



Characteristics of handwriting quality and speed in adults with autism spectrum disorders

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ARTICLE INFO

Keywords:

Handwriting quality
Handwriting speed
Asd
Adults
Predictors

ABSTRACT

Background: Handwriting difficulties affecting production quality and speed have been identified in children and adolescents with autism spectrum disorders (ASD), and several perceptual-motor impairments have been shown to contribute to these difficulties. There has been only one study of handwriting in adults with ASD, and this focused on letter size, reporting macrographia. The present study was therefore intended to explore the other features of handwriting and the role of perceptual-motor skills in this activity in adults with ASD.

Method: We recruited a group of adults with ASD ($n = 21$) and two typically developing control groups, matched on either chronological ($n = 21$) or developmental ($n = 21$) age. Participants performed a handwriting copy task to assess handwriting speed and quality, and five perceptual-motor tasks (finger dexterity, fine motor coordination, graphomotor activity, visuomotor integration, and visual attention).

Results: Adults with ASD had significantly poorer handwriting quality than adults in the two control groups, and lower handwriting speed than adults of the same chronological age. Developmental age was the best predictor of handwriting quality in adults with ASD, whereas visuomotor integration was the best predictor in the control group matched on developmental age. None of the factors we tested influenced production speed in adults with ASD.

Conclusions: Handwriting in adults with ASD appears to show weaknesses and peculiarities. Further studies are needed to explore alternative predictive factors for handwriting speed and quality in adults with ASD, in order to improve handwriting and consequently increase employment opportunities for this population.

1. Introduction

Studies of handwriting in autism spectrum disorders (ASD) have mainly been conducted in children and adolescents, and have generally reported reduced quality and speed of production (see [Kushki, Chau, & Anagnostou, 2011](#), for a review).

Handwriting is a complex activity that requires both high-level (linguistic, semantic, syntactic and orthographic) and low-level (motor, perceptual and kinesthetic) processes (for a review, see [Bara & Gentaz, 2010](#)). In the present study, we were interested in low-level processes, and more particularly in the way that hand movements are produced to form letters.

Handwriting can be assessed using either product or process analysis. To analyze the handwriting *product* in ASD, most studies use standardized tests addressing two aspects of handwriting, namely quality and speed ([Fuentes, Mostofsky, & Bastian, 2009, 2010](#); [Hellinckx, Roeyers, & Van Waelvelde, 2013](#); [Henderson & Green, 2001](#); [Myles et al., 2003](#); [Rosenblum, Simhon, & Gal, 2016](#)). In these

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tests, participants generally have to copy visually presented words, sentences or text on a white sheet of paper (with or without lines, according to the test), in their usual handwriting. Depending on the test, various criteria for letter formation or spatial organization are used to establish an overall handwriting quality score (Rosenblum et al., 2016). Some quality scores are established on the basis of letter size, shape, or consistency, while others are calculated from the number of recognizable letters and the number of errors. Production speed is measured as the number of characters or words produced within a given period of time.

To our knowledge, only 11 studies have focused on the handwriting product in ASD (Asperger & Frith, 1991; Beversdorf et al., 2001; Cartmill, Rodger, & Ziviani, 2009; Fuentes et al., 2009, 2010; Hellinckx et al., 2013; Henderson & Green, 2001; Johnson et al., 2013b; Kushki et al., 2011; Myles et al., 2003; Rosenblum et al., 2016). These showed that, compared with their typically developing (TD) peers, children and adolescents with ASD have several difficulties, reflected in a lower overall quality score (Fuentes et al., 2009, 2010; Hellinckx et al., 2013; Myles et al., 2003; Rosenblum et al., 2016).

Some authors have found that children with ASD produce large handwriting, or *macrographia* (Hellinckx et al., 2013; Johnson et al., 2013b; Myles et al., 2003). However, there is no consensus over this result, as other studies have shown that the size of their handwriting is comparable to that of TD children (Fuentes et al., 2009, 2010; Johnson et al., 2013a). These contradictory results may be explained by methodological discrepancies (sample size, assessment criteria, etc.). For example, whereas Hellinckx et al. (2013) evaluated handwriting size by asking participants to copy out a text on a blank sheet of paper, Fuentes et al. (2009, 2010) evaluated it by asking participants to copy out words on solid lines. Writing on lines influences movement trajectory and handwriting size (Johnson et al., 2015).

