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Foveal load and parafoveal processing: The case of word skipping

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Foveal load and parafoveal processing: The case of word skipping

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Abstract

Three experiments show that localised foveal load does not modulate the probability of skipping the following 4-6 letter parafoveal word (word n+1). In Experiments 1 and 2 the preview of word n+1 was always correct. In Experiment 3 the preview of word n+1 was either correct or incorrect. Localised foveal difficulty did not significantly modulate the effect of preview on the probability of skipping word n+1. The results suggest that the processes that produce modulations of parafoveal preprocessing by foveal load on reading time measures may not apply to the control of word skipping.

As we read, we preprocess text that has not yet been fixated. Such preprocessing results in a greater probability of skipping words that are short, frequent or predictable compared to words that are long, infrequent or unpredictable (for reviews see Brysbaert & Vitu, 1998; Rayner, 1998). There are two different approaches to explaining the mechanisms that control which words are fixated or skipped during reading. The first is to suggest that the processes that determine word skipping are the same or similar to those that influence reading time. The second is to suggest that the processes that determine reading times and word skipping are qualitatively different. The present study investigates this issue by examining whether foveal load modulates parafoveal preprocessing in the same way for both reading times and word skipping.

Studies have suggested that the amount of parafoveal preprocessing, as shown by reading times, is limited by foveal processing difficulty[1] (Henderson & Ferreira, 1990; Kennison & Clifton, 1995; Schroyens, Vitu, Brysbaert, & d'Ydewalle, 1999; White, Rayner, & Liversedge, 2005). These studies used the boundary saccade contingent change technique which involves altering the parafoveal preview (which may be correct or incorrect) such that the word is correct when it is subsequently fixated (Rayner, 1975).

For example, Henderson and Ferreira (1990) compared reading times on critical words (e.g. *despite*) when the preview of that word was correct (e.g. *despite*) or incorrect (e.g. *zqdioyv*) and when the word prior to the critical word was either frequent (e.g. *chest*) or infrequent (e.g. *trunk*). The difference in reading times when the preview is correct or incorrect gives a measure of the extent to which preprocessing of the correct preview facilitates processing once the word is fixated, known as preview benefit (Rayner & Pollatsek, 1989). Henderson and Ferreira showed that preview benefits for the critical word were larger when the previous word was frequent compared to when it was infrequent. That is, parafoveal preprocessing was reduced (preview benefits were smaller) when foveal processing was difficult compared to when it was easy.

Two different accounts have been proposed to explain the finding that parafoveal preprocessing is limited by foveal load. One is based on serial processing of words and a second is based on parallel processing of multiple words. Critically, both these accounts suggest that foveal processing difficulty influences parafoveal preprocessing as shown by both reading times and word skipping.

Serial attention shift models, such as the E-Z reader model (Reichle, Pollatsek, Fisher, & Rayner, 1998; Reichle, Rayner, & Pollatsek, 1999, 2003), have adopted an architecture in which shifts of attention and programming of eye movements are de-coupled. After saccade programming to the following word (word n+1) has begun, linguistic processing of the fixated word (word n) continues. The time to process word n is influenced by foveal load. When processing of word n has finally completed, and usually before saccade programming is complete, attention shifts to word n+1 such that it can be preprocessed. Due to the de-coupling of saccade programming and attention, the time to preprocess word n+1 (whilst fixating word n) is restricted by the time required to complete processing of word n. Critically, the time to attend to word n+1 influences the extent to which word n+1 is preprocessed and therefore the amount of preview benefit for word n+1 (as shown by reading times on word n+1). Similarly, once attention has moved to word n+1, if there is sufficient time before the saccade is executed, and if word n+1 is identified quickly enough, then the saccade programme may be re-programmed to skip word n+1. Therefore both reading times and word skipping are determined by the same mechanism which is influenced by foveal load (time to process word n). Consequently Reichle et al. predict that foveal load should reduce the probability of skipping the following word.

In contrast, in their Glenmore model, Reilly and Radach (2003) suggest that multiple words can be processed in parallel and that there is competition between words for activation related to linguistic processing. Consequently greater processing of the fixated word reduces processing of other words. As a result, foveal load reduces preview benefit for the following word. Reilly and Radach also suggest that each word has a salience value, such that saccades are directed to the word with greatest salience. These salience values are influenced by the same linguistic activation system that influences reading times. Therefore, although not explicitly stated, Reilly and Radach’s account also appears to suggest that word skipping is modulated by foveal load.

