

Handwriting in adults with Down syndrome

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Abstract

Background Although there is growing awareness about the potential for people with Down syndrome (DS) to become literate, we know little about the characteristics of handwriting within this population.

Methods Thirty-three participants took part in this experiment. Eleven adults with DS and 22 typically developing individuals (11 children matched on mental age and 11 adults matched on chronological age) performed a copy task. A French adaptation of the Concise Evaluation Scale for Children's Handwriting (BHK) was used to assess speed and quality.

Results Handwriting of adults with DS was relatively similar to that of the mental age control group, but comparisons with the chronological age control group showed differences on quality and spatial organisation.

Conclusions Results revealed that adults with DS are capable of producing acceptable writing. Observed differences could be explained by the mode of movement control involved in production. Implications for future research and education are discussed.

Keywords: Down syndrome, handwriting, BHK scale, copying, product analysis

Introduction

The aim of the present study was to investigate handwriting in adults with Down syndrome (DS). While there is a long history and tradition of behavioural research on basic motor skills in DS, handwriting ability has been rather neglected, even though it is an important mode of communication. Handwriting is essential for successfully performing activities of daily living and for academic achievement. More efforts therefore need to be focused on determining how people with DS write, given their greater need for skilled intervention.

Overall cognitive development

The IQ of people with DS usually falls within the moderate to severe range of intellectual disability (IQ = 25–55; Epstein, 2001; Pennington & Bennetto, 1998). Research has also indicated that IQ range is skewed with individuals reaching low average and average levels of intelligence in some cases (Carr, 1995; Couzens, Cuskelly, & Jobling, 2004; Tsao & Kindelberger, 2009). Over the past few decades, a great deal of developmental research has focused on one specific behavioural phenotype displayed by

participants with intellectual disability of different aetiologies, showing that the impact of delay is not felt in all areas of development. In the case of individuals with DS, it can already be observed in infants and children, and becomes more pronounced in the course of development (Fidler, 2005). Their cognitive profile includes strengths in aspects of visuospatial processing rather than in verbal function (Dykens, Hodapp, & Finucane, 2005; Hodapp, DesJardin, & Ricci, 2003; Vicari, 2006).

Motor development

Another aspect of the DS phenotype involves difficulties in motor function (Block, 1991; Davis, 2008; Henderson, 1986; Vicari, 2006). It is generally accepted that motor impairments are present, to a greater or lesser extent, in children and adults with DS. These impairments are associated with muscle hypotonia, joint hyperextensibility, delayed acquisition of postural control, and poor balance. Pioneering studies (Carr, 1970; Cowie, 1970) suggested that children with DS exhibit early delays in motor development compared with their typically developing peers, a finding recently confirmed by Palisano et al. (2001). Delay has also been observed in fine

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motor tasks ([Block, 1991](#); [Henderson, 1986](#); [Spanò et al., 1999](#)). In tests assessing manual dexterity, movements of individuals with DS lack precision and appear poorly coordinated. They require more time to learn movements as movement complexity increases. Motor development in people with DS is also characterised by variability. Recent research investigating the kinematic characteristics of movement has contributed to our understanding of the complex motor development of individuals with DS ([Charlton, Ihsen, & Lavelle, 2000](#); [Charlton, Ihsen, & Oxley, 1996](#)), highlighting the fact that motor performance is also characterised by qualitative differences. In reach-to-grasp actions, persons with DS were found to initiate and complete movements more slowly and with greater variability than typically developing children, adopting a different mode of movement control. The authors argued that children with DS need to make corrective movements in the deceleration phase because they have difficulty generating initial impulses. To correct preprogrammed parts of movements that are spatially inaccurate, they use feedback-controlled movement strategies.

