Psychon Bull Rev (2018) 25:1884–1890
DOI 10.3758/s13423-017-1356-y

BRIEF REPORT

When your mind skips what your eyes fixate: How forced fixations lead to comprehension illusions in reading

Elizabeth R. Schotter[1] · Mallorie Leinenger[2] · Titus von der Malsburg[3]

Published online: 1 August 2017

Abstract The phenomenon of *forced fixations* suggests that readers sometimes fixate a word (due to oculomotor constraints) even though they intended to skip it (due to parafoveal cognitive-linguistic processing). We investigate whether this leads readers to look directly at a word but not pay attention to it. We used a gaze-contingent boundary paradigm to dissociate parafoveal and foveal information (e.g., the word *phone* changed to *scarf* once the reader's eyes moved to it) and asked questions about the sentence to determine which one the reader encoded. When the word was skipped or fixated only briefly (i.e., up to 100 ms) readers were more likely to report reading the parafoveal than the fixated word, suggesting that there are cases in which readers look directly at a word but their minds ignore it, leading to the illusion of reading something they did not fixate.

Keywords Word recognition · Text comprehension · Eye movements and reading

It is generally assumed that word processing during reading mostly occurs once the eyes fixate a word and decisions about when to move away are based on the word processing that occurs then. A notable exception is when a reader skips a word because the decision to *not* fixate the word was made based on information from indirect (i.e., parafoveal) vision. The current study investigates the possibility that a reader may fixate a word but not register the information obtained then, instead encoding the information that had been obtained from that location parafoveally on the previous fixation, leading to the illusion of reading something that was not fixated. While at first blush, such a process seems unlikely, it was predicted by Morrison (1984) and his account of how this process occurs is incorporated into current models of oculomotor control in reading (e.g., E-Z Reader, Reichle, Pollatsek, Fisher, & Rayner, 1998). But to date, the field has largely ignored this prediction, assuming that the reading system uses parafoveal processing for linguistic integration with foveal information.

For decades, the prevailing view of parafoveal processing was that information obtained from a *parafoveal preview* of a word before it is fixated is integrated with information obtained from the *foveal target* once it is fixated, leading to facilitated linguistic processing (see Cutter, Drieghe, & Liversedge, 2015; Schotter, Angele, & Rayner, 2012). This process is studied with a gaze-contingent boundary paradigm (Rayner, 1975), in which the preview word is only viewable in parafoveal vision and the target word is only revealed when the eyes move to fixate it. The trans-saccadic integration account was able to accommodate numerous findings, including those in which previews that are linguistically similar to the target lead to faster processing than unrelated previews. However, a recent finding of Schotter and Leinenger (2016) suggests that the *reversed preview benefit* phenomenon they reported – fixation durations were shorter on a target word following an unrelated, easier-to-process preview than an identical preview – cannot be explained via this account. They termed this effect a *reversed* preview benefit because all previous investigations and theories of parafoveal processing find that fixation times are shortest in the identical preview condition by comparing that condition to more difficult to

✉ Elizabeth R. Schotter
eschotter@usf.edu

1 Department of Psychology, University of South Florida, 4202 East Fowler Ave., PCD 4118G, Tampa, FL 33620, USA

2 Department of Psychology, Denison University, Granville, OH, USA

3 Department of Linguistics, University of Potsdam, Potsdam, Germany

process stimuli (e.g., nonword or implausible word previews). By using plausible (see Schotter & Jia, 2016; Veldre & Andrews, 2016) and easier to process (i.e., higher frequency) unrelated previews, which lead to faster processing than identical previews, they demonstrated that a trans-saccadic linguistic integration account was not sufficient and favored an account that suggests that preview benefit arises as a *mechanistic benefit* related to oculomotor preplanning.

Schotter and Leinenger (2016) argue this mechanistic benefit arises because of *forced fixations*, single fixations on a word that are particularly short because the reader intended to skip it (Rayner, 2009) but the realization that the word should be skipped occurred too late (i.e., during a non-labile stage of eye movement programing in which a saccade to the to-be-skipped word cannot be cancelled; Morrison, 1984). Hence, early eye movement decisions during that forced fixation should be more influenced by properties of the preview than the target stimulus to which the system doesn't attend following the (belated) decision to skip. Consistent with this idea, they found that short fixations on the target were only affected by preview frequency whereas long fixations were only affected by target frequency.

