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Eye movements in skilled transcription typing

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Two typists' eye movements were recorded while they transcribed short passages of text. Typists' eye movements were found to be substantially different from eye movements of readers who read the identical stories for comprehension (Inhoff, 1984). In particular, typists' fixation durations were increased and saccade lengths were decreased when compared to those of readers. Furthermore, eye fixations in typing appeared to be completely insensitive to contextual constraints; fixations of readers, on the other hand, are highly sensitive to contextual constraints. However, both readers' and typists' oculomotor behavior was affected by word frequency.

Skilled transcription typing involves the acquisition of visual text via a series of eye movements and the translation of the acquired visual information into an ordered sequence of manual keystrike commands. A number of researchers have studied the nature of the manual performance in typing (e.g., Rumelhart & Norman, 1982; Shaffer, 1976). Relatively little is known, however, about oculomotor control during typing.

In the only oculomotor study available, Butsch (1932) measured typists' oculomotor behavior during speeded transcription typing. He found that the eyes were positioned about eight letters (or eight manual keystrokes) ahead of the executed manual keystroke response. Each fixation lasted about 450 msec, and each saccade moved the eyes about four character spaces to the right of the former fixation position. Relatively few fixations were placed at text positions that had already been typed.

The eye-movement pattern described by Butsch (1932) contrasts markedly with eye movements in reading. Readers' average fixation durations are about 250 msec, average saccade length is about eight character spaces, and approximately 10%-20% of all fixations are regressions that are directed to text locations that have already been read (e.g., Rayner, 1978).

The goal of the present investigation was to further explore oculomotor control in speeded transcription typing. In our experiment, 2 professional secretaries typed short excerpts from *Alice in Wonderland* while their eye movements were monitored. Two eye-movement measures were obtained: first-fixation duration and gaze duration. First-fixation duration refers to the duration of the first fixation that is located on a critical word. Gaze duration refers to the cumulative viewing time that is spent on a word prior to the fixation on another word. (First-fixation duration and gaze durations are identical when only one fixation is placed on a critical word; if more than one fixation is placed on a critical word, gaze duration exceeds first-fixation duration.) Each passage contained 16 critical words, half of which were high-predictability words and half of which were low-predictability words within the story context. Orthogonal to this, half of the words were high-frequency and half were low-frequency words. A prior investigation (Inhoff, 1984) using these passages showed that readers' first-fixation duration on these critical words was a function of the words' predictabilities. First fixations on a word were longer when the word was a low-predictability word than when it was a high-predictability word. Furthermore, gaze durations per word showed a similar effect of predictability and, in addition, gaze durations were longer on low-frequency words than on high-frequency words.

We asked whether typists and readers show the same effects of predictability and of word frequency on first-fixation durations and gaze durations or, alternatively, whether typing and reading instantiate different modes of oculomotor control.

METHOD

Subjects

Two professional typists participated in the experiment. Each typist had at least 3 years of professional typing experience.

Apparatus

Eye-movement recording was accomplished with a Stanford Dual Image Purkinje eye tracker. The eye tracker has a visual resolution which

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is within ¼° of visual angle in the horizontal direction. Text was displayed on a Hewlett Packard CRT, with each letter of text subtending ⅓° of visual angle. The CRT and eye tracker were interfaced with a Hewlett Packard 2100A computer, which controlled the experiment and allowed the measurements of fixation durations to the nearest millisecond (for more details, see Rayner, Inhoff, Morrison, Slowiaczek, & Bertera, 1981). Typing was performed on a low-profile Digital computer keyboard. No recordings of the manual output performance were obtained, although the subjects were not aware of this.

Procedure

Subjects were tested individually. After the typist's head was stabilized by means of a bite bar, a calibration procedure was initiated (for details see Rayner et al., 1981). After this, the subject was instructed to fixate a fixation marker at the left side of the CRT. Upon fixation of the marker, the first sentence of a passage of text was displayed. The subject was instructed to type this line of text fast and free of errors. After the line was typed, the text was erased and the subject refixated the fixation marker at the left side of the CRT. This resulted in the display of another line of text so that each passage was viewed/typed in a line-by-line manner.