Handwriting development

Research on DS is mainly focused on basic motor skills, such as walking, reaching, and grasping. Nevertheless, children spend a large part of their school day performing handwriting ([McHale & Cermak, 1992](#)), and a large body of data supports the view that movement plays a crucial role in letter representation, suggesting that handwriting contributes to the visual recognition of letters ([Longcamp, Zerbato-Poudou, & Velay, 2005](#)). Other authors have proposed that the act of handwriting among children with difficulties can interfere with the simultaneous execution of composition ([Berninger et al., 1997](#); [Fayol & Miret, 2005](#); [Graham, Harris, & Fink, 2000](#)). It may be that when letter production is not fully automatic, the act of handwriting makes increased demands on memory and attentional resources, which, in turn, constrain the higher level cognitive processes required for composition. For adults, handwriting proficiency is necessary for some activities of daily living, such as writing a letter or a cheque, and completing an application form. Thus, even if adults have increased opportunities to use computers to write, they still use handwriting, and their writing processes and performances should be linked to their handwriting abilities. Handwriting is the result of a long learning process, based on linguistic, visuospatial, and perceptual motor skills. The development of handwriting begins with early

scribbling, which becomes more intentional over time ([de Ajuriaguerra & Auzias, 1975](#); [Feder & Majnemer, 2007](#)). Children learn to master all the gestures and moves required by handwriting: they learn the elementary strokes constituting the letters, begin to produce cursive letters, and reduce the size of their writing. This acquisition process is characterised by a gradual improvement in legibility and speed of production. Children initially rely on feedback control, using information from the eyes and muscles to control and plan the movements involved in producing the shapes of the letters. Letters are formed by juxtaposing small segments, resulting in large, jagged letters. Then, gradually, toward the age of 10 years, children start using feedforward control ([Meulenbroek & van Galen, 1988](#); [Zesiger, 1995](#)). By dint of practice and instruction, they become able to use motor programs dedicated to the production of letters, which refer to the internal representation of the movements to be produced. Visual feedback now serves to control the spatial layout of the letters on the page. Although there is growing awareness about the potential for people with DS to become literate, we know nothing about the characteristics of handwriting within this population. For example, out of 4,179 references to DS in PsycINFO, there is only one publication on handwriting, written as a guide for parents and professionals ([Bruni, 2006](#)). Nonetheless, a handful of studies based on surveys of children and adults with DS have shown that adults are able to write familiar words (name, surname) and simple sentences on their own. They can also perform functional tasks, such as writing messages and shopping lists ([Trenholm & Mirenda, 2006](#); [Turner & Alborz, 2003](#)). The longitudinal study by [Turner and Alborz \(2003\)](#) found that, by the age of 21 years, 25% of their cohort had achieved the academic level (reading, writing, and numeracy) of an 11-year-old, 50% had attained the academic level of a 7-year-old, and 25% had attained a level comparable to that of a 5-year-old. Unfortunately, none of these studies focused on actual handwriting. The purpose of the present study was to detect possible specificities of the resulting handwriting in DS. Considering that handwriting is a complex activity that requires several years of learning, we have focused at first on adult participants, who are in a stable state, contrary to children whose handwriting is undergoing development. There is a consensus that the legibility of plans and speed of production are relevant indicators for the objective assessment of handwriting ([Charles, Soppelsa, & Albaret, 2004](#); [Rosenblum, Weiss, & Parush, 2003](#); [Vinter & Zesiger, 2007](#)). These evaluations formed the basis for research into the

developmental sequence of writing and in the clinical identification of children and adults with handwriting problems. In this study, we tried to assess if the handwriting abilities of adults with DS is characterised by a simple delay or if it is disturbed by deficits leading to qualitative differences of the cognitive functioning between persons with DS and typically developing (TD) individuals.

Method

Participants

The sample is based on 33 participants. Eleven adults (seven men and four women) with DS between the ages of 18 and 35 years took part in this experiment. They were recruited via local associations. In order to compare the handwriting characteristics of adults with DS with those of typically developing individuals, 11 children matched on mental age and 11 adults matched on chronological age also took part in the study. The principal characteristics of the sample included in this experiment are shown in Table 1. The Kaufman Assessment Battery for Children (K-ABC; Kaufman & Kaufman, 1983), an intelligence test designed for 2- to 12-year-old children, was administered to the DS group in order to match them with typically developing children. This test is often used to assess cognitive function in individuals with children and adults with DS (Burack et al., 1999; Dykens, Hodapp, & Finucane, 2005).