To summarise, empirical evidence suggests that foveal load modulates parafoveal preprocessing as shown by reading time preview benefit. Both serial and parallel processing based accounts have been proposed that explain this phenomenon. Both these models also predict that foveal load modulates word skipping in a similar way as for preview benefits. However other studies have suggested that the processes that determine when and where the eyes move can be different (Radach & Heller, 2000; Rayner & McConkie, 1976; Rayner & Pollatsek, 1981). Indeed a number of models of eye movement control in reading have been developed in which different mechanisms determine when and where the eyes move. These models either do not predict that foveal load modulates preprocessing as in the case of SWIFT (Engbert, Longtin, & Kliegl, 2002; Kliegl & Engbert, 2003) and the Competition/Interaction model (Yang & McConkie, 2001), or they predict that both the when and the where systems are modulated by foveal load, as in Glenmore (Reilly & Radach, 2003). Nevertheless, accounts which differentiate between mechanisms that determine when and where the eyes move highlight the possibility that although foveal load modulates preprocessing as shown by reading times, foveal load may not necessarily modulate where the eyes move (as shown by the probability of word skipping).

The issue of whether foveal load modulates the probability of word skipping is therefore critical not only for evaluating the architecture of current models, but also for assessing the fundamental question of whether the mechanisms that determine when and where the eyes move are the same or different. Drieghe, Rayner, and Pollatsek (2005) investigated whether foveal load modulated the probability of skipping parafoveal three letter words (see also Kennison & Clifton, 1995). For cases in which there was a correct preview of the parafoveal word, Drieghe et al. showed no significant effect of foveal load on the probability of skipping the following word. Despite the non-significant result, skipping rates were numerically higher when there was low, compared to high, foveal load which is suggestive of the possibility that foveal load may modulate word skipping. Therefore it is important to examine whether foveal load does reliably influence word skipping. Also, as Drieghe et al. only tested the probability of skipping three letter words, it is important to test whether foveal load modulates the probability of skipping slightly longer words.

The present study includes three experiments that test whether localised foveal load influences the probability of skipping four to six letter parafoveal words. The manipulations of foveal load include orthographic regularity, spelling and word frequency. These manipulations are intended to influence the ease with which a specific word can be processed. Importantly, this study does not test whether general processing load modulates word skipping. General processing load may be modified by text difficulty (e.g. contextual factors) or reading strategy. For example, general processing load could modulate global parameters for eye movement control such that increased load might increase fixation durations or shorten saccade lengths (see Yang & McConkie, 2001). Within each of the experiments presented here such general factors are controlled by using the same sentence beginnings up until the critical words across each of the experimental conditions.

For all of the experiments presented here the analyses include only cases in which a single fixation was made on the foveal word and no regressions were made out of the foveal word. Refixations on the foveal word could modify factors which might influence word skipping, such as launch site and the quality of the parafoveal preview. Therefore restricting the analyses to cases in which single fixations were made on the foveal word ensures that any differences in skipping probabilities could not be accounted for by differences in refixation probabilities. Overall, if foveal load influences word skipping then the probability of skipping the parafoveal word (word n+1) should be greater when the foveal word (word n) is easy, compared to difficult, to process.

Experiment 1

In Experiment 1 foveal load was manipulated by orthographic regularity. The foveal word (word n) was either orthographically regular (low foveal load e.g. *miniature*) or orthographically irregular (high foveal load e.g. *ergonomic*) and was followed by the parafoveal word (word n+1) (e.g. *chairs*).

Note that the foveal processing load manipulation in Experiment 1 has been shown to have a small (less than 0.5 character) but reliable influence on initial fixation positions on these words (White & Liversedge, 2006a). Therefore in the present study, initial fixations land nearer to the beginning of the foveal words that are difficult to process (orthographically irregular) than the foveal words that are easy to process (orthographically regular). Consequently, the launch site prior to skipping or fixating word n-1 may have been slightly further away for the high foveal load words compared to the low foveal load words. Launch site may influence skipping probabilities such that saccades launched from further away may be less likely to skip word n+1. Importantly, note that the direction of these effects would have facilitated an effect of foveal load on word skipping such that when foveal load was high word n+1 would be less likely to be skipped. This additional factor would therefore have to be taken into account if orthographic modulations of foveal load were to modulate word skipping.[2]

Method

Participants. One hundred and four native English speakers at the University of Durham were paid to participate in the experiment. The participants all had normal or corrected to normal vision and were naïve in relation to the purpose of the experiment.