RESULTS

Average fixation duration throughout the typing of the two passages was 434 msec for Typist A and 440 msec for Typist B. Most saccades were directed in a forward direction (91% for Typist A and 90% for Typist B). These saccades were relatively short, extending across 2.79 letters (Typist A) and 3.10 letters (Typist B). Accumulating the viewing time during the typing of the passages and dividing this value by the amount of keystroke responses resulted in an average keystroke reaction time of 160 msec for Typist A and of 140 msec for Typist B. The oculomotor behavior of the 2 typists was thus highly similar.

An evaluation of the viewing time of the critical words for each typist is shown in Table 1. As Table 1 indicates, there was no effect of predictability on average first fixations on high- and low-predictability words. Average first-fixation durations were 345 msec on high-predictability words and 342 msec on low-predictability words. Effects of predictability were relatively small in the gaze durations, amounting to 1,042 msec for high-predictability words and 1,093 msec for low-predictability words. In contrast, gaze durations showed marked effects of word frequency. Specifically, gaze durations on high- and low-frequency words averaged 932 msec and 1,203 msec, respectively.

Table 1
Gaze Durations and First Fixations (in Milliseconds) on Critical Words as a Function of Word Frequency and Predictability

	High Predictability		Low Predictability	
	High Frequency	Low Frequency	High Frequency	Low Frequency
	Gaze Duration			
Typist A	982	1,387	1,151	1,387
Typist B	845	955	749	1,082
	First Fixation			
Typist A	379	298	523	406
Typist B	440	264	245	195

DISCUSSION

The result of the experiment showed that typists' eye fixations during transcription typing of short passages of text are considerably different from readers' eye movements during reading of the identical passages for comprehension. Foremost, average fixation durations were nearly doubled and average saccade length was decreased by a factor of about 2.5. These observations are in accord with the results obtained by Butsch (1932).

In addition, our experiment showed that typists' oculomotor behavior was relatively unaffected by semantic constraints that were imposed by prior context. Specifically, first fixations and gaze durations on a critical word did not vary as a function of the predictability of the word. This contrasts with first fixations and gaze durations on the identical words in normal reading, where high-predictability words received shorter first fixations and gaze durations than did low-predictability words. Word frequency, however, affected gaze durations in both typing and normal reading; that is, under both task conditions, low-frequency words received shorter gaze durations than did high-frequency words.

These results suggest that text which is viewed during a fixation in speeded transcription typing is not routed via a semantic processing system before new visual information is acquired. Some linguistic processing of the fixated text appears to have occurred, however, since familiar high-frequency words required less viewing time in typing than did unfamiliar low-frequency words. This word-frequency effect in the gaze durations may result either from differences in the visual processing of the two types of words (visual processing hypothesis) or, alternatively, from differences in the assembly of a manual output program for high- and low-frequency words (manual processing hypothesis). Differences in the assembly of a manual output program may emerge either because manual response programming is interfaced with lexical structures or because high-frequency words are typed more often than are low-frequency words and, thus, contain a more practiced sequence of temporal/spatial finger transitions.

The visual processing view is consistent with the finding that high-frequency words require shorter visual processing times than do low-frequency words under a number of different viewing conditions when manual output demands are held constant. Variations in gaze durations thus occur independently of the assembly of the manual typing commands. The manual processing hypothesis is supported by the finding that skilled typing is affected by word structure, but remains relatively unaffected by semantic manipulations at the sentence and story level (Shaffer, 1973). One way to unconfound visual and manual processing difficulty is to vary the two factors orthogonally; for example, by measuring the viewing time of high-frequency words that are difficult to type (but presumably relatively easy to encode visually) and of low-frequency words that are relatively easy to type.

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