Foveal Processing and Word Skipping during Reading

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Abstract

An eyetracking experiment is reported examining the assumption that a word is skipped during sentence reading because parafoveal processing during preceding fixations reached an advanced level in recognizing that word. Word_n was presented either with reduced contrast, with case alternation or normal. Reingold and Rayner (2006) reported that, compared to the normal condition, reduced contrast increased viewing times on word_n but not on word_{n+1}, whereas case alternation increased viewing times on both words. These patterns were reflected in the fixation times of the current experiment, but a striking dissociation was observed in the skipping of word_{n+1}: The reduced contrast of word_n decreased skipping of word_{n+1}, whereas case alternation did not. Besides the amount of parafoveal processing, the decision to skip word_{n+1} is also influenced by the ease of processing word_n: Difficulties in processing word_n lead to a more conservative strategy in the decision to skip word_{n+1}.

In the past few decades, research on eye movements in reading has produced a vast amount of data and insights into the processing that occurs during reading (for a review, see Rayner, 1998). As a result, many models of the mechanisms underlying eye guidance in reading have been proposed such as the E-Z Reader model (Reichle, Pollatsek, Fisher, & Rayner, 1998; Pollatsek, Reichle & Rayner, 2006) and the SWIFT model (Engbert, Nuthmann, Richter, & Kliegl, 2005). In this paper I will focus on an assumption incorporated in most of these models: word skipping during reading is tightly linked to the amount of parafoveal processing which has occurred during the preceding fixation(s). I will do so mostly within the framework of the E-Z Reader model.

The E-Z Reader model is a quantitative model in which the core assumption is that cognitive processes associated with processing the fixated word are the engine behind eye movements in reading. Word recognition is considered to be a serial lexical process under the control of an attentional beam, with the word in the attentional beam being the only word that is being lexically processed. Two phases of word recognition are being distinguished. The termination of the first phase (L_1) cues the oculomotor system to begin programming a saccade to the next word. In the lexical processing of a word the end of L_1 is considered the point where the processing system, from prior experience, has learned that it is likely that full word identification will be achieved shortly. The end of the second phase (L_2) corresponds with full lexical identification, which cues the attentional beam to shift to the next word. This shift usually occurs before the eyes move to the next word and during the time that the attentional beam is on the parafoveal word (but the eyes are still on the previous word), parafoveal processing occurs. In this manner the E-Z Reader model accounts for the parafoveal preview benefit; the finding that a preview of a word to the right of fixation results in shorter fixations on that word when it is subsequently fixated (Rayner, 1975).

As a result of these assumptions, E-Z Reader predicts that manipulations that exclusively disrupt early encoding of visual and orthographic features of the fixated word influence the processing difficulty of $word_n$ without disrupting the processing of $word_{n+1}$. That is, if the effect of the experimental manipulation would be limited to the L_1 phase of $word_n$, it would not influence the parafoveal processing of $word_{n+1}$, which is not thought to start until L_2 of $word_n$ has been completed. This hypothesis was tested by Reingold and Rayner (2006) in an experiment where participants read sentences in which one word was either presented normally, with case alternation or with severely reduced contrast[1]. The condition with the reduced contrast (the *faint* condition) was assumed to disrupt an early stage in word recognition in which visual features are encoded and abstract letter identities are established (Besner & Roberts, 2003), whereas case alternation has been shown to influence mostly post-encoding lexical processing (Herdmann, Chernecki, & Norris, 1999). The results were straightforward and consistent with the E-Z Reader prediction: Whereas the faint condition resulted in longer fixation times on $word_n$, the differences between the faint condition and the normal condition in the fixation times on $word_{n+1}$ were not significant. The case-alternation condition showed slightly longer fixation times on $word_n$ than the normal condition (and shorter than the faint condition) but did cause the fixation times on $word_{n+1}$ to be significantly longer as compared to the normal condition.