One question that study raises regards what the readers ultimately understand from the text. In forced fixation cases in display change conditions, the word that the reader fixated (i.e., the target) was different than the word that triggered the eye movement program (i.e., the parafoveal preview). Since both words were sensible in the sentence, there are two possibilities for what the reader could reasonably understand – one interpretation includes the preview and the other the target. In fact, when Morrison (1984) proposed these kinds of fixations he suggested that, during these "extremely brief [fixations], perhaps no more than 50 ms to 100 ms… attention is directed to the next word," (p. 681) implying that there may be times when readers fixate a word but do not use the high-acuity information they could obtain there. In this sense, the readers' *mind skips the word their eyes fixate*. Thus, if readers planned eye movements based off of partial or low quality information (i.e., "hedged a bet" on the preview), they might misrepresent the words they saw in the sentence (even in non-display change studies; Slattery, 2009; see Discussion).

A study by Schotter and Jia (2016) provides evidence that in display change experiments readers sometimes encode the preview rather than the target word. They found that if the preview was plausible in the sentence and the reader had not fixated the target (i.e., skipped and had not regressed to it) they were more likely to report reading the preview than if they had fixated the target at any time. This result is not necessarily surprising since we assume skipping occurs because the reader has at least partially recognized the word from parafoveal vision (see Rayner, 2009). However, they also found a preview benefit from a preview that was completely unrelated to the target (yet plausible in the sentence context) relative to an unrelated and implausible preview condition, suggesting that fixation behavior on the target may have been initiated based on linguistic aspects of the preview, irrespective of its relationship to the fixated target. Their explanation for that effect appeals to the same aspect of oculomotor control in reading that underlies the forced fixation account of Schotter and Leinenger (2016; see simulations by Schotter, Reichle, & Rayner, 2014).

Here, we extend these studies to ask a very specific question – even in cases in which the target word *is* fixated, do readers ever encode a different (i.e., preview) word? We expect to replicate the finding that, in the absence of direct fixation on the target, the preview word is more likely to be encoded (Schotter & Jia, 2016). By using the linguistic manipulations employed by Schotter and Leinenger (2016; i.e., plausible, unrelated higher- and lower-frequency previews), we investigate the relationship between forced fixations and the likelihood of encoding the parafoveal preview versus the fixated target.

Method

Subjects

Thirty-seven native English-speaking UC San Diego undergraduates with normal vision participated in the experiment for course credit. All were naïve to the purpose of the study. Twenty-two were included in the analyses; the rest were excluded for seeing display changes more than 20% of the time (reported during debriefing) because detection of display changes alters reading behavior (Slattery, Angele, & Rayner, 2011). This exclusion rate is higher than most boundary paradigm studies because of the inclusion of the probe questions, which drew attention to the display changes by asking which of the two words was in the sentence. Included subjects reported seeing display changes 3% of the time (range = 0–20%; four saw more than four changes and the majority saw none).

Apparatus

Eye movements were recorded with an SR Research Ltd. Eyelink 1000 eye tracker (sampling rate of 1,000 Hz) in tower setup that restrained head movements with forehead and chin rests. Viewing was binocular, but only the right eye was recorded. Subjects were seated 60 cm from an HP p1230 CRT monitor (screen resolution = 1,024 x 768 pixels, refresh rate = 150 Hz). Text was displayed in black 14-point fixed-width Courier New font on a white background in the vertical center of the screen in one line of text (2.41 characters subtended 1 DVA). Display changes were completed, on average, within

4 ms of the tracker detecting a saccade crossing the invisible boundary.