Materials and Design. The foveal word n had orthographically regular (low foveal load) or irregular (high foveal load) word beginnings and these two conditions were manipulated within participants and items. The parafoveal word n+1 was identical for each of the conditions within each item. The foveal words were nine or ten letters long and the parafoveal words were five or six letters long. Sixty of the participants read half of the sentences entirely in upper case, this variable was not included in the analysis[3]. There were 24 critical words in each condition. Word n and n+1 were embedded roughly in the middle of the same sentential frame up to and including word n+1. Each of the sentences was no longer than one line of text (80 characters). See Table 1 for examples of experimental sentences and critical words. Full details regarding the nature of the orthographic regularity manipulation and the construction of the stimuli lists can be found in White and Liversedge (2006a).

Insert Table 1 about here

Procedure. Eye movements were monitored using a Dual Purkinje Image eye tracker. Viewing was binocular but only the movements of the right eye were monitored. The letters were presented in light cyan on a black background. The viewing distance was 70cm and three and a half characters subtended one degree of the visual angle. The resolution of the eye tracker is less than 10 min of arc and the sampling rate was every millisecond.

Participants were instructed to understand the sentences to the best of their ability. A bite bar and head restraint were used to minimize head movements. The participant completed a calibration procedure and the calibration accuracy was checked after every few trials during the experiment. After reading each sentence the participants pressed a button to continue and used a button box to respond “yes” or “no” to comprehension questions.

Analyses. Fixations shorter than 80ms that were within one character of the next or previous fixation were incorporated into that fixation. Any remaining fixations shorter than 80ms and longer than 1200ms were discarded. Five percent of trials were excluded due to either no first pass fixations on the sentence prior to word n-1 or tracker loss or blinks on first pass reading of word n-1 or n.

Results and discussion

Paired samples t-tests were undertaken with participants (t_1) and items (t_2) as random variables. Eleven percent of trials were excluded due to first pass regressions made out of the foveal word and 30 percent of trials were excluded due to skipping or multiple first pass fixations on the foveal word.

Single fixation duration word n. Single fixation durations on word n were significantly longer in the high foveal load orthographically irregular condition (M = 366, SD = 135) than in the low foveal load orthographically regular condition (M = 314, SD = 100), $t_1(103) = 9.63$, $p < .001$; $t_2(23) = 6.4$, $p < .001$. The manipulation of the orthographic regularity of word n was clearly effective[4].

Skipping probability word n+1. There was no difference in the probability of skipping word n+1 on first pass between the high foveal load orthographically irregular condition (0.14) and the low foveal load orthographically regular condition (0.15), $t_1(103) = 1.62$, $p = .107$; $t_2(23) = 1.02$, $p = .319$. Regardless of whether the foveal word had caused reduced (e.g. *miniature*) or increased (e.g. *ergonomic*) foveal processing difficulty, the probability of skipping the following parafoveal word (e.g. *chairs*) was the same. The findings from Experiment 1 show that although orthographic regularity clearly increased processing time on word n, this had no effect on the probability of skipping the following word.

Experiment 2

Orthographic regularity significantly influenced single fixation durations on the foveal word in Experiment 1. Nevertheless, perhaps this manipulation of foveal difficulty was not sufficiently strong to influence subsequent word skipping. Experiment 2 used a stronger manipulation of foveal difficulty. Previous studies have shown that misspellings cause disruption to reading due to the difficulty associated with understanding nonwords as words (e.g. Zola, 1984). Therefore in Experiment 2 foveal difficulty was manipulated by spelling. The foveal words were either spelled correctly (low foveal load e.g. *performer*) or incorrectly (high foveal load e.g. *pwrformer*) and these were followed by the parafoveal words (e.g. *stood*). The method was the same as for Experiment 1 except where noted below.