Turning to the issue of word skipping, in E-Z Reader word skipping is based on the following sequence of events. If (a) the eyes are on $word_n$, (b) the attentional beam has shifted to $word_{n+1}$, and (c) the first phase of word identification of $word_{n+1}$ in the parafovea is rapid enough, the programming of the eye movement to $word_{n+1}$ is cancelled and replaced by the programming of a saccade to $word_{n+2}$. As a consequence, $word_{n+1}$ will be skipped. Critically, E-Z reader states that a word is skipped because it is recognized in parafoveal vision, or more precisely that recognition is imminent. Thus, it follows that the chances of recognizing the parafoveal word (and skipping it) would be reduced when the amount of parafoveal preview is reduced. The amount of parafoveal processing is influenced by the duration of the L2 phase on $word_n$: the saccade programming starts after L1 is concluded and takes a relatively constant amount of time to be executed. As a consequence, a short L2 phase will lead to more parafoveal processing of $word_{n+1}$ than a long L2 phase. Indeed, this is how the E-Z Reader model accounts for the finding that the parafoveal preview benefit is reduced after a low-frequency word as compared to after a high-frequency word (Henderson & Ferreira, 1990).

The aim of the current experiment was to see whether the link between the amount of parafoveal processing and the skipping rate of $word_{n+1}$ is indeed as tight as assumed by the E-Z Reader model. If so, one would expect a condition that does not affect the L_2 phase of $word_n$ (i.e. the faint condition of Reingold & Rayner, 2006) to lead to skipping rates of $word_{n+1}$ comparable to those in the normal condition. A condition that increases the L_2 phase of $word_n$, such as the case alternation condition, would decrease parafoveal processing and as a consequence lower skipping rates of $word_{n+1}$.

There was another reason for running this experiment: Fixation durations on $word_{n+1}$ and the skipping of $word_{n+1}$ are usually considered as correlated measures of the same phenomenon: the amount of preceding parafoveal processing. However, a study looking directly at the effects of foveal word frequency on the skipping of either a correct or an incorrect parafoveal preview of a three-letter word did show a main effect of foveal load (less skipping after a low-frequency word) and preview (the incorrect preview was skipped less often) but the crucial interaction, indicating the influence of the amount of parafoveal processing on word skipping, was not present (Drieghe, Rayner, & Pollatsek, 2005). This interaction has been observed multiple times on the fixation duration of $word_{n+1}$ (e.g. Henderson & Ferreira, 1990), warranting a closer examination of the link between these two measures.

Prior research has shown that skipping rates tend to be higher for short words as compared to long words and high-frequency words as compared to low-frequency words (for a review, see Brysbaert, Drieghe & Vitu, 2005). Therefore, in order to have high enough skipping rates to detect any potential effects, $word_{n+1}$ was a short and very frequent word in the current study.

METHOD

Participants. Thirty Ghent University students, who were native speakers of Dutch with normal or corrected-to-normal vision were paid €8 to participate in the experiment.

Apparatus. Eye movements were measured with an SR Research Eyelink 1000 system. Viewing was binocular but eye movements were recorded from the right eye only. Following calibration, gaze-position error was less than 0.5°. Fixation locations were sampled every millisecond. All sentences were displayed on a single line and all letters were lowercase (except when capitals were appropriate) and in mono-spaced Courier font. The text was presented in black (0.5 cd/m^2) on a white background (97 cd/m^2). The average brightness of $word_n$ in the faint condition was 86 cd/m^2. The display was 60 cm from the subject's eye and 2.4 characters equaled 1° of visual angle.

Materials. Seventy-two sentences were created so that every sentence featured a succession of the following two words: $word_n$, which was five letters long, and $word_{n+1}$, which in half of the sentences was three letters long and in the other half was four letters long. The average frequency was 551 per million for $word_n$ and 2834 per million for $word_{n+1}$ (Baayen, Piepenbrock, & Van Rijn, 1993). Two additional conditions were created by modifying $word_n$: it was presented with case alternation or shown with reduced contrast. A counterbalanced design was employed in which each of the 72 sentences was read only once by each participant, resulting in 24 sentences per condition per participant.

Procedure. Participants were given a description of the experimental procedure and were asked to read sentences on the monitor. They were told that they would be asked questions about the sentences and were instructed to read for comprehension. Participants stopped sentence presentation by pressing a button. The initial calibration of the eye-tracking system required about 5 minutes. Each participant read 12 practice sentences to become familiar with the procedure, four of these sentences featured a case alternation word, four a reduced contrast word, and four sentences featured no modifications. Comprehension questions were asked after 25% of the trials, accuracy answering them was 95%. The experiment lasted about 25 minutes.

