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How beginning handwriting is influenced by letter knowledge: Visual–motor coordination during children's form copying

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ABSTRACT

Even with recent technological advances, handwriting remains the developmental foundation from which communication via written language unfolds. Despite the importance of handwriting to academic success, previous research with beginning school-age children has only indirectly measured the processes of handwriting using post hoc assessments of legibility and accuracy. We adapted new head-mounted eye-tracking methods to directly measure visual–motor coordination of preschool and early elementary school children ($N = 40$) as they copied familiar (English letters) and unfamiliar (Cyrillic symbols) letter-like forms in real time. Results indicated that younger children needed more time to visually process a letter or symbol and initiate a writing action compared with older children despite children of all ages writing letters in a similar amount of time. Analyses also revealed that children copied familiar English letters more efficiently than they copied unfamiliar Cyrillic symbols: They spent more time on and made more visual fixations to the Cyrillic symbols compared with the English letters during the copying task. Finally, children made more visual fixations to less frequently occurring English letters than to more frequently occurring ones. Results are considered in relation to how letter recognition influences the development of automaticity in early handwriting.

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Introduction

Despite the ever increasing use of keyboards for writing in our daily lives, handwriting continues to be a critical skill for functioning in modern society and the developmental foundation from which communication via written language unfolds. Handwriting allows children to begin to write words, form sentences, and eventually transfer knowledge even before they are developmentally able to use keyboards for writing (Stevenson & Just, 2014). Due to the importance of handwriting as a foundation for advancing literacy, the early school years are viewed as a crucial time for teaching children to write (Cameron et al., 2012; Coker & Ritchey, 2015; Treiman & Kessler, 2014).

One of the first steps when teaching handwriting at home or at school is to have young children begin to copy letters. Letter copying is a complex activity requiring the coordination of visual and motor skills in real time. In the current study, we investigated the development of visual–motor coordination during letter copying in beginning writers by adapting head-mounted eye-tracking methods. The potential value of such a process-oriented approach for studying handwriting may be seen in the related literature on reading development.

In the literatures on reading and reading development, a process-oriented approach focusing on the relation between eye movements and information processing has led to significant advances (Grainger, Dufau, & Ziegler, 2016; Kaakinen, Lehtola, & Paattilammi, 2015; Rayner, 1986; Sereno & Rayner, 2003). With this approach, researchers have gone beyond focusing on product—whether or not individuals can read a word—to focusing on the process by which individuals do so, especially in terms of the number and patterns of fixations to a visual stimulus (Rayner, 1998; Starr & Rayner, 2001). By the same token, we can ask about the ongoing process of visual–motor coordination that underlies handwriting—namely, how beginning writers organize their eye movements as they attempt to copy letters by hand.

Letter recognition and handwriting development

The visual processing of letters is the foundation for reading (Grainger, 2008). Visual processing of letters becomes more efficient as experience with a language increases (Wiley, Wilson, & Rapp, 2016). Literate adults identify a letter by visually processing the letter's features and determining the category to which the letter belongs. The categorization of the letter occurs through the visual processing and recognition of the distinctive features, along with the suppression of irrelevant features, for the letter category (Fiset et al., 2008; Pelli, Burns, Farell, & Moore-Page, 2006). Visual parsing of the distinctive features of a letter category allows beginning and expert readers to recognize a letter automatically despite surface variations (e.g., size, font) of an invariant form (Gibson, Gibson, Pick, & Osser, 1962; Gibson & Levin, 1975; Grainger, Rey, & Dufau, 2008; Selfridge, 1959). Developmentally, letter recognition ability has been shown to predict the acquisition of later literacy skills (Schmitterer & Schroeder, 2017; Walsh, Price, & Gillingham, 1988). Specifically, children's speed and accuracy of letter recognition has been found to be a strong predictor of later reading abilities (Lonigan, Burgess, & Anthony, 2000).

How do young children's letter categories develop? One possible mechanism that has been hypothesized to contribute to the development of young children's letter categories is handwriting. James and colleagues have recently proposed that self-generated variability in children's handwriting of a given letter may allow children to establish a robust understanding of the distinctive features that are necessary for recognition of that letter (James, Jao, & Berninger, 2015; Li & James, 2016). Consistent with other work on perceptual category learning (Perry, Samuelson, Malloy, & Schiffer, 2010), research indicates that exposure to different exemplars of a letter-like form, even when self-generated, supports recognition and categorization of that form. Children are better at recognizing a letter-like form following experience with multiple variable exemplars of that form compared with experience with a single exemplar of that form multiple times (Li & James, 2016; Longcamp, Zerbato-Poudou, & Velay, 2005).

The links across letter recognition and handwriting development have also been strengthened through the advent of neuroimaging of young children (James et al., 2015). James and colleagues have