Materials

Seventy-seven high- and low-frequency target noun pairs were taken from Schotter and Leinenger (2016; one pair, *winter–arctic,* was excluded because it was difficult to create a probe question that distinguished their meanings). The pairs were matched in length, had limited orthographic, phonological, and semantic overlap, and were manipulated for lexical frequency (Table 1; Schotter & Leinenger, 2016). Two neutral sentences were created for each pair so that each subject read one sentence with the high-frequency target and another sentence with the low-frequency target,[1] for a total of 154 experimental sentences (see items 1–78 in the Appendix of Schotter & Leinenger, 2016). Example stimuli are shown in (1) and (2), with the high-/low-frequency target words italicized.

(1) The boy found a red *phone/scarf* on his way to school.
(2) Danielle unfortunately forgot her new *scarf/phone* when she left home this morning.

Procedure

Subjects were instructed to read the sentences for comprehension and to respond to questions after every trial. Following display change trials, *probe questions* targeted whether the reader encoded the preview or target (e.g., for example 1, "What did the boy find?" with the alternatives *PHONE* and *SCARF* in all capital letters to avoid subjects using visual memory to answer the question). The location of the preview and target answer options was counterbalanced so that they appeared with equal frequency on the left and right. Following non-display change trials, *comprehension questions* asked about other parts of the sentence to encourage reading for comprehension (e.g., for example 1, "Was the boy on his way to the mall?" with the alternatives *YES* and *NO*). After every question subjects rated their level of confidence in their response (e.g., "How confident do you feel about your answer?" with the alternatives *guessing*, *pretty sure*, and *positive*). After the tracker was calibrated with a 3-point calibration scheme subjects received five practice trials with representative comprehension and probe questions before the experimental trials started.

[1] Order of presentation of the pairs had no effect on the results.

Table 1 Summary statistics for target/preview words

	High-frequency				Low-frequency			
	M	*SD*	*Min.*	*Max.*	*M*	*SD*	*Min.*	*Max.*
Log HAL Frequency/400 mil	10.41	1	8.21	12.66	6.97	1.11	4.61	8.9
Raw frequency per million	135	148	9	786	4	4	0	18
Length	5.82	0.9	5	8	5.82	0.9	5	8
Cloze predictability	0.05	0.13	0	0.8	0.01	0.05	0	0.5
Sentence acceptability	5.46	0.70	3.3	6.7	5.50	0.64	3.5	6.7

Each trial began with the subject fixating a point in the center of the screen, followed by a fixation box located where the beginning of the sentence would appear. Once fixated, the box disappeared and was replaced by the sentence, which remained until the subject indicated they were done reading with a button press. An invisible boundary was located at the end of the pre-target word (i.e., to the left of the space preceding the preview/target word). While the subject's eyes were to the left of the boundary, the preview word was either the high-frequency word (e.g., *phone*) or the low-frequency word (e.g., *scarf*). As per the gaze-contingent boundary paradigm (Rayner, 1975), when the eyes crossed the boundary, either an identical target or the higher- or lower-frequency member of the pair replaced the preview, yielding four conditions: (1) high-frequency target, identical preview, (2) high-frequency target, low-frequency preview (display change), (3) low-frequency target, identical preview, and (4) low-frequency target, high-frequency preview (display change; Fig. 1). The four conditions were counterbalanced across participants and items in a Latin-square design. Order of sentence presentation was randomized for each participant, and the experimental session lasted approximately 45 minutes.

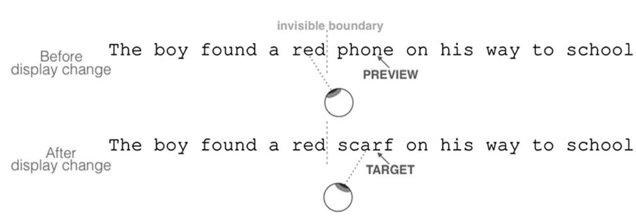

Fig. 1 Example of the experimental paradigm for the low-frequency target, high-frequency preview (display change) condition. The top row represents the sentence before the display change (i.e., with the preview word) and the bottom row represents the sentence after the display change (i.e., with the target word). The gray vertical dashed line represents the location of the invisible boundary that triggered the display change