Procedure

Ethical approval for this research was obtained from the ethics committee of PsyCLE Center (University of Provence, France). This research was conducted in accordance with the approved research protocol with regard to the rights and dignity of the participants. We informed participants about the purpose and the procedure of the research (duration and nature of the tasks) in order to obtain their informed consent. A psychologist assessed each participant. For participants with DS, K-ABC evaluations were carried out over at least two sessions. The French adaptation (Charles et al., 2004) of the Concise Evaluation Scale

for Children's Handwriting (BHK; Hamstra-Bletz & Blöte, 1993) was used to examine the handwriting samples. This test measures handwriting quality and speed in a copy task. It consists of copying out a standard text, or at least the first five sentences if the participant is a very poor writer, within the space of 5 minutes. The first five sentences comprise mono-syllabic words, after which the text becomes more complex. The participants are told to write as they usually do, with no time or quality constraints. The evaluation is based on 13 items assessing the quality of the words and letters and the spatial arrangement of the written text (e.g., writing is too large, widening of left-hand margin, bad letter or word alignment, insufficient word spacing, acute turns in connecting joins to letters, irregularities in joins, collisions of letters, inconsistent letter size, incorrect relative height of various kind of letters, letter distortion, ambiguous letter forms, correction of letter forms, unsteady writing trace). Items are measured on a 6-point Likert-type scale, resulting in a score of 0 to 5 for each item, ranging from the most legible to the least legible. A low score indicates good performance and a high score poor performance. The speed of production was measured in terms of the number of characters written during the 5 minutes. All 33 handwriting samples were analysed by the same rater. The BHK is distinguished by the amount of research devoted to investigating its psychometric properties (Hamstra-Bletz & Blöte, 1993). Interrater reliability for the total score is high ($r = .76-.89$). The BHK scores correlate well with teachers' evaluations of writing quality ($r = .78$). The BHK scale is sensitive to developmental changes and has also been found to discriminate between children with and without dysgraphia (Hamstra-Bletz & Blöte, 1993; Smits-Engelsman, Niemeijer, & van Galen, 2001). As a result, the practicality of administration and psychometric properties suggest that the BHK can be used in the early identification of persons with handwriting difficulties.

Data analysis

The dependent variables in the handwriting task, measured and analysed separately, were (a)

Table 1. Characteristics of participants included in the experiment

	DS group	MA group	CA group
Age	MA: 6.2 years ($SD = 1.2$ years) CA: 23.4 years ($SD = 6.2$ years)	6.2 years ($SD = 1.2$ years)	23.5 years ($SD = 5.3$ years)
Gender	7 males/4 females	7 males/4 females	7 males/4 females
Total	11	11	11

Note. CA = chronological age; MA = mental age; SD = standard deviation.

handwriting quality—calculated as the mean score on word and letter production and spatial arrangement, and (b) copying speed. To test for differences in handwriting between the adults with DS and the chronological age (CA) and mental age (MA) control groups, Mann–Whitney U tests were performed on the data yielded by the BHK.

Results

Handwriting quality score

Analyses were performed in order to compare the handwriting measures of all three groups. Table 2 presents an overview of the scores of the three groups on the BHK.

There was no significant difference between the BHK handwriting quality scores of the participants with DS and those of children matched on MA ($U = 69.5$, $p < .57$), with the former performing just as well as the latter on overall legibility. However, even though there was no significant difference on the overall score, analyses of different items in the BHK scale did reveal small specific differences (see Table 3). Joins between letters were omitted more frequently in the DS group than in the MA group (“Irregularities in joins”; $U = 110$, $p < .01$). Adults with DS were more efficient in keeping the size of x-height letters constant (“Inconsistent letter size”; $U = 27$, $p < .03$), but displayed more difficulty in respecting the relative heights of the various kinds of letters (“Incorrect

relative height of the various kinds of letters;” $U = 88$, $p < .02$). Analyses involving the CA group revealed significant differences ($U = 112$, $p < .01$), with adults with DS displaying less overall proficiency. We supplemented these data with comparisons between groups on different criteria of the BHK. There were significant differences between adults with DS and adults matched on CA on seven criteria: “Writing is too large” ($U = 95.5$, $p < .02$), “Bad letter or word alignment” ($U = 92.5$, $p < .04$), “Insufficient word spacing” ($U = 113$, $p < .01$), “Inconsistent letter size (of x-height letters)” ($U = 93.5$, $p < .01$), “Correction of letter forms” ($U = 88$, $p < .02$), and “Unsteady writing trace” ($U = 82.5$, $p < .04$). Compared with that of the CA control group, the handwriting of adults with DS was larger and the letter forms more unsteady and corrected. These participants also had more difficulty with the spatial layout of the characters on the page.