Method

Participants. Forty-four native English speakers at the University of Durham participated in the experiment.

Materials and Design. The foveal word n was either spelled correctly (low foveal load) or misspelled (high foveal load) and these two conditions were manipulated within participants and items. The foveal words were all nine or ten letters long and the parafoveal words were five or six letters long. Half the foveal words were preceded by a frequent word and half by an infrequent word, this variable was not included in the analysis. Except for word n-1 (which had high or low word frequency), word n and word n+1 were embedded in sentence frames which were otherwise identical for each condition. See Table 2 for examples of experimental sentences and critical words. Full details regarding the nature of the misspelling manipulation, the word frequency manipulation, and construction of the stimuli lists can be found in White and Liversedge (2006b, Experiment 1).

Insert Table 2 about here

Procedure. Participants were instructed that some sentences would contain misspellings but that they should read and understand the sentences to the best of their ability.

Analyses. Seven percent of trials were excluded.

Results and discussion

The results were analysed in the same manner as for Experiment 1. Sixteen percent of trials were excluded due to first pass regressions made out of the foveal word and 30 percent of trials were excluded due to skipping or multiple first pass fixations on the foveal word.

Single fixation duration word n. Single fixation durations on word n were significantly longer in the high foveal load misspelled condition (M = 376, SD = 162) than in the low foveal load correctly spelled condition (M = 307, SD = 92), $t_1(43) = 7.59$, $p < .001$; $t_2(47) = 6.98$, $p < .001$. The manipulation of spelling accuracy on word n was clearly effective.

Skipping probability word n+1. There was no difference in the probability of skipping word n+1 on first pass between the high foveal load misspelled condition (0.3) and the low foveal load correctly spelled condition (0.3), (*t*s < 1). Regardless of whether the foveal word had caused reduced (e.g. *performer*) or increased (e.g. *pwrformer*) foveal processing difficulty, the probability of skipping the following parafoveal word (e.g. *stood*) was the same. Therefore, similar to Experiment 1, Experiment 2 showed no effect of foveal load on the probability of skipping the following word, even when a very strong manipulation of foveal processing difficulty was used.

Experiment 3

Foveal difficulty was manipulated by orthographic regularity in Experiment 1 and by spelling in Experiment 2. The findings of both these experiments suggest that localised foveal load does not modulate the probability of skipping the following word. In order to ensure that this finding is robust across a range of different types of localised foveal load, Experiment 3 used word frequency to modulate foveal processing difficulty. In addition, both Experiments 1 and 2 used long foveal words. Experiment 3 therefore tested whether the findings held for short foveal words. Furthermore, Experiment 3 manipulated the nature of the preview of the parafoveal word.

In Experiment 3 the foveal words (word n) had high word frequency (low foveal load e.g. *happy*) or low word frequency (high foveal load e.g. *agile*) and these were followed by the parafoveal word (e.g. *girl*). The boundary saccade contingent change technique (Rayner, 1975) was used such that the preview of the parafoveal word was either correct (e.g. *girl*) or incorrect (e.g. *bstc*). The reading time data for the parafoveal word in Experiment 3 are reported in White et al. (2005) (Group 1 data). When foveal load was low (e.g. *happy*), there was 47ms gaze duration preview benefit for the subsequent word (e.g. *girl*) whereas when foveal load was high (e.g. *agile*) there was only 1ms gaze duration preview benefit. Similar to Henderson and Ferreira (1990) these results show that the difficulty of the foveal word modulates preprocessing (preview benefit) for the following word. Therefore in Experiment 3 foveal load is clearly modulating parafoveal preprocessing, at least as shown by when the eyes move.

If foveal load modulates the probability of skipping the following word then the correct preview of word n+1 will be more likely to be skipped when the foveal word is easy (high frequency) compared to difficult (low frequency) to process. If this is the case then the influence of foveal load on the probability of skipping the visually dissimilar incorrect preview should provide further insight into the nature of such an effect. First, foveal load may influence the probability of skipping word n+1 regardless of the characteristics of word n+1. That is, foveal load should have the same effect on the probability of skipping word n+1 both when the preview is correct (e.g. *girl*) and incorrect (e.g. *bstc*). Second, it might be argued that words should usually only be skipped if they are familiar (Reichle et al., 1998, 1999, 2003). Consequently the incorrect preview of word n+1 (e.g. *bstc*) should be skipped only very rarely because it is an unfamiliar nonword. That is, there should be an interaction such that foveal load modulates the probability of skipping the correct, but not the incorrect, previews of word n+1. The Method for Experiment 3 is the same as for Experiment 1 except where noted below.

