Effects of Parafoveal Plausibility During Reading

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Abstract

There is controversy concerning the question of whether meaning can be extracted from a parafoveal word during reading and whether this might occur in an overlapping fashion with the lexical processing of the currently-fixated word. We suggest that previous attempts to investigate this have been bedevilled by problems associated with the use of priming methodology. Instead, we used an eye movement contingent change technique and manipulated the plausibility of the parafoveal preview, resulting in it being either valid, a plausible alternative, anomalous, or an illegal letter string. The results showed (a) a meaning-based parafoveal-on-foveal effect, (b) preview benefits driven by both orthographic and semantic influences, and (c) continuing disruption associated with orthographically dissimilar previews. We suggest that this pattern is most consistent with models of eye movement control that allow for distributed attention during reading.

Keywords: Eye movements; preview benefit; plausibility; parafoveal-on-foveal effects; boundary technique; reading.

Introduction

The nature of Preview Benefit (PB) – the advantage accruing to the reader from an accurate parafoveal preview of the following word – critically informs our understanding of the reading process, indicating those features which are, and are not, extracted from an as yet unfixated word. Using the boundary paradigm (Rayner, 1975), many studies have shown that both orthographic and phonological features appear to be extracted from parafoveal words (see Schotter, Angele & Rayner, 2012, for a review); however, evidence for a semantic PB remains controversial (see Radach & Kennedy, 2013*;* Rayner, White, Kambe, Miller & Liversedge, 2003).

While both serial (e.g., E-Z Reader; Reichle, Warren, & McConnell, 2009) and parallel (e.g., SWIFT; Engbert, Nuthmann, Richter & Kliegl, 2005) models of eye movement control during reading provide accounts of orthographic and phonological PB, only parallel models appear capable of accounting for semantic PB. In serial models, lexical processing is restricted to one word at a time, with attention moving to the parafoveal word only when the currently fixated word has been fully identified. Serial models therefore typically only accommodate very early stages of word recognition occurring on parafoveal words before a saccade remarries fixation location with attention. In contrast, in parallel models, all words within the perceptual span can be processed simultaneously, up to and including the level of semantic processing.

Studies investigating semantic PB have typically manipulated the sematic relatedness of the preview and the target word, on the basis that responses to semantically related word pairs are facilitated compared to unrelated pairs (Meyer & Schvaneveldt, 1971). By extension, it is suggested that semantically related previews should facilitate target viewing compared to unrelated previews. Using the boundary paradigm, Rayner Balota and Pollatsek (1986) asked participants to read sentences such as *"My younger brother has brilliantly composed a new song for the school play"*, in which the pre-fixation preview of "song" was either "song" (valid), "tune" (related), "door" (unrelated), or "sorp" (a visually similar nonword). Only once the eye passed an invisible boundary, located before the critical word, did the target word "song" appear. Despite showing that their critical words produced facilitation in a classic priming experiment, Rayner et al found no evidence for a semantic PB during reading. However, in this example sentence, we see that the word to the left of the target contains only three letters, and as short words are frequently skipped (Rayner & McConkie, 1976), the prior fixation may in fact have fallen two words to the left of the target, seriously reducing the chance of it eliciting a semantic PB.

A more general problem with experiments investigating semantic PB using associative previews is that while there may be semantic facilitation, there is also a word change that might be expected to give rise to some form of inhibition. Semantically related word pairs, such as north–south, rattle-bottle and arms–legs, (from Rayner et al, 1986), have very different meanings, and this could exert an inhibitory effect on on-going sentence interpretation. Rayner et al (1986) attempted to test this possibility by asking participants to rate their sentence pairs for similarity of meaning and reanalysing the results from only the 20 sentence pairs rated as most similar in meaning. Since this analysis again failed to show a semantic PB, they dismissed this as an explanation for their null result. However, a measure of overall sentence meaning does not necessarily capture the extent to which a local change in word meaning might have disrupted the reading process at the point at which it occurred. We conclude, therefore, that interference resulting from word change remains a possibility.

