



An examination of writing pauses in the handwriting of children with Developmental Coordination Disorder



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ABSTRACT

Difficulties with handwriting are reported as one of the main reasons for the referral of children with Developmental Coordination Disorder (DCD) to healthcare professionals. In a recent study we found that children with DCD produced less text than their typically developing (TD) peers and paused for 60% of a free-writing task. However, little is known about the nature of the pausing; whether they are long pauses possibly due to higher level processes of text generation or fatigue, or shorter pauses related to the movements between letters. This gap in the knowledge-base creates barriers to understanding the handwriting difficulties in children with DCD. The aim of this study was to characterise the pauses observed in the handwriting of English children with and without DCD. Twenty-eight 8–14 year-old children with a diagnosis of DCD participated in the study, with 28 TD age and gender matched controls. Participants completed the 10 min free-writing task from the Detailed Assessment of Speed of Handwriting (DASH) on a digitising writing tablet. The total overall percentage of pausing during the task was categorised into four pause time-frames, each derived from the literature on writing (250 ms to 2 s; 2–4 s; 4–10 s and >10 s). In addition, the location of the pauses was coded (within word/between word) to examine where the breakdown in the writing process occurred. The results indicated that the main group difference was driven by more pauses above 10 s in the DCD group. In addition, the DCD group paused more within words compared to TD peers, indicating a lack of automaticity in their handwriting. These findings may support the provision of additional time for children with DCD in written examinations. More importantly, they emphasise the need for intervention in children with DCD to promote the acquisition of efficient handwriting skill.

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1. Introduction

Developmental Coordination Disorder (DCD) is the term used to refer to children who present with motor coordination difficulties, unexplained by a general medical condition, intellectual disability, sensory or neurological impairment (American Psychiatric Association [APA], 2013). Handwriting difficulties are mentioned in the formal diagnostic criteria for DCD (APA, 2013), are frequently mentioned in parent and teacher reports and are the most common reason for referral to

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occupational therapy services for this population (Asher, 2006). While a knowledge base surrounding their handwriting deficits has emerged in recent years (Jolly & Gentaz, 2013; Prunty, Barnett, Wilmut, & Plumb, 2013; Rosenblum & Livneh-Zirinski, 2008), the underlying mechanisms of the handwriting deficits are still unclear. In particular, there is a limited understanding of the excessive pausing during handwriting reported in this population (Rosenblum & Livneh-Zirinski, 2008). This creates barriers for healthcare professionals in terms of prescribing intervention, as it is unclear what the pausing behaviour in the handwriting process actually represents. In a recent study we found that children with DCD produced less text than their typically developing (TD) peers in four handwriting tasks from the Detailed Assessment of Speed of Handwriting (DASH; Barnett, Henderson, Scheib, & Schulz, 2007; Prunty et al., 2013). However, closer inspection of the handwriting process through the use of a digital writing tablet revealed that the slowness in production was not due to slower movement of the pen, but due to a higher percentage of the task spent pausing (with the pen either in the air, or resting on the page) (Prunty et al., 2013). This 'pausing phenomenon' in the handwriting of children with DCD was initially revealed in a study in Israel by Rosenblum and Livneh-Zirinski (2008), where children with DCD were found to spend considerably more time than controls with the pen in the air. However, beyond the findings of these studies, little is known about the behaviour of pausing and the possible cognitive or physical explanations for why they occur in the handwriting of children with DCD. It is imperative to understand this pausing behaviour, as it has been shown to significantly impact on the production of text in children with DCD (Prunty et al., 2013).