The majority of studies have reported difficulty with letter formation among children and adolescents with ASD (Cartmill et al., 2009; Fuentes et al., 2009; Hellinckx et al., 2013; Henderson & Green, 2001; Johnson et al., 2013b; Myles et al., 2003). The handwriting of children with ASD is characterized by poor spatial arrangement of the letters, compared with that of their TD peers (Hellinckx et al., 2013; Myles et al., 2003; Rosenblum et al., 2016). Children and adolescents with ASD make fewer spaces between letters and words, compared with control groups matched on age and IQ (Fuentes et al., 2010; Johnson et al., 2013a; Rosenblum et al., 2016). Regarding handwriting speed, some studies have shown that they write more slowly than their peers (Hellinckx et al., 2013; Henderson & Green, 2001), although Cartmill et al. (2009) failed to find any significant difference between children with ASD and TD controls matched for age, IQ and academic level.

All these studies looked at children and adolescents, and there has so far been only one study of handwriting in adults with ASD, who were compared with adults matched on chronological age (CA) and level of general cognitive functioning (Beversdorf et al., 2001). Focusing on letter height, these authors found that the handwriting of participants with ASD was characterized by larger letters than that of controls, as observed in children and adolescents with ASD (Johnson et al., 2013b; Myles et al., 2003). This macrographia may reflect a compensatory strategy designed to maximize tactile-kinesthetic sensations and thus make it easier to control the trajectory of handwriting movements—a strategy adopted by TD children in the course of learning (Chartrel & Vinter, 2006; Zesiger et al., 2000).

Many factors contribute to the development of handwriting in TD children (Kaiser, 2009) and children with ASD (Hellinckx et al., 2013; Kushki et al., 2011). A deficit in one or more of these factors can affect both the quality and speed of handwriting. Age has been found to be a predictor of the development of handwriting quality and speed in both TD children (Sage, 2010) and children with ASD (Hellinckx et al., 2013). General motor skills and fine motor skills have also been identified as predictive factors of handwriting quality in children with ASD (Fuentes et al., 2009; Hellinckx et al., 2013). Strong correlations have been found between motor skill scores on stressed gait tasks (heel walking, toe walking, walking on the sides of the feet, and tandem walking) and balance tasks (standing and hopping on one foot), time taken to execute movements, and overall handwriting quality score in children with ASD (Fuentes et al., 2009). Visuomotor integration also contributes to handwriting performances in ASD (Hellinckx et al., 2013; Mayes & Calhoun, 2007). Children with ASD score significantly lower on visuomotor integration (copying geometric forms) and visual perception (identifying a geometric form among other similar figures) than their TD peers (Hellinckx et al., 2013), but visuomotor integration is a predictive factor for handwriting quality in both groups. In adolescents with ASD, perceptual reasoning has also been found to predict handwriting quality, indicating changes in the underlying mechanisms (Fuentes et al., 2010). Regarding handwriting speed, one study reported that during a copy task, children with ASD who also had reading problems spent more time reading the words and less time writing, indicating that reading skills are a predictive factor for handwriting speed in ASD (Hellinckx et al., 2013).

As indicated above, there has so far been only one study of the handwriting product in adults with ASD, which reported macrographia (Beversdorf et al., 2001).

It was this lack of information on handwriting in adults with ASD that led us to conduct the present two-part study, designed to 1) characterize the handwriting of adults with ASD in terms of quality and speed of production, and 2) identify the predictive factors for handwriting quality and speed in the adult participants.

Given the limited information available on handwriting in adults with ASD, it is important to ascertain whether and to what extent the handwriting difficulties observed in children and adolescents persist in adults and hamper them in their daily and professional lives, in order to implement the most appropriate interventions. To achieve this better understanding, we need to identify the predictors of handwriting. Given our clinical experience with adults across the whole autism spectrum, we predicted that some of them at least, particularly those with associated verbal or intellectual disabilities, would have poorer handwriting quality and speed than adults of the same CA and developmental age (DA). We also investigated whether clinical and perceptual-motor features (i.e., age, sex, handedness, visuomotor integration, visual attention, finger dexterity, graphomotor skills and fine motor coordination) influence handwriting quality and speed.

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