Method

Participants. Thirty-two students at the University of Massachusetts were paid or received course credit to participate in the experiment.

Materials and Design. Two variables, foveal processing difficulty (word n) and parafoveal preview (word n+1), were manipulated within participants and items. The foveal word n was easy to process (high frequency, *happy*) or difficult to process (low frequency, *agile*). The preview of word n+1 before it was first fixated was correct (*girl*) or incorrect (*bstc*). The foveal word n was either five or six letters long and the parafoveal word was always four letters long. Full details regarding the nature of the materials and construction of the stimuli lists can be found in White et al. (2005). See Table 3 for examples of experimental sentences and critical words.

Insert Table 3 about here

Procedure. The eye contingent boundary technique was used (Rayner, 1975); the display changes occurred within 5ms of detection of the boundary having been crossed. Sentences were displayed at a viewing distance of 61cm and 3.8 characters subtended one degree of visual angle.

Analyses. Trials were excluded due to: (a) display changes happening too early, (b) tracker loss or blinks on first pass reading of words n or n+1 and (c) zero reading times on the first part of the sentence. Seventeen percent of trials were excluded[5].

Results and discussion

Fourteen percent of trials were excluded due to first pass regressions made out of the foveal word and 22 percent of trials were excluded due to skipping or multiple first pass fixations on the foveal word. A series of 2 (word n foveal load: frequent, infrequent) by 2 (word n+1 preview: correct, incorrect) repeated measures Analyses of Variance (ANOVAs) were undertaken with participants (F_1) and items (F_2) as random variables. Table 4 shows the mean single fixation durations on word n and the probability of skipping word n+1 for Experiment 3.

Insert Table 4 about here

Single fixation duration word n. Single fixation durations on word n were significantly longer in the high foveal load infrequent condition than in the low foveal load frequent condition, $F_1(1,31) = 11.99$, $p < .01$; $F_2(1,40) = 18.37$, $p < .001$. There was no effect of the preview of word n+1, $F_1(1,31) = 1.16$, $p = .29$; $F_2 < 1$, and no interaction between the frequency of word n and the preview of word n+1, $F_1(1,31) = 1.81$, $p = .188$; $F_2(1,40) = 2.99$, $p = .092$, for single fixation durations on word n. Therefore the manipulation of foveal load on word n was clearly effective and the preview of word n+1 did not significantly influence reading times on word n.

Skipping probability word n+1. The parafoveal words were more likely to be skipped when the preview was correct (.185) compared to when it was incorrect (.135), this effect was significant across participants, $F_1(1,31) = 4.91$, $p = 0.03$, but not items, $F_2(1,40) = 2.63$, $p = 0.113$. Importantly, the effect of preview on the probability of word skipping indicates that the linguistic characteristics of parafoveal words influences whether they are subsequently fixated. The parafoveal word n+1was skipped on 17% of trials when the foveal word n was high frequency and 15% of trials when the foveal word was low frequency. Foveal load had no significant effect on the probability of skipping the parafoveal word (*F*s < 1) and there was no interaction between foveal load and the parafoveal preview, $F_1 < 1$; $F_2(1,40) = 1.51$, $p = 0.226$.

As in Experiments 1 and 2, there was no difference in the probability of skipping a correct preview of word n+1 when there was low (0.18) compared to high (0.19) foveal load. Therefore, regardless of whether the foveal word had caused reduced (e.g. *happy*) or increased (e.g. *agile*) foveal processing difficulty, the probability of skipping the following parafoveal word (e.g. *girl*) was the same. However note that word n+1 was numerically less likely to be skipped when there was high foveal load and an incorrect parafoveal preview, compared to the other conditions. The nature of this interactive pattern is similar to that shown by Drieghe et al. (2005) (see Drieghe et al. for an extended discussion of possible explanations).Critically, the absence of any effect of foveal load on the probability of skipping the correctly spelled word n+1 suggests that whatever might have caused the numerical effect for incorrect previews does not hold during normal reading of correctly spelled text.

