Human Movement Science 43 (2015) 183–200

Contents lists available at ScienceDirect

Human Movement Science

journal homepage: www.elsevier.com/locate/humov

Combining sigma-lognormal modeling and classical features for analyzing graphomotor performances in kindergarten children

Thérésa Duval [a], Céline Rémi [a,*], Réjean Plamondon [b], Jean Vaillant [a], Christian O'Reilly [b,c]

[a] LAMIA, Université des Antilles et de la Guyane, Campus de Fouillole, Département de mathématiques et informatique, BP 250, 97 159 Pointe à Pitre Cedex, Guadeloupe
[b] Laboratoire Scribens, Département de Génie Électrique, École Polytechnique de Montréal, C.P. 6079 Succ. Centre-ville, Montréal H3C3A7, Canada
[c] Département de psychiatrie, Université de Montréal, 2900 Boulevard Edouard-Montpetit, Montréal, QC H3T 1J4, Canada

ARTICLE INFO

Article history:
Available online 2 May 2015

PsycINFO classification:
222

Keywords:
Handwriting learning
Kindergarten children
Sigma-lognormal
Kinematic theory
Fine motor control modeling
Movement patterns

ABSTRACT

This paper investigates the advantage of using the kinematic theory of rapid human movements as a complementary approach to those based on classical dynamical features to characterize and analyze kindergarten children's ability to engage in graphomotor activities as a preparation for handwriting learning. This study analyzes nine different movements taken from 48 children evenly distributed among three different school grades corresponding to pupils aged 3, 4, and 5 years. On the one hand, our results show that the ability to perform graphomotor activities depends on kindergarten grades. More importantly, this study shows which performance criteria, from sophisticated neuromotor modeling as well as more classical kinematic parameters, can differentiate children of different school grades. These criteria provide a valuable tool for studying children's graphomotor control learning strategies. On the other hand, from a practical point of view, it is observed that school grades do not clearly reflect pupils' graphomotor performances. This calls for a large-scale investigation, using a more efficient experimental design based on the various observations made throughout this study regarding the choice of the graphic shapes, the number of repetitions and the features to analyze.

* Corresponding author.
E-mail addresses: tduval@etu.univ-ag.fr (T. Duval), cremi@univ-ag.fr (C. Rémi), rejean.plamondon@polymtl.ca (R. Plamondon), jean.vaillant@univ-ag.fr (J. Vaillant), christian.oreilly@umontreal.ca (C. O'Reilly).

http://dx.doi.org/10.1016/j.humov.2015.04.005
0167-9457/

1. Introduction

The ability to plan and control the execution of handwriting movements is crucial. At school these abilities lead to handwriting efficiency and reduce risks of muscular tension, fatigue and loss of motivation. Such neuromotor abilities depend on the degree of achievement of motor program implementation (Senatore & Marcelli A., 2012). Motor programs can be seen as movement guides, a set of command patterns which activate the proper muscle synergies to carry out a specific task. Motor programs are fully expanded and integrated around age 10 (Meulenbroek & VanGalen, 1988). Children are then able to select the required writing tool and to mobilize the appropriate muscles to produce a specific sequence of movements.

Numerous studies deal with understanding the school-based handwriting learning process. They have provided numerous consistent elements for describing the phenomenon called handwriting growing. For a review of changes and evolution of handwriting over time, see (Rosenblum, Weiss, et al., 2003). As such, these studies have shown that the handwriting learning process induces a regular progression of the visual quality and legibility of the static trace at a first stage. Around 8–9 years of age, there is a visual degradation of the trace which is due to a change of the strategy involved in controlling the effect of handwriting movements. These studies have also shown that the *rapidity*, *fluidity and regularity* of children's handwriting movements are gradually enhanced with the time spent in primary school and practice. These three qualitative performance criteria are commonly used as indicators of children's motor abilities for planning and controlling the execution of graphic or handwriting movement patterns (Pontart et al., 2013; Sage, Zesiger, & Garitte, 2009).

According to statistical studies, across various countries and time periods, between 5% and 25% of children still fail to achieve a satisfying level of handwriting ability in primary school. In such cases, they cannot meet primary school performance requirements and might face learning difficulties (Šlachtová, Neumannová, & Dupalová, 2013). To try to better assist with the detection and remediation of such situations, several studies have attempted to define ways and means to differentiate the categories of graphomotor difficulties children face, while others have identified more efficient ways to detect and correct them (Kaiser, Albaret, & Doudin, 2011; Matijević-Mikelić, Košiček, Crnković, & Zvjezdana Trifunović-Maček, 2011; Rosenblum, Weiss, et al., 2003). Some of these works have established scales measuring the level of handwriting development, such as the De Ajuriaguerra scales (Ajuriaguerra, Auzias, & Denner, 1971) or adaptations of the BHK (Hamstra-Bletz & Blöte, 1993). These scales, which include some appreciation of the kinetic aspects of handwriting, such as rapidity and fluidity, help in monitoring the learning progress in order to take appropriate action and prevent children from developing long-term handwriting difficulties. But because these scales are based on the production of handwritten words and sentences, their principle cannot be used for kindergarten children.

In the French educational system, children spend at least three years in kindergarten during a prescholar period experimenting and practicing pre-calligraphic exercises. French kindergarten comprises three grades: younger grade (YG), middle grade (MG) and older grade (OG). The specific movement patterns which the teacher trains the children in can be complex, like isolated cursive and/or script letters, or smaller graphical units. Activities with these movement patterns are offered to children to develop their fine motor control, dexterity, and technical abilities (Kaiser et al., 2011). At first, motor and perceptive stimulations are taught to the YG pupils to produce unguided or semi-guided handwritten traces. At this stage, the children learn the notion of orientation and the necessary ability to use their bodies to imprint traces on paper using writing tools. For this step, in the French system, only graphical units and script letters are considered. Next, in MG, pupils are taught to master scripting tools to produce smooth, well-oriented traces. At this grade, the teaching reinforces children's abilities to differentiate different traces, to adopt good scripting posture, to write both in clockwise and counter clockwise directions, and to manage their hand position in the scripting area (e.g. a sheet). At MG, graphical units and script letters are still used for training children's graphomotor abilities. Cursive letters can be learned but it is not systematic. Finally, in OG, children are trained to master