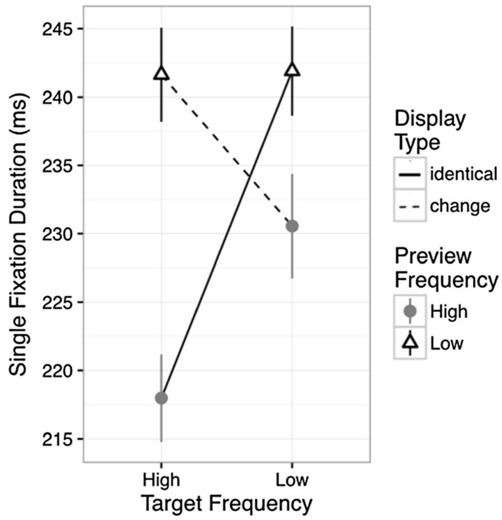

Fig. 2 Raw single fixation duration on the target word as a function of target frequency, display type, and preview frequency. Error bars represent ± 1 SEM

Results

Following Schotter and Leinenger (2016), fixations shorter than 81 ms were either combined with an adjacent fixation when within one character space or remained in the dataset; fixations longer than 800 ms were eliminated. Trials with a blink or track loss on the target during first pass reading were excluded, as were trials where the display change was triggered by a j-hook or completed after fixation on the target, leaving 2,909 trials available for analysis (86% of the original data). *Single fixations* (the critical measure for investigating forced fixations), in which the reader fixates the target word only once before moving on, occurred on 70% of the included trials, leaving 2,022 single fixations available for analysis.

We analyzed single fixation durations with linear mixed-effects models (LMMs) that had the same structure as in Schotter and Leinenger (2016). Two models were used, allowing us to directly estimate the magnitude of the preview effects (display type) for each target frequency type (high or low) separately. The fixed effects in the first model included one treatment-coded contrast for target frequency with the high-frequency target as the baseline, one sum-coded contrast for display type capturing the effect of the display change in the high-frequency condition, and the interaction of these factors capturing the difference of the magnitude and sign of the display type effect between the high and low-frequency targets. The second model was identical to the first except that low-frequency targets served as the baseline. We entered subjects and items as crossed random effects (see Baayen, Davidson, & Bates, 2008), using the maximal random effects structure (Barr, Levy, Scheepers & Tily, 2013).

To fit the LMMs, we used the lmer function from the lme4 package (version 1.1-12; Bates et al., 2015) within the R Environment for Statistical Computing (version 3.3.1; R Development Core Team, 2015). Analyses were performed on both raw and log-transformed data (because of skewed residuals in fixation time measures) and were similar; we report geometric (back-transformed log) means in the text because Schotter and Leinenger (2016) argued they better capture forced fixations (i.e., *short* single fixation durations) and raw means are plotted in Fig. 2 for completeness.

Single fixation duration

The results of this analysis (Table 2) replicate those reported by Schotter and Leinenger (2016; Experiment

Table 2 Results of linear mixed effects models for raw and log-transformed single fixation duration on the target from models with the high-frequency target as the baseline (left columns) or the low-frequency target as the baseline (right columns)

	Model with high-frequency baseline			Model with low-frequency baseline		
	b	SE	|t|	b	SE	|t|
Raw data						
Intercept	**227.17**	**8.00**	**28.41**	**233.68**	**8.00**	**29.22**
Target frequency effect	6.51	3.42	1.90	−6.51	3.42	1.90
Display type for baseline	**22.66**	**4.71**	**4.81**	**−11.78**	**5.47**	**2.15**
Display type * frequency	**−34.44**	**8.11**	**4.25**	**34.44**	**8.11**	**4.25**
Log-transformed data						
Intercept	**5.37323**	**0.03390**	**158.51**	**5.40279**	**0.03227**	**167.42**
Target frequency effect	**0.02956**	**0.01413**	**2.09**	**−0.02956**	**0.01413**	**2.09**
Display type for baseline	**0.10705**	**0.02045**	**5.23**	**−0.06370**	**0.2212**	**2.88**
Display type * frequency	**−0.17075**	**0.03418**	**5.00**	**0.17075**	**0.03418**	**5.00**

Significant effects are indicated by boldface

Note: the frequency effect in the raw data is not statistically significant because of the crossover interaction (i.e., the effect estimate is averaged across display type)