Altarriba, Kambe, Pollatsek and Rayner (2001) used a variant of this technique with fluent English-Spanish bilinguals. They employed semantically related previews which were translations with virtually the same meaning as the targets, thereby reducing the possibility of interference. All changes involved a word preview from the other language that was either: *cognate* (orthographically and semantically similar), *noncognate* (semantically similar but orthographically dissimilar), *pseudocognate* (semantically unrelated but orthographically similar), or *control* (unrelated orthographically and semantically). They found no evidence for a semantic PB in the absence of orthographic similarity. However, it remains possible that facilitation might not cross over between the lexica of the two languages, and as Hohenstein, Laubrock and Kliegl (2010) point out, since the previews and targets were in different languages, switching costs (Meuter & Allort, 1999) might mask any semantic PB.

Hohenstein et al (2010) suggest that the elusive nature of semantic PB may result from a lack of control over the preview duration of masked words. To test this possibility, they used fast priming (Sereno & Rayner, 1992) and the boundary paradigm in a novel way. Prior to landing on the pretarget word, the target was masked with an illegal letter string. Once the eye landed on the pre-target word, this illegal nonword preview changed to either a semantically related or unrelated prime for durations of 35ms, 80ms or 125ms, after which point, the target was displayed. Hohenstein et al report a significant semantic PB only when the prime duration was 125ms (Experiments 1 & 2). When primes were presented in bold typeface, a significant effect was observed with 80ms primes, although, the 125ms effect was no longer significant (Experiment 3). Given the transient nature of the effects and variability across experiments, these results would benefit from replication.

An alternative way to explore when the meaning of a word becomes available is to investigate plausibility effects. For example, Murray and colleagues (Kennedy, Murray & Boissiere, 2004; Murray, 2006; Murray, 1998; Murray & Rowan, 1998) recorded eye movements in a series of experiments where plausibility was manipulated. Participants read a sentence and then pressed a button, triggering another sentence to be displayed; the task being to indicate whether the two sentences were the same or different. These studies showed effects of the plausibility of the combination of the initial noun phrase with the verb, for example, "*The hunters stacked….*" vs "*The bishops stacked…*", and in a number of the studies, this was reflected not only in fixations falling on the verb, but also in some eye movement measures before the verb was directly fixated, suggesting the extraction of meaning from words in the parafovea. However, Rayner et al (2003) report being unable to replicate one of Murray et al's findings in a reading study and suggest that their results may have been task specific.

Starr and Inhoff (2004; Experiment 1) also investigated the consequences of providing a contextually inappropriate word to the right of fixation. They masked a critical word with itself, a contextually inappropriate word, or a legal or illegal nonword. In addition to finding clear orthographic parafoveal-on-foveal effects, a trend also emerged in which a contextually inconsistent word in the parafovea reduced gaze duration by 22ms on the pre-target word compared to an accurate preview. However, a subsequent analysis excluding the 45% of cases where fixations fell near the ends of the pre-target words (possibly as a result of oculomotor error) showed no reliable effect. The contextually inconsistent preview also gave rise to inflated fixation times when the target was fixated, but this effect could be attributed to a lack of orthographic overlap, rather than any extraction of parafoveal meaning.

While plausibility related parafoveal-on-foveal effects remain controversial, it is widely accepted that the plausibility of words within a sentence can have an immediate impact on fixation durations falling on the word. For example, Rayner, Warren, Juhasz and Liversedge (2004) presented participants with a series of sentences in which a critical noun was either plausible (likely), implausible (unlikely) or anomalous (inappropriate), given the preceding sentence context. They found that anomalous words had an immediate impact on gaze duration, while effects of implausibility were reflected only in later measures. Interestingly, they also discovered a plausibility-related parafoveal-on-foveal effect, with gaze duration on the word preceding the anomalous one being 17ms and 14ms longer than in the control and implausible conditions, respectively. The authors, however, attribute this effect to oculomotor error.

Whether or not one questions the interpretation of apparent semantic parafoveal-on-foveal effects, it is clear that manipulating the plausibility of a word can produce robust effects on the reading pattern when that word is fixated. This study capitalised on that finding and presented participants with sentences in which a critical word (n+1) was masked prior to receiving a direct fixation by either a (a) valid (identical), (b) plausible but different, or, (c) anomalous word, or (d) an illegal nonword. Once the eye passed an invisible boundary located before $word_{n+1}$, all previews were replaced with the valid preview. If meaning is extracted from the parafovea, it would be expected that an anomalous preview should exert an immediate impact on $word_{n+1}$ fixations compared to the plausible preview condition. Conversely, if the meaning of the parafoveal word is not extracted while fixating $word_n$, then plausible and anomalous previews should both produce the same cost, as a result of their lack of orthographic overlap with the target. The illegal nonword served as a baseline against which the magnitude of PB could be judged.