Figure 1 provides examples of the handwriting of adults with DS and children matched on mental age and adults matched on chronological age. Differences between participants with DS and control group on quality (e.g., letter size, spacing of letters and words, overwritten letters, unrecognisable letters) and spatial arrangement of the written text (e.g., vertical and horizontal alignment) are apparent with comparisons based on CA.

Speed of production

Table 4 illustrates the wide variation in mean copying speed between participants. Copying speed, as measured by the BHK in terms of the number of letters written within the first 5 minutes, yielded no significant difference ($U = 76.5$, $p < .31$) between adults with DS and children matched on MA,

Table 2. Overall scores (mean and SD) of the DS and control groups on the BHK

Groups	DS group	MA group	CA group
Handwriting quality score	17.2 (7.7)	15.8 (5.4)	5.2 (2)

Table 3. Scores (mean and SD) of DS and control groups on individual items of the BHK scale

Test items	DS group	MA group	CA group
1. Writing is too large	2.1 (1.9)	1.1 (1.6)	0.3 (0.5)
2. Widening of left-hand margin	0 (0)	0 (0)	0 (0)
3. Bad letter or word alignment	2.9 (1.9)	4.1 (1)	1.2 (0.9)
4. Insufficient word spacing	2.3 (1.6)	2.3 (2.05)	0.1 (0.3)
5. Acute turns in connecting joins to letters	0.3 (0.9)	0.6 (0.8)	0 (0)
6. Irregularities in joins (break in the trace)	4.2 (1.5)	1.4 (1.4)	3.3 (1.8)
7. Collisions of letters	0.3 (0.6)	0.3 (0.6)	0.1 (0.3)
8. Inconsistent letter size (of x-height letters)	0.6 (0.9)	2.4 (1.9)	0.1 (0.3)
9. Incorrect relative height of the various kinds of letters	1.2 (1.4)	0 (0)	0 (0)
10. Letter distortion	0.8 (1.2)	0.2 (0.6)	0.1 (0.3)
11. Ambiguous letter forms	1.2 (1.4)	0.5 (0.8)	0.1 (0.3)
12. Correction of letter forms	0.8 (1.1)	1.8 (1.3)	0 (0)
13. Unsteady writing trace	0.6 (0.8)	1.1 (1.1)	0 (0)

Adults with DS

il fait très beau
je suis bien
je vois de l'eau
mais je ne sais pas
où elle va
l'eau venait sur les côtés avec une grande
force. Des enfants étaient près de moi.
le plus

Il fait très beau
Je suis bien
Je vois de l'eau
mais je sais pas
où elle va
L'eau venait

Children matched on mental age

il fait très beau
je suis bien
je vois de l'eau
mais je ne sais pas
où elle va
l'eau venait sur

il fait très beau
je suis bien
je vois de l'eau
mais je ne sais pas
où elle va
l'eau

Adults matched on chronological age

Il fait très beau
Je suis bien
Je vois de l'eau
mais je ne sais pas
où elle va.
L'eau venait sur les côtés, avec une grande
force. Des enfants étaient près de moi. Le plus petit
demandait ses affaires à une femme.
Cette femme, qui était grande et belle, devait
être une amie. Elle lui avait pris la main,
et je les voyais aller vers une pièce.
C'était la plus belle de notre ville! Un des enfants,
demandait des choses à un autre, mais, je ne
savais pas ce que c'était.
J'étais très loin; alors, je me dirigeais doucement
vers eux, pour mieux voir. Ces deux
enfants me regardaient. Il me fit signe
de venir, avec lui, dans le groupe.
J'entendais des rires et des paroles joyeuses. J'étais content
avec ils.

Il fait très beau
Je suis bien
Je vois de l'eau
mais je ne sais pas
où elle va
L'eau venait sur les côtés, avec une grande
force. Des enfants étaient près de moi. Le plus petit,
demandait ses affaires à une femme.
Cette femme, qui était grande et belle, devait être une amie.
Elle lui avait pris la main, et je les voyais aller vers une
pièce: la plus belle de notre ville! Un des enfants, demandait
des choses à un autre, mais, je ne savais pas ce que c'était.
J'étais très loin; alors, je me dirigeais doucement vers eux,
pour mieux voir. Un des enfants me regardait. Il me fit
signe de venir, avec lui, dans le groupe.
J'entendais des rires et des paroles joyeuses. J'étais content
avec ils.

