Vision Res. Vol. 31, No. 11, pp. 2009–2015, 1991
Printed in Great Britain.

0042-6989/91 $3.00 + 0.00

RESEARCH NOTE

AGAINST THE EXISTENCE OF A RANGE EFFECT DURING READING

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(Received 20 August 1990; in revised form 22 February 1991)

Abstract—Some experiments have shown that saccades towards isolated targets which are presented at variable eccentricities in one block of trials, overshoot the near targets and undershoot the far targets. This phenomenon, called the "range effect" was claimed by McConkie, Kerr, Reddix and Zola (*Vision Research, 28*, 1107–1118, 1988) to be the explanation for the fact that in normal reading the eye lands closer to the beginning of a word when it is launched far from the word than when it is launched near to the word. The present experiment tested this hypothesis by presenting isolated words at variable eccentricities from the fixation point, in one block of trials. Results were against the existence of a range effect during reading, since they showed that the eye's initial landing position in the word did not differ as a function of its eccentricity.

INTRODUCTION

In order to understand what determines eye guidance during text reading, many authors have studied the influence of both visual and linguistic factors on saccade lengths and initial landing positions in words. From this research it appears that in most cases, the initial landing position in words is located near the middle of words (Dunn-Rankin, 1978; Rayner, 1979; McConkie, Kerr, Reddix & Zola, 1988; Vitu, O'Regan & Mittau, 1990), and varies as a function of the length of the word the eye is leaving (O'Regan, 1979), and the length of the word the eye is saccading towards (O'Regan, 1979; McConkie *et al.*, 1988; Vitu *et al.*, 1990; Coeffé, 1985). Moreover, McConkie *et al.* (1988) recently showed that the eye's initial landing position in words depends also on the position relative to a word where the eye is launched from: when the eye starts near the word, first fixation position is further into the word than when the eye begins far from the word.

To explain their results, McConkie *et al.* (1988) proposed the following hypothesis: during text reading, the goal of the saccade would be to bring the eye near the center of gravity of each word selected in peripheral vision. However, because of constraints of the oculomotor system such as the "range effect", the eye would not systematically succeed in landing at that position.

The range effect (Kapoula, 1985; Kapoula & Robinson, 1986) which affects saccades towards isolated targets presented at variable eccentricities in one block of trials, is such that when the eye has to accurately fixate a given target, it tends first to land near the mean of the range of possible eccentricities, instead of directly saccading towards the position of the target. Thus, targets presented at a small or a large eccentricity are respectively overshot and undershot. As suggested by McConkie *et al.* (1988), a range effect would occur during text reading, in such a way that the eye would tend to execute a saccade whose length corresponds to the mean of the possible saccade lengths in such a situation. The consequence would be that the target the eye would try to attain (assumed to be the middle of the word selected in peripheral vision), would be overshot in the case when the eye is launched from near the word, and undershot in the case when the eye is launched far from the word, thereby implying initial landing positions at the end or at the beginning of the word.

However, the results obtained by McConkie *et al.* (1988) showing that the eye's initial landing position in words during text reading

depends on the launch site, could result from the "global effect" instead of the range effect. The global effect or "center of gravity effect" has been shown in oculomotor tasks by Coren and Hoenig (1972) and Findlay (1981) and has been replicated many times. When two targets appear simultaneously in peripheral vision, the eye tends first to land at an intermediate position between both targets, a position which corresponds approximately to the center of gravity of the global configuration formed by both targets. In the same way, it has been shown that the eye's initial landing position in a word can be shifted towards the end of this word when it appears simultaneously with another word located to its right (Vitu, 1991). Thus, it could be that during text reading, the eye is deviated from its goal by the presence of other elements around the target word, in such a way that when the eye is far from the target word characters present between the fixation point and the target word would pull the eye to the very beginning of this word. On the contrary, when the eye is near to the target word it would be pulled to the end of this word.

In order to distinguish between these two hypotheses, the following experiment directly tested the hypothesis proposed by McConkie *et al.* (1988). In other words, the purpose here was to test the existence of a range effect in a reading situation. In the same block of trials, isolated words were presented at variable eccentricities from the fixation point. The eye's initial landing position in words was measured as a function of the eccentricity at which the words appeared. If the hypothesis proposed by McConkie *et al.* (1988) is correct, we expect that the first fixation position in words should vary as a function of the eccentricity of presentation, in such a way that for small eccentricities, the eye would tend to land at the end of words and for large eccentricities, the eye would tend to land at the very beginning of words. The test word appeared either visible or masked in peripheral vision, in order to see the influence of peripheral preprocessing on such a phenomenon.

METHOD

Eight subjects participated in the experiment. All were native French speakers and unfamiliar with the purpose of the experiment.

Subjects sat in an adjustable chair, their eyes at a distance of 50 cm from the computer screen. Their head was stabilized by a chin forehead rest. After a calibration phase, the first trial began. An asterisk that the subject had to fixate appeared on the left side of the screen. When an accurate fixation was detected (to within $\frac{1}{4}$ character from the center of this asterisk), it was transformed into a cross and two words appeared in the right peripheral visual field. The first word (the test word) was located with the left edge of its first letter at a variable excentricity from the asterisk (at 1, 3, 5, 7 and 9 characters which corresponded respectively to 0.6, 1.8, 3.0, 4.2 and 5.4 deg) and appeared visible or masked in peripheral vision as a function of the peripheral preprocessing condition. The second word (or comparison word) was spaced one character-space from the end of the test word and was always masked until the eye fixated it. The task was to read the first word and then the second one and to decide whether the two words were identical. When the computer detected a saccade towards the test word, the test word became visible in the "without peripheral preprocessing" condition. When the eye saccaded towards the comparison word, the test word was masked and the comparison word became visible. When the subject had read both words, he had to press one button if the words were identical and to press another button if they were different. Then the next trial began.

On certain trials, the stimuli presented in peripheral vision were not words but isolated letters. This permitted a check of calibration accuracy during the experiment. The procedure was identical: subjects had to fixate first the first letter and then the second one in order to indicate whether both letters were identical. The isolated letters were presented at random positions in the peripheral visual field.

The procedure used to mask words was the following. Each letter of a word was modified in such a way that the number of lighted pixels in the matrix defining the masked character was identical to the number in the corresponding unmasked character, the lighted pixels appearing at random positions in the matrix. Thus the masked words were non-homogeneous stimuli such as words but having the same number of lighted pixels.

The test words were of length 5 and 9 letters. The two word lengths and the five possible eccentricities of the test word were mixed in one block of trials. The two conditions of peripheral preprocessing were run in two separate blocks of trials. The order of the two blocks was