RESULTS

Fixations durations shorter than 100 ms and longer than 1200 ms were removed from the analyses. Three eye movement measures were computed. First fixation duration is the duration of the first fixation on a word; single fixation duration refers to when only one fixation is made on the word; gaze duration is the sum of all fixations on a word prior to moving to another word. Trials on which the eye-tracker lost track of the eye position were removed. As a result, about 0.3% of the trials were excluded from the analyses. After the computation of the skipping percentages of $word_n$, an additional 27% of the trials were removed from the analyses of the other eye movement measures for one of the following two reasons: (a) $Word_n$ was skipped (19.8% of the trials), or (b) the participant made a regression from $word_n$ (7.4% of the trials). A series of repeated measures analyses of variance (ANOVAs) were undertaken with participants (F1) and items (F2) as random variables. All the reported *p* values for the contrasts were Bonferroni adjusted.

Skipping of word$_n$. The skipping probabilities associated with word$_n$ are shown in Table 1. The typographical modifications of word$_n$ exerted a significant influence on the skipping rates [$F1(2,58)=8.33$, $p<.001$; $F2(2,142)=14.19$, $p<.001$]. Contrasts showed that word$_n$ was skipped 6% more often in the normal condition than in the faint condition, which in turn was skipped 7% more often than word$_n$ in the case alternation condition, although some p-values in the participant analysis were no longer significant after Bonferroni corrections [normal vs. case alternation: $t1(29)=5.13$, $p<.001$; $t2(71)=5.21$, $p<.001$; normal vs. faint: $t1(29)=1.81$, $p>.10$; $t2(71)=2.57$, $p<.05$; case alternation vs. faint: $t1(29)=-1.96$, $p>.10$; $t2(71)=-2.83$, $p<.05$].

INSERT TABLE 1 ABOUT HERE

Fixation times on word$_n$. The fixation times on word$_n$ are shown in Table 1. All measures show the same pattern: the normal condition is associated with the shortest fixation times and dramatically longer fixation times are observed in the faint condition. The manipulation of word$_n$ was significant in the analysis of the first fixation durations [$F1(2,58)=106.85$, $p< .001$; $F2(2,142)=242.26$, $p< .001$]. Contrasts showed that the first fixation duration in the faint condition was 127 ms longer than in the case alternation condition, which in turn was read 12 ms slower than the normal condition [normal vs. case alternation: $t1(29)=-3.00$, $p<.05$; $t2(71)=-3.01$, $p<.05$; normal vs. faint: $t1(29)=-10.35$, $p<.001$; $t2(71)=-17.56$, $p<.001$; case alternation vs. faint: $t1(29)=-10.35$, $p<.001$; $t2(71)=-15.58$, $p<.001$]. The manipulation of word$_n$ was also significant for the single fixation duration [$F1(2,58)=75.01$, $p<.001$; $F2(2,142)=194.40$, $p< .001$], which was 174 ms longer in the faint condition as compared to the case alternation condition. The case alternation condition received single fixation durations 12 ms longer than the normal condition. [normal vs. case alternation: $t1(29)=-2.38$, $p<.10$; $t2(71)=-3.29$, $p<.01$; normal vs. faint: $t1(29)=-8.97$, $p<.001$; $t2(71)=-15.20$, $p< .001$; case alternation vs. faint: $t1(29)=-8.57$, $p<.001$; $t2(71)=-13.74$, $p<.001$]. Finally, the effect of the typographical manipulations was also significant in the analyses of the gaze durations [$F1(2,58)=87.62$, $p<.001$; $F2(2,142)=486.38$, $p<.001$]. The gaze duration was 264 ms longer in the faint condition than in the case alternation condition which in turn was 23 ms longer than in the normal condition [normal vs. case alternation: $t1(29)=-3.47$, $p<.01$; $t2(71)=-3.60$, $p<.01$; normal vs. faint: $t1(29)=-9.70$, $p<.001$; $t2(71)=-25.85$, $p<.001$; case alternation vs. faint: $t1(29)=-9.20$, $p<.001$; $t2(71)=-21.25$, $p<.001$][2].