General Discussion

All three of the experiments presented here show no effect of localised foveal load on the probability of skipping four to six letter words. The results are consistent with Drieghe et al.’s (2005) finding that, for correctly spelled words, there was no significant difference between the probability of skipping three letter words when there was high, compared to low, foveal load. Although Drieghe et al. showed a numerical difference in skipping probabilities, the fact that none of the experiments here showed more than a 0.01 difference in skipping probabilities for correctly spelled words suggests that there is no reliable effect of foveal load on the probability of word skipping when reading normal text. These findings contrast with studies which demonstrate that foveal load modulates parafoveal preprocessing as shown by preview benefit (Henderson & Ferreira, 1990; Kennison & Clifton, 1995; Schroyens et al., 1999; White et al., 2005). Furthermore, the fact that the same experiment demonstrated such effects for reading times (as reported in White et al.) but shows no such effects for word skipping (Experiment 3) is particularly poignant. Together, these findings provide strong evidence for the notion that localised foveal load modulates preview benefits but not the probability of skipping the following word.

Although the experiments presented here suggest that localised foveal load does not influence the probability of word skipping, as noted in the Introduction this does not preclude the possibility that general processing load may have a global influence on skipping rates. Indeed, note that the skipping probabilities are higher in Experiment 2 than in either Experiments 1 or 3. This could be because the sentence beginnings included context relevant to the remainder of the sentence in Experiment 2, and because word n+1 tended to occur later in the sentence in Experiment 2 compared to the other experiments. Such differences could have influenced general processing load which may have modulated skipping probabilities.

The current study suggests that localised foveal load modulates parafoveal preprocessing as shown by reading times, but not as shown by word skipping. It is possible that foveal load may influence word skipping, but this effect may be so very small that it is undetectable in standard reading experiments. Alternatively, reading times and word skipping may be influenced by qualitatively different processes. The latter suggestion would be inconsistent with accounts which suggest that foveal load influences reading times and word skipping by the same mechanism (Reichle et al., 1998, 1999, 2003) or due to a common input (Reilly & Radach, 2003). However, if necessary such models might be adapted such that the word skipping mechanism operated independent of foveal load.

The possibility that reading times and word skipping are controlled by qualitatively different processes supports the notion that different processes might determine when and where the eyes move (Rayner & McConkie, 1976). Indeed, White and Liversedge (2006b) also showed that foveal difficulty does not modulate parafoveal orthographic influences on where words are first fixated. This finding suggests that saccade targeting to a word is also independent of foveal processing load. However note that the processes that determine word skipping and saccade targeting may be different to other types of “where” decisions such as refixations and regressions.

The findings presented here indicate that words may be preprocessed qualitatively differently for the mechanisms that determine reading times and word skipping. Parafoveal preprocessing that is limited by foveal load influences the mechanisms that determine reading times. In contrast, word skipping mechanisms may be influenced by parafoveal preprocessing that occurs regardless of foveal load. For example, the processes that determine reading times may be sensitive to the progress of word recognition and sentence comprehension processes. Such language comprehension processes might be limited by processing load such that a parafoveal word is preprocessed to a lesser extent when there is high, compared to low, foveal load. Therefore reading time preview benefits for parafoveal words reflect reduced preprocessing of words when there is high, compared to low, foveal load. In contrast, the processes that determine word skipping may acquire information from parafoveal text in an automatic manner, independent of comprehension difficulty, such that words can be skipped even if they have not been recognised.

The processes that determine word skipping may be different from those which determine reading times because word skipping may only be influenced by parafoveal information. Note that as a result, the eyes may sometimes become “out of sync” with the location of attention (the progress of sentence comprehension). For example, when reading the phrase “*agile girl*”, the high frequency word *girl* may be skipped before the low frequency word *agile* has been fully processed. Consequently processing of skipped words may continue on subsequent fixations. This suggestion is consistent with the finding that there are more regressions following skips, compared to first pass fixation, of words (Vitu, McConkie, & Zola, 1998). Such an automatic word targeting mechanism may sometimes move the eyes away from what needs to be processed. However a system based on simple parafoveal linguistic processing may be most optimal for selecting which words to fixate given the very limited time periods available for saccade programming.