The concept of 'pausing' during writing is complex in nature and cannot be considered without recognising handwriting as a component of the writing process. Handwriting is 'language by hand' (Berninger & Graham, 1998; Berninger, Abbott, Abbott, Graham, & Richards, 2002) and there are many cognitive processes which occur before, during and after the pen is placed on the page (Kandel, Soler, Valdois, & Gros, 2006; Van Galen, 1991). Van Galen's (1991) psychomotor model of handwriting which informs the current investigation illustrates this, by describing the process from the transformation of language into the sequencing of handwriting movements. At the highest level of the model is the activation of the intention to write followed by semantic retrieval, syntactical construction and spelling. The first step in the motor process is to select the appropriate allograph, which according to Van Galen (1991) is the activation of the motor programme (retrieval of an allograph action pattern from long-term motor memory). Following the activation of the motor programme the module of size control and speed is activated (Van Galen, 1991). The muscle synergies from both the agonist and the antagonistic muscles are then recruited during the muscular adjustment module, which results in the real time movement of the pen (Van Galen, 1991). Van Galen's model of handwriting, although the most complete in the literature, is not without limitations. According to Kandel and Spinelli (2010) it fails to account for parallel processing at different levels of the model, which results in an increased duration of the handwriting movements. In addition, research by Kandel, Soler, Valdopis and Gros (2006) in French writers has demonstrated that letters are not programmed individually, but rather in chunks, and the temporal profile is determined by the number of syllables in the word. This emphasises the relationship between the production of handwriting and the cognitive and linguistic aspects of writing and must be accounted for when examining pausing behaviour in more detail.

The definition of a pause in writing is inconsistent in the literature. Rosenblum and Livneh-Zirinski (2008) defined a pause as a pen lift from the writing tablet. However, it was not clear as to how long the pen needed to be raised from the surface in order to be classified as a pause. In the writing literature Alamargot, Chesnet, Dansac, and Ros (2006) and Alamargot, Plane, Lambert, and Chesnet (2010) defined a pause as a period of 15 ms or more with the pen not in contact with the tablet. The rationale for such a short pause threshold was to include all writing events that occurred; including raising the pen to think of an idea or briefly to dot an 'i'. Other authors have omitted to define a pause and made reference only to the fact that pauses occurred during the writing task (Accardo, Genna, & Borean, 2013). In addition to the debate on how pauses are classified, it is also unclear even in the literature on writing what exactly a pause represents. Thus, the pause thresholds used in the current study are grounded in evidence where possible, while some aspects of the analysis are exploratory in nature.

In relation to pausing in children with DCD, Rosenblum and Livneh-Zirinski (2008) proposed anomalies in the lower level processes of handwriting, such as between stroke muscular adjustments, as reasons for excessive pausing. Alternative explanations for the excessive pausing include physiological factors such as fatigue (Rosenblum & Livneh-Zirinski, 2008). However, none of these theories have been tested and it remains unclear whether children with DCD pause excessively for short periods of time (i.e. <1 s), or whether they pause for longer periods possibly as an indication of fatigue or higher-level writing processes such as planning (i.e. >4 s). In a study by Alamargot et al. (2010) on French writers it was found that longer pauses possibly reflected processes such as planning. In their study, five participants with varying levels of writing expertise were asked to compose a text by extending a narrative provided to them. There were no time constraints and they were asked to write as much as they felt was necessary to finish the story. The participants included three school students, one in grade 7 (12 years old), one in grade 9 (14 years old) and the third in grade 12 (17 years old). The remaining two participants included a university graduate student (22 years old) and an established expert author. The writing task was completed on a writing tablet and eye-tracking was used to infer processes that occurred during pauses in the writing. Alamargot et al. (2010) analysed four types of pausing activity for each writer which they labelled as 'quartiles'. The quartiles consisted of pauses between 78 and 189 ms, 129 and 416 ms, 194 and 624 ms, 695 and 23,248 ms. The participant in grade 7 had the most pauses in quartile 4 (longer pauses) compared to the other four writers. In fact, the 7th grade writer had pauses as long as 13–18 s at times. According to Alamargot et al. (2010) the longer pauses were due to a strategy known as step-by-step production of text, where the child switches between planning and formulation of the text to cope with the cognitive demands of handwriting. Indeed as the level of writing expertise increased, the number of longer pauses decreased

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