Figure 1. Examples of handwriting of DS and control groups.

Table 4. Scores (mean and SD) of DS and control groups on the BHK copying speed measure

Groups	DS group	MA group	CA group
Copying speed	114.7 (80.7)	72.4 (10.4)	521.3 (55.5)

although the former produced characters more rapidly. Analyses based on the CA group indicated a large gap between the groups ($U=0$, $p < .01$). On average, adults with DS wrote 114 letters in 5 minutes, whereas the CA group wrote 521 letters in the same amount of time.

Discussion

Theoretical implications

The present experiment focused on the handwriting produced by adults with DS when asked to copy out a standard text. The results revealed that adults with DS were capable of producing acceptable handwriting. The latter was of good quality and easily legible. These data are in accordance with the reported academic achievements of people with DS (Trenholm & Mirenda, 2006; Turner & Alborz, 2003). First, handwriting of adults with DS was relatively similar to the MA group's handwriting. We

failed to find any statistical differences on the overall handwriting quality score or on copying speed. Analyses of individual items in the BHK scale revealed small specific differences. Adults with DS displayed more irregularities in joins, which can be explained by the type of writing they used. All children adopted cursive writing, whereas participants with DS mixed cursive and noncursive writing styles, as did the CA control group. According to Hamstra-Bletz and Blöte (1993), the style characteristics are mainly a matter of personal choice rather than poor writing ability. Adults with DS were more efficient at keeping the size of x-height letters constant, but exhibited greater difficulty respecting the relative heights of the various kinds of letters. However, temporal data indicated that adults with DS were relatively successful compared with children matched on MA. These analyses based on legibility of plans and production speed showed that the handwriting performances of the participants with DS were as expected, given their mental age. This result suggests that handwriting of adults with DS is not characterised by a specific deficit, but rather by developmental delay. Second, comparisons with adults matched on CA showed up differences in quality and spatial organisation. Adults with DS exhibited difficulties with letter formation, spacing, size, slant, and alignment. The spatial arrangement of the written text was also more difficult. In comparison to adults without disability, the handwriting abilities of adults with DS are typically characterised by spatially inconsistent motor behaviour and fine motor deficits. In the present study, participants with DS were less proficient, as they produced only 114 letters in 5 minutes, as opposed to 521 for the CA group. These characteristics could be explained by the mode of control movement involved in production. Their large, jagged letters, correction of letter forms, difficulties with spatial arrangement, and slower movements suggest that the movements of participants with DS were based on feedback control. It would seem that adults with DS, like children in the early stages of learning (Meulenbroek & van Galen, 1988; Zesiger, 1995), preferentially use information from the eyes and muscles to control and plan movements involved in producing the shapes of the letters. This hypothesis on handwriting is in line with findings for basic motor skills, such as walking, reaching, and grasping. Many scientists (Block, 1991; Charlton et al., 2000; Davis, 2008; Henderson, 1986; Vicari, 2006) have found that children and adults with DS move more slowly, less accurately, and in a less coordinated fashion than their peers without disability. People with DS exhibit delays in motor skills and motor planning. In the

present study, their handwriting was also characterised by variability. Third, results revealed inter-individual differences on handwriting quality and copying speed. On both these measures, the standard deviations of adults with DS were higher than those of the MA and CA control groups. This study indicated that handwriting in the DS population is characterised by considerable interindividual differences.

Limitations and future research

Because of the limited number of participants, caution should be taken when interpreting these data. Furthermore, adults with DS were recruited via local associations. They had benefited from early intervention and most of them were attending mainstream schools. These kinds of experiences, even if we did not control them, could have had some influence on handwriting abilities. Analyses of product quality are only a first step in the right direction: we also need to investigate the underlying process. It is important to note that the scales used here relate to the written output and not to the process of handwriting performance, although the latter may yield valuable information about the characteristics of the writer's handwriting. Other studies are needed to examine handwriting processes by referring to the computerised measurement and analysis of a different set of variables, such as time, space, and pressure while the participant is actually performing a writing task. However, our results provide innovatory outcomes and should encourage researchers to continue exploring this area. Future studies should therefore focus on movement control during writing tasks, in order to improve our understanding of the handwriting process in adults with DS. More effort needs to be devoted to determining how children and adults with impaired cognitive abilities learn to write, given their greater need for skilled intervention.

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