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Lifts and stops in proficient and dysgraphic handwriting

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ABSTRACT

In this study, the handwriting performances of dysgraphic children were compared to those of proficient children and adults. The task consisted in writing a single word at normal and fast speeds. A distinction was made between two kinds of pauses, which are often confounded: pen lifts, when the pen is above the paper, and pen stops, when it is immobile on the paper. The number and duration of lifts and stops were analyzed, together with the mean velocity. No difference in the number of lifts was observed between the three groups of writers, but the lift durations were shorter for adults. While dysgraphic children were able to write as fast as proficient children, their stops were more numerous and longer than those of proficient children who, themselves, made more stops than adults. A distinction was made between short, normal, and long, abnormal, stops. The results of this study suggest that pen stops are more appropriate than pen lifts in differentiating the handwriting fluency of dysgraphic and proficient children.

1. Introduction

The main goal of handwriting is to leave a written trace on paper. For a long time, all analyses devoted to handwriting production were based on, and carried out with respect to, the written trace. The handwriting movement, the process, was thus deduced *a posteriori* from the static trace, the final result. In this context, handwriting was considered as a continuous movement interrupted by 'pauses' or 'breaks' i.e. temporary halts in the flow of the written trace (Olive, 2010; Sumner, Connelly, & Barnett, 2012). These pauses were visible under the form of trace interruptions. Many of these pauses

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are 'normal' in the sense that they are simply imposed by the text to be written. This is the case for the between-word and between-letter spaces, and for the between-stroke spaces within some letters. It is worth noting that, in principle, these pauses correspond to jumps from one point to another, for instance, from the end of a letter to the start of the following letter. Therefore, the term 'pause' deserves to be questioned; the term 'lift' may prove more appropriate.

In the last thirty years, with the development of digitizer-based technology, it has become possible to record and analyze the motion of the pen during handwriting with a good temporal and spatial resolution. The interest in handwriting movement has increased, particularly as regards the temporal and kinematic characteristics of normal and pathologic handwriting performance. Simultaneously, it has become possible to determine precisely how many lifts occurred and how long they lasted. Several studies were devoted to a comparison of these aspects of handwriting for dysgraphic children and proficient children. Most of them observed that dysgraphic children showed a lack of continuity and fluency, longer lift duration or extended lift intervals between strokes (Kosterman, Westzaan, & Van Wieringen, 1994; Rosenblum, Parush, & Weiss, 2003b; Rosenblum, Weiss, & Parush, 2001; Rosenblum, Weiss, & Parush, 2003a; Schoemaker, Shellekens, Kalverboer, & Kooistra, 1994; Schoemaker & Smits-Engelsman, 1997; Smits-Engelsman, Van Galen, & Portier, 1994; Sovik, Arntzen, & Thygesen, 1987; Wann & Jones, 1986). It should be remembered that, with the first digitizers, the pen coordinates were not available when the pen was not in contact with a surface and thus, it remained impossible to follow the pen displacement during the lifts; lifts were still, therefore, defined as 'pauses' or temporary halts while writing. It is for this reason, also that many studies of handwriting have used sequences of cursive letters not involving pen lifts. Nevertheless, changes in the lift number and duration have been considered as reflecting either low-level (motor) or high-level (cognitive) writing processes. Low-level process lifts were related to the dynamics of handwriting motor execution and, as such, could serve to give the child the opportunity to program sequences of movements for character or word formation, and to select the optimal size, speed, and angle, as well as to adjust wrist and finger positions (Meulenbroek & Van Galen, 1984). Raising the pen could also be justified by the need to visually control the written trace. High-level lifts are those generated by the cognitive processes of writing, such as language formulation, which involves working memory (Kellogg, 1996; McCutchen, 1996, 2000; Peverly 2003). By and large, during a copying and/or reproduction task (Peverly, 2003), or during text composition, in which conceptual and linguistic processes are involved (Olive & Piolat, 2002), lifts shorter than 250 milliseconds were assumed to reflect transcription, whereas longer lifts were assumed to reflect planning, translating or reviewing (Peverly, 2003).

Today, with the arrival of new graphic tablets, it is possible to record the (x,y) pen coordinates even when it is not in contact with the tablet (up to one and half centimeters above its surface). Thanks to this, it has been confirmed that the pen was far from 'pausing' during the lifts and that the 'in air' movements formed a considerable part of the handwriting movements, the rate and duration of which is significantly greater for dysgraphic children, for instance (Rosenblum et al., 2001; Rosenblum et al., 2003a,b).

The use of a pen tablet also allows us to identify possible real pauses of the pen occurring during the writing trace, when the pen is in contact with the paper. In other words, during such pauses the writer does not lift the pen but, yet, stops it. Therefore, for the sake of clarity, we will simply refer to these pauses as 'stops'. A stop is a time period during which the pen is immobile. Contrary to lifts, which are unequivocally characterized by the fact that the pen is no longer in contact with the paper, there are several ways of defining a stop. In theory, two successive points presenting the same pen coordinates can delimit a stop. According to this definition, the minimal detectable stop depends on the sampling rate of the graphic tablet: the greater the sampling rate, the shorter the minimal detectable stop duration and, thus, the greater the number of potentially observable stops. For example, for a 100 Hz sampling rate, the shortest potentially detectable stop is 20 ms, which falls to 10 ms for a 200 Hz sampling rate (see Methods). Of course, occurrences of 10 ms stops are more probable than 20 ms stops. In addition, the spatial resolution of the pen tablet is also crucial for delimiting the stops. The shorter the distance between two adjacent points, the harder it is to attain exactly the same coordinates and, as a result, the lower the possibility of detecting a stop. Practically, with a spatial resolution of 2080 dpi, a displacement of 0.005 mm is observable. Therefore, although temporal and spatial resolutions act in opposite ways, it has become easier to detect stops in handwriting. Another way of