Skipping of word$_{n+1}$. The skipping probabilities associated with word$_{n+1}$ are shown in Table 1. The modifications of word$_n$ resulted in a significant effect on the skipping of word$_{n+1}$ [$F1(2,58)=6.78$, $p<.01$; $F2(2,142)=12.04$, $p<.001$]. Contrasts showed that this was entirely due to the skipping of word$_{n+1}$ in the faint condition which happened on average 12% less often than in the other two conditions [normal vs. case alternation: all t's< 1, n.s.; normal vs. faint: $t1(29)=2.73$, $p<.05$; $t2(71)=3.54$, $p< .01$; case alternation vs. faint: $t1(29)=3.38$, $p<.01$; $t2(71)=4.81$, $p< .001$]. Because word skipping is influenced strongly by word length an extra ANOVA was run with word length as a factor. The skipping rates of word$_{n+1}$ computed separately for the three-letter and four-letter words are also shown in Table 1. The main effect of word length was significant [$F1(1,29)=53.85$, $p<.001$; $F2(1,35)=37.48$, $p<.001$]. Three-letter words were skipped on average 18% more often than the four-letter words. The main effect of the manipulation of word$_n$ was also significant [$F1(2,58)=6.77$, $p<.01$; $F2(2,70)=10.82$, $p<.001$]. Again this effect was caused by the skipping probabilities of the faint condition being lower than in the other two conditions [normal vs. case alternation: $F(1,29)< 1$, n.s.; $F2(1,35)=1.06$, $p>.20$; normal vs. faint: $F1(1,29)=8.18$, $p<.05$; $F2(1,35)=8.85$, $p<.05$; case alternation vs. faint: $F1(1,29)=9.98$, $p<.05$; $F2(1,35)=24.02$, $p< .001$]. There was no interaction between word length and the typographical manipulations (all F's< 1, n.s.).

Fixation times on word$_{n+1}$. It is important to stress here that the current experiment was specifically designed for examining the effects of the typographical manipulations on the skipping of word$_{n+1}$ (i.e. by using short and frequent words), and as a consequence it is less suited for the analysis of the fixation times on word$_{n+1}$. This is due to two reasons: (a) Because very short words were used as word$_{n+1}$ to elicit as much skipping as possible, the amount of data of the fixation times on word$_{n+1}$ is limited, and (b) when dealing with short words which are skipped very often, the effects can be polluted by so-called mislocated fixations (see Drieghe, Rayner, & Pollatsek, 2008; Nuthmann, Engbert, & Kliegl, 2005). That is, there are discrepancies between where a saccade is targeted and where it lands. For a very short word, this can quite often lead to an unintentional landing on or skipping of the word, which will influence the fixation times on the word, and can even lead to other patterns as those typically observed in longer words. As will be apparent from the fixation times shown in Table 2, the patterns observed on $word_{n+1}$ were quite different depending on the word length of $word_{n+1}$, so the analysis of the fixation times will be presented separately for three-letter and four-letter words.

INSERT TABLE 2 ABOUT HERE

Because the three-letter word was skipped so often, the amount of data caused the fixation times on $word_{n+1}$ to be not very informative. Indeed, no significant effects were observed from the typographical manipulation of $word_n$ on any of the fixation time measures on the three-letter $word_{n+1}$ [first fixation duration: $F1(2,38)=1.06$, $p>.20$; $F2<1$, n.s., single fixation duration: all F's< 1, n.s.; gaze duration: all F's< 1, n.s.]. A somewhat clearer picture emerged from the fixation times on the four-letter $word_{n+1}$. The manipulation on $word_n$ had a marginally significant effect on the first fixation durations on $word_{n+1}$ [$F1(2,44)=2.52$, $p<.10$; $F2(2,66)=3.48$, $p<.05$][3]. A similar picture emerged from the analysis of the single fixation durations on $word_{n+1}$: the effect of the manipulation on $word_n$ was marginally significant in the items analysis [$F1(2,44)=1.41$, $p>.20$; $F2(2,66)=2.90$, $p>.05$]. Note that the first and single fixation durations in the faint condition seem to be somewhat shorter than in the normal condition. This is contrary to the Reingold and Rayner data, which show slightly longer (also non-significant) observations for these measures. Whereas this difference could be due to the higher skipping rates in the current study, resulting in more pollution by mislocated fixations, the statistical non-significance of these observations in both studies prevents drawing any conclusions. Finally, the gaze duration on $word_{n+1}$ also showed a marginally significant effect of the manipulation on $word_n$ in the item analyses [$F1(2,44)=1.41$, $p>.20$; $F2(2,66)=2.90$, $p>.05$]. Because in the gaze duration data the pattern reported by Reingold and Rayner (2006) quite strongly emerges in the means, an extra contrast was carried out directly testing whether the gaze duration in the case alternation condition was longer than in the other two conditions. This contrast was only marginally significant [$F1(1,22)=2.73$, $p=.11$; $F2(1,33)=3.58$, $p=.06$]. Summarizing, even though neither the design of the experiment nor the amount of data allows us to draw strong conclusions about the fixation times on $word_{n+1}$, one can consider the fixation times to be compatible with those reported by Reingold and Rayner (2006): In the analysis restricted to the stimuli where some statistical power was involved (i.e. the four-letter words), the case alternation condition is consistently associated with the longest fixation times. This is corroborated by the fact that in the measure presumably least infected by mislocated fixations (i.e. the gaze duration analysis), a marginally significant effect emerges of the case alternation condition with an effect size (on average 17 ms longer than the other two conditions) very closely resembling the effect size observed by Reingold and Rayner (2006).