To summarise, the results suggest that qualitatively different mechanisms might determine parafoveal preprocessing as shown by reading times (preview benefit) and word skipping. Future accounts of eye movement control in reading may need to adopt an architecture in which there is separate processing of, and possibly inputs to, the mechanisms that determine preview benefits and word skipping.

Footnotes

[1] These studies used incorrect preview conditions in which multiple letters were incorrect. Other studies which have used incorrect previews containing a single internal incorrect letter have not shown any modulation of preprocessing by foveal load (Drieghe, Rayner, & Pollatsek, 2005; White & Liversedge, 2006b).

[2] Similar reasoning also applies in Experiment 2. The misspellings used in Experiment 2 were also found to modulate saccade targeting (White & Liversedge, 2006b).

[3] In Experiment 1 type case did not significantly influence reading times on the foveal word n.

[4] For all three of the experiments the foveal load manipulation for word n also significantly influenced first fixation durations and gaze durations on word n.

[5] Note that a larger proportion of data was excluded in Experiment 3 compared to Experiments 1 and 2 because the display contingent change technique requires that additional data must be excluded due to display changes happening too early.

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Tables

Table 1. Examples of Experimental Sentences and Critical Words for Each Condition in Experiment 1. Word n is Shown in Italics. For Each Sentence Frame, Version a. is the Low Foveal Load (Regular Beginning Word) Condition and Version b. is the High Foveal Load (Irregular Beginning Word) Condition.

1a. Last Friday the modern *miniature* chairs were placed in the dolls house.

1b. Last Friday the modern *ergonomic* chairs were transported to the shops.

2a. He hated the heavy *primitive* tools that the farmer gave him to use.

2b. He hated the heavy *pneumatic* tools that were used to dig up the road.

3a. He knew that the clever *candidates* would produce impressive answers.

3b. He knew that the clever *auctioneer* would ask him about the valuable lots.

4a. She knew that the modern *extension* would add value to the house.

4b. She knew that the modern *ointments* would work if she could get them in time.

Table 2. Examples of Experimental Sentences and Critical Words for Each Condition in Experiment 2. Word n is Shown in Italics. For Each Sentence Frame, Version a. is the Low Foveal Load (Correctly Spelled) Condition and Version b. is the High Foveal Load (Misspelled) Condition.

1a. After the circus act the famous *performer* stood to receive the applause.

1b. After the circus act the famous *pwrformer* stood to receive the applause.

2a. At the meeting the whole *committee* voted against the planning application.

2b. At the meeting the whole *ctmmittee* voted against the planning application.

3a. The tourists enjoyed talking to the young *traveller* about his many experiences.

3b. The tourists enjoyed talking to the young *tlaveller* about his many experiences.

4a. The brave explorers knew that the great *endeavour* would need a lot of effort.

4b. The brave explorers knew that the great *ezdeavour* would need a lot of effort.

Table 3. Examples of Experimental Sentences and Critical Words for Each Condition in Experiment 3. Word n is Shown in Italics. For Each Sentence Frame, Version a. is the Low Foveal Load (High Frequency) Condition and Version b. is the High Foveal Load (Low Frequency) Condition. The Incorrect Preview of Word n+1 is Shown in Parentheses.

1a. Outside the school the *happy* girl (bstc) skipped around the other children.

1b. Outside the school the *agile* girl (bstc) skipped around the other children.

2a. The supporters cheered when the *local* team (wtdr) finally won the match.

2b. The supporters cheered when the *inept* team (wtdr) finally won the match.

3a. The cook ordered the *daily* food (gkhn) from the local market.

3b. The cook ordered the *bland* food (gkhn) from the local market.

4a. The child pestered the *green* fish (jbws) that was hiding behind the pondweed.

4b. The child pestered the *timid* fish (jbws) that was hiding behind the pondweed.

Table 4. Experiment 3. Single Fixation Durations on Word n. Standard Deviations in Parentheses. Probability of Skipping Word n+1.

Word n	Preview of word n+1	Word n	Word n+1
		Single fixation duration	Skipping probability
Frequent	Correct	277 (83)	0.18
	Incorrect	295 (103)	0.16
Infrequent	Correct	321 (112)	0.19
	Incorrect	311 (110)	0.11