; Martin, 2006) are two measures commonly used with children with handwriting difficulties (Doyle & Goyen, 1997). In a survey by Doyle and Goyen (1997) the VMI was identified as the most popular tool in working with children with handwriting difficulties in paediatric occupational therapy practice in Australia with similar results also found in Canada (Feder et al., 2000). The TVPS (Gardner, 1982; Martin, 2006) has also proven popular in similar surveys (Burtner et al., 2002; Chu & Hong, 1997; Feder et al., 2000; Reid & Jutai, 1997; Roger et al., 2005). According to surveys, therapists use these assessments to either screen children for handwriting difficulties (Wallen & Walker, 1995) or identify possible underlying deficits contributing to their handwriting performance (Goyen & Duff, 2005). In the case of the VMI, the ability of a child to copy the first 9 shapes on the test has been shown to predict handwriting legibility in young children (Daly, Kelley, & Krauss, 2003). It is therefore used to investigate this aspect of handwriting performance in particular. However the relationship between the VMI and handwriting legibility does seem to diminish after the age of 5 years (Pinto & Camilloni, 2012). The TVPS on the other hand does not require a motor component but it measures seven aspects of visual perception in subtests including visual discrimination, visual memory, spatial relationships, form constancy, sequential memory, visual figure-ground and visual closure (Martin, 2006). While there is no mention of handwriting within the test manual, visual perceptual deficits identified by the TVPS are often assumed by practitioners to underlie and contribute to handwriting difficulties, particularly with legibility. For example, according to Schneck and Amundson (2010) if a child has poor visual perception in form constancy, they would not be able to recognise errors in their own handwriting. Similarly, if a child has difficulties with figure-ground or visual closure they may have difficulties copying and producing letters of an appropriate shape or size (Schneck & Amundson, 2010). While most of the subtests have been linked to legibility of handwriting, performance on the visual memory and visual sequential memory subtests have been found to relate to handwriting speed in typically developing children (Tseng & Chow, 2000).

Although popular in clinical practice, these tests have come under scrutiny in recent years with some studies examining their role in detecting handwriting difficulties in children. While no study seems to have examined this in the TVPS, Goyen and Duff (2005) examined the efficacy of using the VMI to identify children with handwriting difficulties. They investigated 35 children aged 9–12 years with handwriting difficulties using a range of handwriting product assessments including the Evaluation Tool of Children's Handwriting (ETCH: Amundson, 1995), the Test of Legible Handwriting (TOHL: Larsen &

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