Method

Participants

Twenty-eight native English speakers with normal or corrected to normal vision took part for course credits or £5 payment.

Materials and Design

Ninety-six experimental sentences were constructed. As can be seen in the example below, each contained a critical word pair, comprising a 6 letter verb ($word_n$) followed by a 6 or 7 letter noun ($word_{n+1}$). To facilitate processing, $word_n$ was always high frequency (mean 135 occurrences per million, by Kucera & Francis, 1967). $Word_{n+1}$ was assigned one of four pre-fixation previews, all chosen to be very low in predictability: valid (e.g. "dinner" - identical), plausible (e.g., "coffee" – an alternative that fitted the preceding context), anomalous (e.g. "caught" - a word that produced a semantic or grammatical violation), or an illegal nonword (e.g., "fumeio" – a letter string containing combinations not found in the English dictionary, in this case "eio"). The frequency of these three preview words did not differ (means 132, 144 and 140 per million respectively, all *t*s<1). Previews were displayed until the eye passed an invisible boundary located prior to the space before $word_{n+1}$, shown below with a "|". When the eye crossed this boundary, the target word was then displayed.

n n+1
The mother was making| dinner in the kitchen for her two children and her husband.

Plausibility ratings were provided by 12 participants, who did not take part in the eye tracking experiment. Participants rated all three versions of each sentence up to and including $word_{n+1}$ (illegal letter strings were not included). They used a rating scale from 1 (low) to 7 (high) plausibility. Additionally, they could use "U" instead of providing a numerical rating if they felt the sentences were ungrammatical; "U" scores were coded as 0 for purposes of analysis. The valid and plausible fragments were both rated as highly plausible (means = 6.3 and 6.2, respectively), with no significant difference between these conditions ($t(95)=.85$, $p=.40$). The mean rating for the anomalous condition was 1.0 which differed significantly from both the valid ($t(95)=44.63$, $p<.001$), and plausible conditions ($t(95)=45.90$, $p<.001$).

Four counterbalanced item lists were created, each containing the 96 experimental sentences together with 19 filler and 8 practice items and 20 comprehension questions. $Word_{n+1}$ previews initially masked the target, with each item list containing an equal number of valid, plausible, anomalous and illegal nonword previews. Each participant was presented with the items in a different randomised order.

Apparatus

A dental composition bite bar and chin rest were used to minimise head movements. Sentences were displayed on a VDU screen in white monopitch font on a black background. At a viewing distance of 50cm, each character subtended approximately 0.3 degrees of a visual angle. Reading was binocular, but only eye movements from the right eye were recorded using a "Dr. Bouis" infrared pupil-centered computation device sampled with a 12-bit A-D at 2ms intervals. The apparatus was calibrated after every fourth sentence. In order to answer questions, right-hand ("*yes*") and left-hand ("*no*") button boxes were provided.

Procedure

Verbal and written instructions were provided. Calibration consisted of looking at a series of horizontally aligned numbers. Once optically set up and calibrated, participants fixated a cross, which after receiving a 100ms stable fixation, triggered display of a sentence. Participants were asked to read for comprehension, but not to adjust their usual reading style. If presented with a question, they were asked to respond using the button boxes.

Results and Discussion

Data were analysed treating both participants (F_1) and items (F_2) as random variables. In all analyses item file was treated as a between-groups dummy factor. Analysis focused on the pretarget word (n), the target word (n+1) and a spillover region comprising the following three words. A number of eye movement measures are reported for each region: the duration of the first and last fixations, gaze duration (summed duration of all fixations until the eye exits the region in either direction), go-past time (summed duration of all fixations, including regressions until the following region is first fixated) and first pass skipping probability. Participants clearly read carefully, with 86% overall accuracy on the comprehension questions.

