Perception & Psychophysics
1981, 30 (4), 395-396

Notes and Comment

Saccade size in reading depends upon character spaces and not visual angle

ROBERT E. MORRISON and KEITH RAYNER
University of Massachusetts, Amherst, Massachusetts 01003

Recently there has been a considerable amount of research involving the use of eye movements to study the reading process (Rayner, 1978). This trend is similar to another large-scale research effort undertaken a number of years ago that also dealt with eye movements and reading (Huey, 1908; Tinker, 1958, 1963; Woodworth, 1938). One difference between the earlier research and the more current work is that more sophisticated equipment is now used and display changes contingent upon the position of the eye can be made (McConkie & Rayner, 1975; O'Regan, 1980; Rayner, 1975). Much of the research using dynamic display changes has focused on perceptual aspects of the reading process.

Despite this widespread activity, it is still the case that a rather elementary aspect concerning visual factors has not been adequately resolved. That is, it remains unclear as to whether saccades are executed to traverse a certain amount of visual angle or a certain number of letters. For example, eye movements in reading might average around 2 deg of visual angle (Rayner, 1978) because they serve the purpose of bringing text into foveal vision for detailed analysis. If saccades are determined by a critical visual angle, then when viewing distance is decreased (or if the letters are larger) and fewer characters fall within the fovea, the number of characters per saccade will decrease.

On the other hand, larger letters or closer viewing distances might allow the letters to be perceived farther out in extrafoveal vision. Is so, readers might execute saccades of a greater visual angle in order to cover a desired number of characters.

If either of these alternatives is correct, measures of saccade length in one metric (either visual angle or character spaces) will remain constant as letter size or viewing distance is altered (both change the size of the retinal image, hence the number of letters falling within the fovea), while measures in the other metric will change drastically as retinal image size changes.

Huey (1908) and O'Regan (1980) have addressed this issue and argued that number of characters represents the critical determinant of saccade size. Unfortunately, their arguments rest on logical grounds rather than on a simple empirical demonstration. Thus, we have asked subjects to read sentences presented on a cathode ray tube while their eye movements were monitored by a Stanford Research Institute Dual Purkinje Eyetracker. Sets of sentences were written such that word length and grammatical class were matched word by word for each triplet, but different lexical items were used. Subjects then read one sentence at a viewing distance of 36 cm, another sentence matched for word length at a viewing distance of 53 cm, and a third sentence at a viewing distance of 71 cm (14, 21, and 28 in., respectively). Viewing distance was appropriately counterbalanced across subjects, and type size was held constant throughout the experiment. At 71 cm, 2.85 characters equaled 1 deg of visual angle.

Across the subjects tested, the results were quite consistent. As viewing distance increased, saccade size (in character spaces) did not differ significantly ($F = 1.02$). The average saccade traversed 5.43, 5.30, and 5.70 characters[1] at viewing distances of 36, 53, and 71 cm, respectively. These mean saccade sizes correspond to visual angles of 3.81, 2.48, and 2.00 deg. As viewing distance increased, fixation duration increased slightly from 237 msec at 36 cm to 253 msec at 53 cm and 260 msec at 71 cm. That fixation duration tends to increase at greater distances is probably due to the fact that the letters might be slightly less discriminable, resulting in longer fixations. The important point of our demonstration, however, is that the number of characters per saccade remains constant when type size is held constant and viewing distance doubles.[2] Hence, it is clear that Huey and O'Regan were correct in their assertion that number of characters represents the appropriate measure of how far the eyes move in a saccade during reading.

This work was supported by Grant HD12727 from the National Institute of Child Health and Human Development. Requests for reprints should be sent to Robert Morrison, Department of Psychology, University of Massachusetts, Amherst, Massachusetts 01003.

REFERENCES

HUEY, E. B. *The psychology and pedagogy of reading*. New York: Macmillan, 1908.

MCCONKIE, G. W., & RAYNER, K. The span of the effective stimulus during a fixation in reading. *Perception & Psychophysics*, 1975, 17, 578-586.

O'REGAN, K. The control of saccade size and fixation duration in reading: The limits of linguistic control. *Perception & Psychophysics*, 1980, 28, 112-117.

O'REGAN, K. Elementary perceptual and eye movement control processes in reading. In K. Rayner (Ed.), *Eye movements in reading: Perceptual and language processes*. New York: Academic Press, in press.

0031-5117/81/100395-02$00.45/0

RAYNER, K. The perceptual span and peripheral cues in reading. *Cognitive Psychology*, 1975, 7, 65-81.
RAYNER, K. Eye movements in reading and information processing. *Psychological Bulletin*, 1978, 85, 618-660.
TINKER, M. A. Recent studies of eye movements in reading. *Psychological Bulletin*, 1958, 55, 215-231.
TINKER, M. A. *Legibility of print*. Ames: Iowa State University Press, 1963.
WOODWORTH, R. S. *Experimental psychology*. New York: Holt, 1938.

NOTES

1. Since we were interested in comparing individual fixation patterns on sentences matched for word length, we demanded a very strict calibration routine. The sentence was not presented unless the subject was fixating a cross at the left-hand edge of where the first word in the sentence would subsequently appear. This usually resulted in a couple of fixations separated by a very short saccade at the beginning of the sentence, since the reader did not saccade well into the first part of the sentence (often skipping over an article like "the") as in reading connected text. If these short saccades are ignored, the mean saccade lengths are around 6.5-7.0 character spaces as we usually find in our lab.

2. Since preparing this report, we have become aware of the fact that O'Regan (in press) has conducted a very similar study. He tested five rather than three viewing distances, but also found that the number of characters per saccade remains constant as viewing distance increases and that fixation duration increases slightly as viewing distance increases.

(Manuscript received July 20, 1981;
accepted for publication July 21, 1981.)