1). There was a main effect of target word frequency (|t| = 2.09) with longer reading times in the low-frequency target condition than the high-frequency target condition. There was a significant crossover interaction between display type and target frequency (|t| = 5.00; Fig. 2) so we report the effects of display type separately for the two models (i.e., the two target frequencies). In the high-frequency target condition, we observed a standard preview benefit (|t| = 5.23) where single fixation durations were longer when the display changed (236 ms) than when it was identical (212 ms). In the low-frequency baseline condition, we observed a reversed preview benefit (|t| = 2.88) in which single fixation durations were longer when the display was identical (238 ms) than when it had changed (223 ms).

Replicating Schotter and Leinenger (2016, Experiment 1), single fixation duration showed a standard preview benefit for high-frequency target words and a reversed preview benefit for low-frequency target words. This demonstrates the reliability of the originally reported effect and is an important pre-condition for the following analyses, which investigate the cognitive-linguistic consequence of forced fixations on the understanding of words.

Comprehension measures

Subjects responded correctly to comprehension questions 96% of the time (range: 89–100%), indicating that they were reading and understanding the general meaning of the sentences; they were more confident when responding accurately than inaccurately (rating their confidence as *positive* 91% and 53% of the time, respectively). Of more interest is how readers responded to the probe questions, which assess which word (preview or target) they had encoded, and how the response to this question relates to fixation behavior on the target. In general, subjects had high confidence in their responses to the probe questions, higher for the target when it was fixated (rating *positive* 95% vs. 79% for the preview) and lower when it was skipped (rating *positive* 77% vs. 87% for the preview) and not reread. For the analyses that follow we only include trials in which the subjects reported being *positive* (the results do not change when the non-positive trials are included).

Fixation probability and word encoding To address whether fixating the word (either not skipping during first pass or rereading during a second pass) has an influence on encoding it, we conducted a logistic regression on the subjects' responses to the probe question (preview coded as 1, target as 0). The predictors were whether the word was fixated during first pass (fixation coded as 1, skipping as 0) and whether the

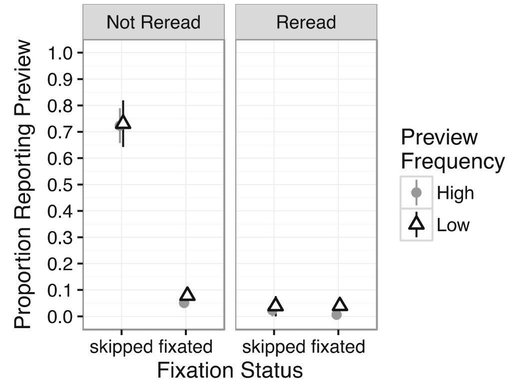

Fig. 3 Rates of reporting the preview as a function of preview frequency, whether the word was skipped, and whether the reader reread the target. Error bars represent ± 1 SEM

reader reread the word (reread coded as 1, not reread as 0). We included the full random effects structure for subjects but only the intercept and slope for skipping for items because the maximal model did not converge. Both the main effects of skipping and rereading were significant, as well as the interaction (all ps < .05). Subjects almost always reported reading the target except when they skipped the word and did not reread it, in which case they were more likely to report the preview (Fig. 3); there was no difference between higher or lower frequency previews.

Fixation duration and word encoding The preceding results are unsurprising; when the target word was never fixated (i.e., skipped and not reread) the likelihood of the reader reporting the preview was much higher than when the target was ever fixated. This suggests that the information obtained in foveal vision has more influence on word recognition than information obtained parafoveally, but when words are only viewed in parafoveal vision that representation prevails most of the time. However, the critical question about the role of parafoveal preprocessing in reading regards situations that involve forced fixations (i.e., short single fixations on the target word) that happened only because they could not be cancelled in time. Therefore, we investigated the relationship between single fixation duration on the target and what word the reader reported. Note that this analysis is correlational because neither fixation duration nor subject report of the word are under experimental control. Still, the results are quite striking and do suggest a relationship in line with our hypothesis. We analyzed only the data from trials in which the target was not reread because they allow us to investigate forced fixations directly (unsurprisingly, trials with rereading almost always led to reporting the target, see Fig. 3) but for completeness we plot the data for both types of trials in Fig. 4.