Effects of $Word_{n+1}$ Preview on $Word_n$

The probability of fixating $word_n$ did not vary across conditions (both *F*s<1) and first fixation duration, gaze and go-past time showed no reliable effect of preview type (all *F*s<1.3). A trend did however emerge in last fixation duration (F_1 (3,72) = 2.81, $p<.05$; F_2 (3,276) = 2.05, $p=.11$) with shorter fixations when the preview was either an illegal nonword or an anomalous word. While first and last fixation durations constitute overlapping sets, the two measures potentially tap into differing processes. It is not surprising, therefore, to find a trend emerging statistically only for those fixations which were the last to fall on the word. For this measure, pairwise comparisons showed no significant difference between the valid and plausible conditions (F_1 (1,24) = 2.07, $p=.16$, F_2 (1,92) = 2.21, $p=.14$), however, when these two conditions were combined and compared to the anomalous condition, durations were reliably shorter in the anomalous condition (F_1 (1,24) = 5.30, $p<.05$, F_2 (1,92) = 4.29, $p<.05$), suggesting that this preview attracted attention from $word_n$. The same trend emerged when an illegal nonword fell to the right of fixation, although the difference between the combined valid and plausible conditions and the illegal nonword preview was only reliable over subjects (F_1 (1,24) = 4.54, $p<.05$, F_2 (1,92) = 1.10, $p=.30$). The pattern overall, however, suggests that readers respond similarly to both orthographic illegality and

anomaly to the right of fixation. This speed-up seems similar to the finding by Starr and Inhoff (2004) of a trend towards shorter gaze durations on the pre-target word when the target preview was contextually inconsistent.

Table 1: Fixation times (ms) and skipping probability (%) on $word_n$ as a function of $word_{n+1}$ preview

	FFD	LFD	Gaze	Go-Past	Skip
Valid	257	257	274	301	8
Plausible	263	264	280	305	8
Anomalous	255	253	278	305	8
Illegal	258	253	268	296	10

Interestingly Rayner et al (2004) reported an effect of parafoveal anomaly on $word_n$ in the opposite direction, with longer fixations when there was an anomalous word to the right of fixation. They concluded this must result from mislocated fixations, with the reader staying and processing $word_{n+1}$ from a sub-optimal parafoveal location. But a reduction in fixation duration does not permit the same interpretation. These results and the pattern apparent in Starr and Inhoff's contextually inconsistent condition appear more consistent with Kennedy's (1998, 2000) attractor hypothesis, in which something unexpected in the periphery attracts attention, resulting in shorter fixation durations on the preceding word. Parafoveal-on-foveal effects have frequently been reported as a consequence of orthographic peculiarities to the right of fixation; however, here we see it, to an equivalent extent, as a consequence of meaning.

$Word_{n+1}$ Preview Effects on $Word_{n+1}$

There was no reliable effect of preview on the skipping of $word_{n+1}$ (F_1 (3,72) = 1.50, p=.22; F_2 (3,276) = 1.70, p=.16). There was, however, a consistent effect of prior preview in all durational measures: first (F_1 (3,72) = 7.43, p<.001; F_2 (3,276) = 5.81, p<.01), and last fixation durations (F_1 (3,72) = 4.69, p<.01; F_2 (3,276) = 3.5, p<.05), gaze duration (F_1 (3,72) = 8.87, p<.001; F_2 (3,276) = 8.71, p<.001), and go-past time (F_1 (3,72) = 7.65, p<.001; F_2 (3,276) = 9.29, p<.001). As can be seen from Table 2, the longest durations were associated with words previously masked by an illegal nonword, followed by anomalous then plausible previews, with valid previews associated with the shortest durations.

Table 2: Fixation times (ms) and skipping probability (%) on $word_{n+1}$ as a function of $word_{n+1}$ preview

	FFD	LFD	Gaze	Go-Past	Skip
Valid	267	267	298	331	5
Plausible	277	275	299	345	6
Anomalous	281	277	313	370	7
Illegal	287	283	331	389	4

Pairwise comparisons revealed that a preview of an illegal nonword increased fixation durations across all measures: first (F_1 (1,24) = 47.02, p<.001; F_2 (1,92) = 18.06, p<.001); and last fixation durations (F_1 (1,24) = 21.87, p<.001; F_2 (1,92) = 14.97, p<.001); gaze duration (F_1 (1,24) = 23.00, p<.001; F_2 (1,92) = 23.68, p<.001) and go-past time (F_1 (1,24) = 15.69, p<.001; F_2 (1,92) = 26.67, p<.001).

