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THE RETURN SWEEP IN READING

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1. INTRODUCTION

A comprehensive model of eye movement control in reading will have to take into consideration not only progressive and regressive inter- and intraword saccades, but also the large return sweep saccades that bring the eyes from the end of one line of text to the beginning of another line (Suppes 1994). In normal text, about 20 percent of all fixations are preceded or followed by a return sweep and the contribution of these fixations to total reading time is substantial. From the perspective of text design, the optimal line length is assumed to depend on the reader's ability to programme and execute an accurate return sweep and to avoid the costs of additional corrective saccades (Tinker 1963, Heller 1982). Given both theoretical and practical importance, surprisingly little is known about the parameters characterising return sweeps and the factors that control them. This chapter is an attempt towards closing this gap. We will first consider return sweeps as a special case of large goal-directed saccades and briefly look at previous findings. We will then present descriptive data on return sweep landing positions and the occurrence of corrective saccades and explore the effects of line length and text justification on these variables.

1.1. The Return Sweep in Reading: A Special Case of Large Goal-Directed Saccades

For almost a century, experimental psychologists and physiologists have been interested in the characteristics of saccadic eye movements. Many recent studies have focused

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on one specific aspect: with increasing amplitude, saccades tend to undershoot their target and are frequently followed by small corrective saccades, which bring the eye close to the target. In a typical experiment, subjects are asked to fixate an abruptly appearing target displayed somewhere in the visual field. Studies using this task showed a mean undershoot of about 10 % of the required movement amplitude (e.g. Becker 1972). Much smaller amplitude errors can be observed when targets are stationary at fixed positions (e.g. Lemij and Collewijn 1987).

The latencies of corrective saccades are in the order of 120–160 ms and therefore shorter than common oculomotor reaction times. Subjects are usually not aware of the fact that they make corrective saccades, which leads to the conclusion that they represent a reflex-like behaviour (see Deubel 1994). The reason for the saccadic undershoot found in most experiments is still not clear. The limited quality of the visual signal coding target position does not seem to be the primary cause (de Bie et al. 1987). There is now consensus that corrective saccades are visually guided, but extraretinal feedback comes into play when saccade errors are large (e.g. Becker 1976). At the end of the primary saccade, the deviation of the saccade landing position from the intended goal is calculated on the basis of retinal feedback. A corrective saccade is initiated if this deviation exceeds a certain value.

The majority of results concerning the characteristics of (large) saccades were obtained using simple paradigms including sudden target onsets in an otherwise rather unstructured visual field. One might argue that this is not a typical example of every-day oculomotor behaviour, which consists mainly of saccades to stationary objects. Scanning single points is not very “meaningful” and in this respect fundamentally different from a task like reading.

Here, the goal of a saccade is not given by instructions, but by the demands of text processing. It is important to note that during reading, saccade programming is a task secondary to the primary task of visually processing text information. The co-ordination of these two tasks and the degree to which they can be carried out in parallel are currently discussed in reading research (Rayner et al. 1998, Underwood and Radach 1998). It appears that because of the dual-task nature of reading, the oculomotor system is not operating at its maximum performance and systematic oculomotor error is an inherent feature of eye behaviour (Radach and McConkie 1998). Given these considerations, return sweeps may be an appropriate model of large goal-directed saccades in a visually well structured environment. Their analysis may lead to insights into the programming of large saccades, which might not be obtained by using simple laboratory tasks that require only little cognitive effort.

1.2. The Return Sweep in Reading: A Review of Previous Findings

Early investigations into the return sweep were motivated by applied questions. Tinker and co-workers analysed the influence of typographical factors on the readability of text (Tinker 1963). They found an increase in reading time for text with lines exceeding a certain length. The authors attributed this to a substantial increase in the occurrence of regressive saccades after the return sweep (Paterson and Tinker 1940). Heller (1982), who varied line length between 13 and 28 degrees, obtained similar results. For the shortest lines he observed corrective saccades in 10 % of all cases, increasing to 53 % for the longest lines. Mean latencies of corrective saccades were 138 ms. He also reported large interindividual variations for the probability of making corrections. For texts which were rated as difficult, he found slightly more corrective saccades following return sweeps as compared to easy texts. This relation also held when the number of fixations on the lines was