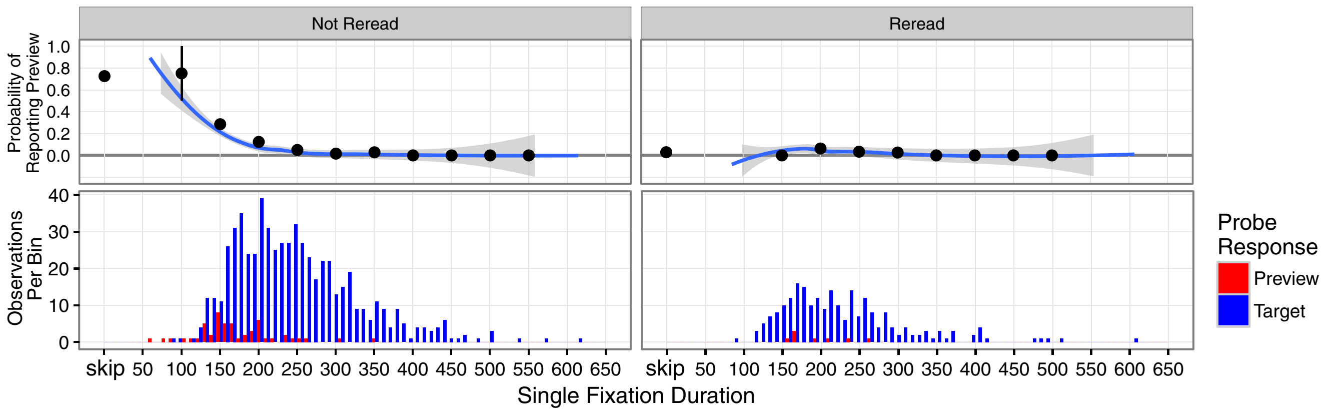

Fig. 4 Probability of reporting the preview as a function of fixation behavior (skipping or 50-ms bins of single fixation duration; top panel) and distribution of single fixation durations on the target word (10-ms bins) as a function of which word was reported in response to the probe question (bottom panel) for trials in which the target was re-read (right panel) or not reread (left panel). The blue line in the top panel represents a loess smoothed fit line for non-binned data and the grey envelope represents a 95% confidence interval, error bars on binned data represent ± 1 SEM

For the analyses, we aggregated fixation behavior into bins of 50 ms (i.e., skip, 50–100 ms, 100–150 ms, etc.) up to 350 ms (durations beyond this were sparse and not of theoretical interest – the target was always reported; see Fig. 4). We conducted a logistic regression on responses to the probe question with successive difference contrasts to compare the rate of reporting the preview between each successive bin pair (the random effects had intercepts only because of over-parameterization). The comparison between the rate of reporting the preview when the target was skipped was not significantly different from when the target was fixated for 50–100 ms ($b = 0.2686$, $z = 1.97$, $p = .84$) but as single fixation duration increased the rate of reporting the preview decreased, such that at each successive bin comparison the rate of reporting the preview was lower than the previous bin (all $ps < .001$; Table 3).

Table 3 Results of logistic regression on the likelihood of reporting the preview as a function of first-pass fixation behavior for trials in which the target was not reread and the reader reported being positive in their response

Contrast	b	|z|	p
Intercept	**0.9349**	**2.34**	**< .05**
Skip vs. 50–100 ms	0.2686	0.197	.84
50–100 vs. 100–150 ms	**−1.8665**	**3.56**	**< .001**
100–150 vs. 150–200 ms	**−3.2081**	**6.89**	**< .001**
150–200 vs. 200–250 ms	**−4.4559**	**7.75**	**< .001**
200–250 vs. 250–300 ms	**−5.6235**	**6.47**	**< .001**
250–300 vs. 300–350 ms	**−5.0394**	**5.87**	**< .001**