DISCUSSION

Reingold and Rayner (2006) tested a prediction from the E-Z Reader model that manipulations which disrupt early encoding of visual and orthographic features but not the ensuing lexical processing of $word_n$ would influence the fixation times on $word_n$ but not on $word_{n+1}$. Indeed, they observed that reducing the contrast of $word_n$ led to increased fixation times on $word_n$ but did not change the fixation times on $word_{n+1}$. The case alternation manipulation, which disrupts post-encoding lexical processing, resulted in longer fixation times on both $word_n$ and $word_{n+1}$. Whereas these patterns were also reflected in the current study in the fixation times on $word_n$ and – not significantly – on $word_{n+1}$, a different pattern was observed in the skipping rates of $word_{n+1}$: The faint condition reduced skipping of $word_{n+1}$ and there was no difference between the case alternation and the normal condition. Whereas the lack of a difference in skipping rate between the case alternation and the normal condition might be due to ceiling effects (skipping rates were very high in both conditions), this cannot explain the observed effect in the faint condition.

Based on the assumption that fixation times and skipping rates would both be reflections of the same phenomenon (i.e. amount of parafoveal processing), comparable patterns were expected in both measurements. This was clearly not the case. To interpret this surprising finding it is important to note that the skipping rates of $word_{n+1}$ reflect the effects observed in the fixation times on $word_n$. The condition with the longest fixation times, the faint condition, is also the condition with the lowest skipping rates on $word_{n+1}$. This makes sense if one looks upon skipping as a mechanism which consists in cancelling the planned saccade to the next word, a mechanism the eye guidance system will use only when *all* indications point in the direction that skipping the following word will not impede reading rate or hinder text understanding. The novel thing here is that skipping is not exclusively influenced by the amount of parafoveal processing but also by the ease of foveal processing. In other words, a difficult foveal word – even when the difficulty is limited to the L_1 stage as it perceived by the E-Z Reader model – will cause the system to adopt a more conservative strategy in deciding whether to skip the next word.

Alternatively, one could consider the current results as arguing against the purity of the faint condition as a manipulation that exclusively affects early stages of word recognition. Whereas this possibility cannot be ruled out, it is unlikely that any disruption in the later stages of the processing of $word_n$ would result in the short fixation durations observed on $word_{n+1}$.

The current findings are compatible with the results reported by Drieghe et al. (2005) who examined the influence of foveal load on the skipping of the next word (see also White, 2007). They observed that a low-frequency $word_n$ led to reduced skipping of $word_{n+1}$ and that an incorrect parafoveal preview was skipped less often than a correct preview, but these two effects did not interact. Clearly, the decision to skip $word_{n+1}$ is influenced by more factors than the amount of parafoveal processing. The ease of processing of $word_n$ also influences this decision. As such, the conclusions of this study suggest some modification is needed in the current implementation of the E-Z Reader model.

References

Baayen, R. H., Piepenbrock, R., & Van Rijn, H. (1993). The Celex Lexical Database (CD-ROM). Linguistic Data Consortium, University of Pennsylvania, Philadelphia, PA.

Besner, D., & Roberts, M. A. (2003). Reading nonwords aloud: Results requiring change in the dual route cascaded model. Psychonomic Bulletin & Review, 10, 398-404.

Brysbaert, M., Drieghe, D., & Vitu, F. (2005). Word skipping: Implications for theories of eye movement control in reading. In G. Underwood (Ed.), Cognitive Processes in Eye Guidance. Oxford University Press, pp. 53-77.

Drieghe, D., Rayner, K., & Pollatsek, A. (2005). Word skipping during reading revisited. Journal of Experimental Psychology: Human Perception and Performance, 31, 954-969.

