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Handwriting difficulties in children with attention deficit hyperactivity disorder (ADHD)

Agnese Capodiecì*, Simona Lachina, Cesare Cornoldi

University of Padua, via Venezia 12, 35129 Padova, Italy



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ABSTRACT

Handwriting is fundamental in school and everyday life situations. Legibility guarantees that writing productions communicate information, and speed is often crucial, especially in children with attention deficit and hyperactivity disorder (ADHD), in order to increase the likelihood of their being able to work efficiently and stay on-task during school activities. Preliminary reports have shown an impairment in handwriting of children with ADHD, but evidence is still unclear, especially in the case of speed where research has offered contradictory results. Children's performance, furthermore, has yet to be investigated under the cognitive loading conditions typical of academic tasks in classroom. To shed light on this matter, we examined the handwriting performance in a simple condition but also under (verbal or spatial) working memory (WM) load in 16 fourth- and fifth-grade children with symptoms of ADHD and 16 matched control children. Our results showed that the groups speed differed significantly only in the verbal WM loading condition, where children with symptoms of ADHD wrote more slowly and showed a greater intra-individual variability than controls. Handwriting legibility was affected by verbal WM loading too. These findings are discussed in relation to their educational and clinical implications.

What this paper adds?

This paper adds to our theoretical and empirical understanding of the handwriting abilities and the relationship between them and working memory (WM) in children with symptoms of Attention Deficit and Hyperactivity Disorder (ADHD). Literature has shown that children with ADHD may fare worse in spelling. There are still scarce evidence or even conflicting results, instead, regarding their performance in terms of handwriting, especially in the case of speed, but researchers have yet to consider this issue in depth, in situations under time pressure and memory concurrent requests (as in everyday life and at school, where the child's WM may be overloaded). WM is a relevant variable and has a fundamental role in all writing processes. We know from the literature that children with ADHD have difficulties in various executive functions, and verbal and spatial WM in particular, and this may affect their writing speed as well as their writing legibility. In a typical classroom situation, children need to write quickly generating a WM overload that may be accentuated by the presence of numerous distractors that also affect WM. Until now, however, no studies had systematically examined writing speed in a context involving a WM overload. The present study demonstrated the importance of WM in handwriting skills and in intra-individual variability comparing children with symptoms of ADHD with typically developing children, whose performance was substantially similar in a control situation but presented great differences in the presence of a concurrent WM load.

* Corresponding author.

E-mail addresses: agnese.capodiecì@phd.unipd.it (A. Capodiecì), simona.lachina@studenti.unipd.it (S. Lachina), cesare.cornoldi@unipd.it (C. Cornoldi).

1. Introduction

1.1. Handwriting skills in school context

Handwriting is an important and complex skill that combines different components, requires the integration of cognitive, psychomotor and biophysical processes acquired over an extended period of time (Adi-Japha et al., 2007) and also interacts with the linguistic processes involved in maintaining and processing the verbal to-be-written material (Berninger & Abbott, 1994). Despite the introduction of computerized writing systems, handwriting is still a prerequisite for most classroom activities.

If we consider handwriting per se, excluding the expressive and orthographic components, there are many aspects to consider when examining children's handwriting, including the legibility of the productions, the speed and rate variability of its production. Legibility is obviously crucial to meet the main functions of writing concerning maintenance and transmission of knowledge. However speed is also very important because it not only affects efficiency in performing classroom activities, but also enables children to keep up with classwork (by copying from the blackboard, for instance, taking notes, or writing under dictation). Thus, the ability to keep abreast with their peers when writing by hand becomes crucial for children who tend to go off-task, such as those with attentional problems.

Writing speed develops in a rather linear manner during primary school, and the overall development of graphic skills continues during secondary school (Feder and Majnemer, 2007). In this respect, it is particularly important for children to acquire automatized processes in writing graphic signs that can be written quickly and accurately without the need for conscious attention. A low level of automaticity when writing by hand generates a poor performance, in qualitative and quantitative terms (Connelly & Hurst, 2001).

1.2. Cognitive difficulties and intra-individual variability in children with Attention Deficit and Hyperactivity Disorder

Children with Attention Deficit and Hyperactivity Disorder (ADHD) have a diagnostic profile mainly featuring inattention, hyperactivity and impulsivity (American Psychiatric Association, 2013). They may also have a number of associated problems with a potential bearing on their writing activity. These include difficulties in executive functions, including working memory (WM; Kuntsi, Oosterlaan, & Stevenson, 2001; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005), and inconsistency in cognitive responses, leading to a high intra-individual variability (IIV) due to marked fluctuations in their performance. In particular, IIV appears to be among the best predictors of ADHD (Castellanos & Tannock, 2002), has been studied in relation to various cognitive tasks and may be relevant also in the case of children's with ADHD handwriting (Borella, Chicherio, Re, Sensini, & Cornoldi, 2011).

1.3. Writing difficulties of children with ADHD

In front of substantial evidence concerning spelling and expressive writing difficulties associated with ADHD (e.g. Cornoldi, Del Prete, Gallani, Sella, & Re, 2010; Luisotto, Borella, & Cornoldi, 2011; Re, Pedron, & Cornoldi, 2007), handwriting has been scarcely studied.

Some studies on handwriting in ADHD (e.g. Brossard-Racine, Majnemer, Shevell, Snider, & Bélanger, 2011; Fliers et al., 2009; Shen, Lee, & Chen, 2012) have suggested that children with ADHD have not only poor spelling skills but also weak handwriting skills. These results were confirmed by a recent meta-analysis (Graham, Fishman, Reid, & Hebert, 2016) that compared the writing performance of grade 1–12 students with ADHD to their normally achieving peers. The average weighted effect sizes showed that students with ADHD obtained lower scores than their normally achieving peers for a number of writing dimensions also interesting handwriting. Also studies specifically considering the effect of stimulant medication on handwriting performance of children with ADHD (Brossard-Racine et al., 2015; Rosenblum, Epsztein, & Josman, 2008) found that handwriting difficulties are common in children with ADHD, and medication alone is not sufficient to resolve these difficulties.

Writing difficulties of children with ADHD may prompt teachers' negative opinions and be a cause of stress and frustration for the children concerned (Whalen, Henker, & Granger, 1990), negatively affecting their self-esteem and self-acceptance (Brossard-Racine, Majnemer, Shevell, & Snider, 2008). The relevance of handwriting for children with ADHD is also confirmed by recent research, which showed that their writing expression skills were an important predictor of their academic results 18 months on (Molitor et al., 2016).

1.4. Unclear results about handwriting in children with ADHD

However the observations concerning the difficulties of children with ADHD in handwriting offer partly unclear results and mainly consider the order and legibility of their written productions (e.g. Langmaid, Papadopoulos, Johnson, Phillips, & Rinehart, 2014) sometimes with reference to qualitative observations of teachers (Cornoldi, Gardinale, Masi, & Pettenò, 1996). However, in the case of ADHD handwriting, also speed appears particular relevant as writing slowly can be a crucial issue for children with ADHD because they find it difficult to comply with the time constraints on school work (Amundson & Weil, 1996), but evidence on differences in handwriting speed between children with ADHD and matched controls is unclear and even contradictory. For example, Ross, Poidevant, and Miner (1995) assessed writing speed in children with ADHD from first to fifth grade, comparing them with a typically developing (TD) control group matched for gender and schooling. The children were asked to write the numbers from zero to nine (in letters) and their own name repeatedly as quickly as possible for 1 min. The results showed no difference between the two groups. Similarly, Re (2006) investigated whether ADHD affected the writing skills of secondary school students, finding that those at

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