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Development of the letter identity span in reading: Evidence from the eye movement moving window paradigm

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ABSTRACT

By means of the moving window paradigm, we examined how many letters can be identified during a single eye fixation and whether this letter identity span changes as a function of reading skill. The results revealed that 8-year-old Finnish readers identify approximately 5 characters, 10-year-old readers identify approximately 7 characters, and 12-year-old and adult readers identify approximately 9 characters to the right of fixation. Comparison with earlier studies revealed that the letter identity span is smaller than the span for identifying letter features and that it is as wide in Finnish as in English. Furthermore, the letter identity span of faster readers of each age group was larger than that of slower readers, indicating that slower readers, unlike faster readers, allocate most of their processing resources to foveally fixated words. Finally, slower second graders were largely not disrupted by smaller windows, suggesting that their word decoding skill is not yet fully automatized.

Introduction

The amount of information that can be extracted during a single eye fixation in reading is intimately linked to the development of reading skill. In support of this claim, Rayner (1986) found that when reading skill improves, the amount of information that can be extracted during a single fixation increases as well. In particular, he found that increased reading skill goes hand in hand with the ability to extract more information about the length and the letters of words to the right of fixation. The main goal of the current study was to examine the number of letters readers can identify during a fixation.

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More specifically, we examined how far to the right of fixation readers extract letter identity information and how this skill develops across elementary school years toward adulthood.

Studies with adult readers (for a summary, see Rayner, 1998) have established that the global perceptual span—the area from which useful information is extracted during a fixation in reading—extends from the beginning of the currently fixated word to approximately 14 or 15 characters to the right of fixation. The global perceptual span comprises an area of high visual acuity, the foveal area, and an area where acuity is not as good, the parafoveal area. Under normal reading conditions (with respect to font size and reading distance), the foveal area extends approximately 6 to 8 characters around the fixation point and the parafoveal area functionally extends up to 15 characters to the right of fixation (when reading from left to right). The remainder of the visual field is the periphery, from which no information relevant to reading is extracted. Even though the global perceptual span is physiologically symmetric, in languages such as English and Finnish that are read from left to right, the span of effective vision is asymmetric to the right, that is, toward new text information (Rayner, 1998).

The global perceptual span can be divided into three different regions based on the type of information obtained around an eye fixation: information about word lengths, letter features, and letter identities. It has become clear that word length information is extracted farthest away from the fixation with the help of spaces between words (e.g., McConkie & Rayner, 1975; Rayner, 1986). This information is used to program saccades to upcoming words. Consistent with this, the majority of saccades land near the center of words (e.g., McConkie, Kerr, Reddix, & Zola, 1988; Rayner, 1979; Vitu, McConkie, Kerr, & O'Regan, 2001) and rarely on the spaces between words (e.g., Abrams & Zuber, 1972). The area from which word length information is extracted is referred to here as the *word length span*. Whereas letter identity information refers to identities of specific letters, letter features refer to more global letter shapes. For example, *o* and *c* share the same basic shape of roundness, whereas *b* and *h* both are ascenders. Here we refer to the area from which letter feature information is extracted as the *letter feature span* and the area from which letter identity information is extracted as the *letter identity span*. Naturally, identifying a letter means that one has also identified the global visual features of that letter. On the other hand, readers may extract letter shape information without obtaining access to letter identity information. This is likely to happen for letters appearing farther away from the current fixation. With specific textual manipulations combined with the moving window technique (McConkie & Rayner, 1975), the letter feature and letter identity spans can be assessed separately, as explained in more detail below.

The moving window technique

By using the moving window technique developed by McConkie and Rayner (1975), the different components of the global perceptual span can be assessed accurately and reliably. In this technique, reading performance associated with the nonmanipulated text (baseline condition) is compared with reading performance of a text with an experimenter-defined window around the current fixation point (window condition). The text outside the experimenter-defined window is mutilated, whereas the text inside the window is shown intact. The window moves in synchrony with the eye movements so that readers always see a fixed amount of original text. Each time readers move their eyes, a new region of the original text is shown around the fixation and the remaining text area becomes mutilated (see Fig. 1). Readers are able to make eye movements as usual, but the amount of useful information available on each fixation is varied depending on the window size. The underlying idea is that when the window becomes smaller than the global perceptual span or any component of it, reading will be disrupted in comparison with reading in the baseline condition. (A special case of the moving window technique is the eye movement contingent display change paradigm of Rayner, 1975, where only one word in the parafovea is manipulated prior to fixating it and is subsequently changed into the correct form during the saccade entering it.)

Different types of manipulations are needed to examine the different components of the global perceptual span (see Fig. 2). For instance, to examine the letter identity span, as is done in the current study, one needs a condition in which letter identity information outside predefined windows is withheld and then compared with the baseline condition in which no text information is withheld. Moreover, this window condition should preserve letter feature information outside the window so as to be