Drieghe, D., Rayner, K., & Pollatsek, A. (2008). Mislocated fixations can account for parafoveal-on-foveal effects in eye movements during reading. Quarterly Journal of Experimental Psychology, in press.

Engbert, R., Nuthmann, A., Richter, E., & Kliegl, R. (2005). SWIFT: A dynamical model of saccade generation during reading. Psychological Review, 112, 777-813.

Henderson, J. M., & Ferreira, F. (1990). Effects of foveal processing difficulty on the perceptual span in reading - Implications for attention and eye-movement control. Journal of Experimental Psychology: Learning, Memory and Cognition, 16, 417-429.

Herdmann, C. M., Chernecki, D., & Norris, D. (1999). Naming case alternated words. Memory & Cognition, 27, 254-266.

Kliegl, R., & Engbert, R. (2005). Fixation durations before word skipping in reading. Psychonomic Bulletin & Review, 12, 132-138.

Nuthmann, A., Engbert, R., & Kliegl, R. (2005). Mislocated fixations during reading and the inverted optimal viewing position. Vision Research, 45, 2201-2217.

Pollatsek, A., Reichle, E.D., & Rayner, K. (2006). Tests of the E-Z Reader model: Exploring the interface between cognition and eye-movement control. Cognitive Psychology, 52, 1-56.

Rayner, K. (1975). Perceptual span and peripheral cues in reading. Cognitive Psychology, 7, 65-81.

Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. Psychological Bulletin, 124, 372-422.

Reichle, E. D., Pollatsek, A., Fisher, D. L., & Rayner, K. (1998). Toward a model of eye movement control in reading. Psychological Review, 105, 125-157.

Reingold, E. M., & Rayner, K. (2006). Examining the word identification stages hypothesized by the E-Z Reader model. Psychological Science, 17, 742-746.

White, S. J. (2007). Foveal load and parafoveal processing: The case of word skipping. In R. P. G. Van Gompel, M. H. Fischer, W. S. Murray and R. L. Hill (Eds.), Eye movements: a window on mind and brain. Elsevier, pp. 409-424.

Footnotes

1. Reingold and Rayner also had a condition that presented $word_n$ in boldface. Like the case-alternation condition, this condition was assumed to affect postlexical processing and did influence fixation times in a fashion similar to the case-alternation condition.

2. Because E-Z Reader states that a word is skipped by cancelling the saccade to the skipped word, it predicts an inflated fixation duration prior to skipping (for a discussion, see Kliegl & Engbert, 2005). Controlling for launch position by restricting the analysis to single fixations on $word_n$, no differences were observed between the fixation duration prior to skipping or landing on $word_{n+1}$ in the Normal condition [198 ms prior to skipping vs. 201 ms prior to landing, $t1(28)<1$; $t2(62)=-1.15$, $p>.20$], the Case Alternation condition [212 ms vs. 207 ms, $t1(26)=1.26$, $p>.20$; $t2(64)<1$], or in the Faint condition [383 ms vs. 393 ms, $t1(24)<1$; $t2(50) = 1.805$, $p>.05$].

3. Contrast were carried out for all comparisons between conditions. However, none of the contrasts for the fixation times on $word_{n+1}$ resulted in significant effects (all p's$>.05$).

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Table 1. Probability of skipping (Skip) word$_n$, as well as viewing times on word$_n$ (in ms): First Fixation Duration (FFD), Single Fixation Duration (SFD) and Gaze Duration (GD). Skipping probability of word$_{n+1}$ for all word lengths, and restricted to the 3 letter and 4 letter words.

	Word$_n$				Word$_{n+1}$ Skip		
	Skip	FFD	SFD	GD	All	3 LW	4 LW
Normal	.26	197	199	209	.61	.72	.52
Case Alternation	.13	209	211	232	.62	.69	.53
Faint	.20	336	385	496	.50	.59	.41

Table 2. First Fixation Duration (FFD), Single Fixation Duration (SFD) and Gaze Duration (GD) on word$_{n+1}$ for the three-letter words and for the four-letter words (in ms).

	Word$_{n+1}$ 3 letter word			Word$_{n+1}$ 4 letter word		
	FFD	SFD	GD	FFD	SFD	GD
Normal	197	202	205	204	204	205
Case Alternation	182	183	189	208	207	220
Faint	201	202	204	190	192	201