Readers also appear to have noticed the change from the plausible preview to the valid target, reflected in a reliable increase in first fixation duration (F_1 (1,24) = 5.66, p<.05; F_2 (1,92) = 5.00, p<.05). However, the similar trends in last fixation duration and go-past time failed to achieve statistical significance (F_1 (1,24) = 3.22, p=.08; F_2 (1,92) = 2.62, p=.11 and F_1 (1,24) = 3.70, p=.06; F_2 (1,92) = 1.73, p=.19, respectively) and there was no effect in gaze duration (both Fs<1). Overall, this pattern suggests that the change from a different, though plausible, word was noticed immediately and resulted in an increased probability of regressing, as reflected in go-past time, but not in gaze duration, since this is terminated by the regressive movement. It is not clear, however, whether this is an effect of meaning change, since it could equally be a consequence of the lack of orthographic overlap between the plausible preview and target.

A test of the effect of meaning can, however, be found in the contrast between plausible and anomalous previews, since both involve a change in orthography. The results here suggest that the meaning of $word_{n+1}$ was indeed extracted while fixating $word_n$. While both first and last fixation duration showed no evidence of an increased cost of anomaly (all Fs<1), the 14ms increase in gaze duration was significant by-subjects and approached significance by-items (F_1 (1,24) = 4.78, p<.05; F_2 (1,92) = 2.99, p=.08) and with regressions taken into account, the 25ms increase in go-past time was significant by-subjects and very close to significant by-items (F_1 (1,24) = 5.88, p<.05; F_2 (1,92) = 3.51, p=.06).

As can be seen in Table 3, an increase in go-past time following anomalous previews also arose in the spillover region (see below). Combining $word_{n+1}$ and the spillover regions, the difference in go-past between the plausible (898ms) and anomalous (946ms) conditions was significant by both subjects and items (F_1 (1,24) = 7.29, p<.05; F_2 (1,92) = 6.17, p<.05). This effect – an immediate and robust slowing in the anomalous condition - is in the expected direction based on, for example, the findings of Rayner et al (2004), who suggest that anomalous words "hit the reader over the head" (p. 1297). It seems from these results however, that the genesis of this effect can be parafoveal, with the reader detecting anomaly far earlier than previously thought.

It could be suggested that these results stem from $word_n$ receiving full lexical access, allowing an attention shift to $word_{n+1}$ which also received full lexical access and semantic interpretation, all prior to $word_{n+1}$ being fixated. While possible, this seems extremely unlikely with both the low predictability and length of $word_{n+1}$ conspiring against such rapid parafoveal identification.

These results strongly suggest that parafoveal preview effects are not restricted to the extraction of orthographic

and phonological features, but rather, that higher level linguistic processing can be engaged when previewing words to the right of fixation, and when the input changes, as happened here, this interferes with later comprehension.

$Word_{n+1}$ Preview Effects in the Spillover Region:

As shown in Table 3, the spillover region was rarely skipped, with little difference between the preview conditions (both *F*s<1). Both first and last fixation durations were unaffected by $word_{n+1}$ preview type (all *F*s<1), as was gaze duration (F_1 (3,72) = 1.56, p=.21; F_2 (3,276) = 1.62, p=.18). There was, however, a highly significant effect of $word_{n+1}$ preview on go-past time (F_1 (3,72) = 6.98, p<.001; F_2 (3,276) = 10.48, p<.001), with higher durations when $word_{n+1}$ had been changed.

Table 3: Fixation times (ms) and skipping probability (%) in the spillover region as a function of $word_{n+1}$ preview

	FFD	LFD	Gaze	Go-Past	Skip
Valid	256	247	465	505	1
Plausible	254	249	480	553	0
Anomalous	254	254	486	576	1
Illegal	255	250	485	541	1

Pairwise comparisons show go-past time significantly higher following an illegal nonword compared to a valid preview (F_1 (1,24) = 7.65, p<.05; F_2 (1,92) = 5.99, p<.05). This finding is difficult to reconcile with models such as E-Z Reader in which orthographic extraction occurs during the first stage of lexical processing on a word (L_1). L_1 can commence on $word_{n+1}$ if the word is parafoveally available while fixating $word_n$. However, if preview is denied, L_1 is delayed until $word_{n+1}$ is fixated, resulting in the standard $word_{n+1}$ PB. But as soon as L_1 is complete, a saccade is programmed to $word_{n+2}$, at which point the second stage of lexical processing (L_2) commences. Since it is postulated that this stage follows orthographic extraction, the time for attention to shift to $word_{n+2}$ should only ever be a function of later linguistic processing and not delayed by difficulties with orthographic extraction. According to the E-Z Reader model, therefore, it should never be the case that fixation durations are inflated after $word_{n+1}$ has been passed – unless of course they are 'mislocated', but in that case the response should be to stay and process, rather than to regress, as seen here.

While the 48ms increase following a plausible compared to a valid preview was significant (F_1 (1,24) = 20.68, p<.001; F_2 (1,92) = 17.53, p<.001, the 23ms increase following an anomalous compared to a plausible preview was not (F_1 (1,24) = 1.70, p=.21; F_2 (1,92) = 2.47, p=.12). Somewhat surprisingly, spillover effects relating to a lack of orthographic overlap between preview and target appear to show a longer time course than effects of parafoveal meaning, with the latter exerting a more immediate impact, mostly reflected in the cumulative duration measures on $word_{n+1}$.

General Discussion

This study set out to investigate whether PB is restricted to the orthographic and phonological properties of a parafoveal word or whether meaning can also be extracted before a word is directly fixated. Prior research has failed to show much evidence for a semantic PB, but we suggest this may be due to the use of semantically related previews, with the word change interfering with target processing, rather than facilitating the recognition process. By varying the plausibility of previews, we have found two important semantic effects.

First, we found evidence that an anomaly in the parafovea can attract attention, resulting in shorter fixation durations on pre-target words. While others have reported anomaly-related parafoveal-on-foveal effects (Kennedy, Murray & Boissiere, 2004; Murray, 1998; Murray & Rowan, 1998; Rayner et al, 2004; Starr & Inhoff, 2004), this appears to be the first study to find a reliable effect that cannot be attributed to a potentially mislocated fixation. As Liversedge, Paterson and Pickering (1998) point out, when faced with difficulty the reader has three options: (a) stay and resolve the problem, (b) make a regression, or (c) proceed, in anticipation that later words will help resolve the difficulty. It seems that here readers have had a tendency to opt for the latter option, which as Liversedge et al point out, can result in reduced fixation durations.

Second, $word_{n+1}$ PB was influenced by the plausibility of the preview. This effect cannot be explained in terms of orthographic overlap since both the plausible and anomalous word previews differed from the target. The nature of the effect was distinctly different depending on whether a plausible or anomalous preview was employed; with anomalous previews exerting a more immediate and robust effect on $word_{n+1}$ viewing times. Since these previews were only available prior to $word_{n+1}$ receiving a direct fixation, the results clearly provide evidence for the extraction of meaning from a word in the parafovea.

A proponent of serial word processing might attempt to explain these findings with the suggestion that the meaning effects arose when attention moved to $word_{n+1}$ following foveal identification of $word_n$, but before the eye movement was executed. However, this would necessitate that there is enough of a lag between the shift of attention and the eye movement not only to enable the L_1 stage of processing of $word_{n+1}$ to be completed, resulting in a potential skip, but that there was enough time for L_2 also to be completed, allowing meaning extraction to occur. However, $word_{n+1}$ was skipped rarely and no more often when it had been anomalous, and in any case, it seems rather unlikely that all this processing could somehow be shoehorned into the time between the termination of lexical processing of $word_n$ and the execution of the saccade out of it.

Given the form of the $word_{n+1}$ effects found here, it seems that the approach of looking for meaning effects using semantic associates is likely flawed. Even if there is some semantic facilitation from the associated word preview, the magnitude of this would appear to be more than outweighed

by the interference generated by a word change. This sort of combination of facilitation and inhibition might possibly explain why Hohenstein et al (2010) only found a semantic PB with a fast prime duration of 125ms on the pre-target word (unless the prime's saliency was enhanced). Shorter prime durations might not allow time for semantic processing to occur, while longer durations might strengthen the interference.

A final important finding relates to the continued effect of masking $word_{n+1}$ with an orthographically dissimilar preview, shown in longer fixation durations in the spillover region. While serial models can account for shorter fixation durations in the spillover region - since longer fixation durations on $word_{n+1}$ following an invalid preview would allow more $word_{n+2}$ preview to accrue – the finding of a continuing increase in fixation duration cannot be afforded the same interpretation.

Overall, the results of this study are difficult to reconcile with models of eye movement control that allow only strictly serial sequential lexical processing. Rather, they seem more compatible with a perspective in which multiple words may be lexically processed in an overlapping fashion.

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