Significant effects are indicated by boldface

Discussion

The majority of information a reader explicitly encodes is obtained through foveal vision; when we used a gaze-contingent display change paradigm to dissociate parafoveal and foveal information and subjects reported which word they had read, they mostly reported the foveally fixated target. Unsurprisingly, when readers only viewed the word parafoveally (i.e., skipped and did not reread it) they were more likely to report the preview (~70% of the time). There were also cases in which the reader fixated the target but reported reading the preview; primarily when the fixation lasted less than 100 ms. Although fixations this brief are rare (see Fig. 4, bottom-left panel), their durations are in line with the estimate provided by Morrison (1984). We propose these cases represent forced fixations (i.e., were intended skips that could not be executed because of the non-labile stage of saccade programming) and lead to a high rate of reporting the preview word (Fig. 4, top-left panel) because readers did not attend to the target word, essentially they *fixated it with their eyes but skipped it with their minds*.

It might seem like misrepresentation of fixated words would only be likely in gaze-contingent boundary experiments (Rayner, 1975) where words *are experimentally* changed between the parafovea and fovea. However, in non-display change studies readers also sometimes misperceive one word as a different, unpresented word that is visually similar to but more expected than the presented word (i.e., a plausible, orthographically similar, higher frequency neighbor; Slattery, 2009). Forced fixations can explain such findings in that they might be driven by cases where readers relied on imprecise parafoveal information, a "hedged bet" to plan the subsequent saccade, rather than the higher-resolution foveal word once fixated. Thus, the potential for misrepresentation of the text is likely to be a general aspect of the reading process that exists independently of display-change studies, but can be revealed and investigated by using such a paradigm strategically, as we have done here. We must note that we excluded subjects who noticed many display changes; it is unclear why they noticed so many more than the included subjects and whether these findings generalize to them, as well.

Our findings suggest that the reading system makes sophisticated use of both parafoveal and foveal information to support efficient reading behavior. Parafoveal information is used to plan eye movements to optimize speed (i.e., to skip over or fixate a word only briefly; cf. parafoveal postview of leftward words, Jordan, McGowan, Kurtev, & Paterson, 2016). Most of the time (i.e., for fixations longer than 100 ms) the system takes advantage of high quality visual information provided by the fovea to encode the identities of words, and the system may risk being less precise when word encoding only happens based on low-resolution parafoveal information. The present data therefore confirm an important counterintuitive prediction of models of oculomotor control in reading (see Schotter & Leinenger, 2016) and introduces the finding that readers sometimes think they had read a word they did not fixate.

References

Baayen, R. H., Davidson, D. H., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language, 59,* 390–412.

Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language, 68,* 255–278.

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software, 67,* 1–48.

Cutter, M. G., Drieghe, D., & Liversedge, S. P. (2015). How is information integrated across fixations in reading? In A. Pollatsek & R. Treiman (Eds.), *The Oxford handbook of reading* (pp. 245–260). Oxford: Oxford University Press.

Jordan, T. R., McGowan, V. A., Kurtev, S., & Paterson, K. B. (2016). A further look at postview effects in reading: An eye-movements study of influences from the left of fixation. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 42,* 296–307.

Morrison, R. E. (1984). Manipulation of stimulus onset delay in reading: Evidence for parallel programming of saccades. *Journal of Experimental Psychology: Human Perception and Performance, 10,* 667–682.

R Development Core Team. (2015). *R: A language and environment for statistical computing*. Vienna: R Foundation for Statistical Computing. https://www.R-project.org/

Rayner, K. (1975). The perceptual span and peripheral cues in reading. *Cognitive Psychology, 7,* 65–81.

Rayner, K. (2009). The Thirty Fifth Sir Frederick Bartlett Lecture: Eye movements and attention during reading, scene perception, and visual search. *The Quarterly Journal of Experimental Psychology, 62,* 1457–1506.

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.

Schotter, E. R., Angele, B., & Rayner, K. (2012). Parafoveal processing in reading. *Attention, Perception & Psychophysics, 74,* 5–35.

Schotter, E.R. & Jia, A. (2016). Semantic and Plausibility Preview Benefit Effects in English: Evidence from Eye Movements. *Journal Experimental Psychology: Learning, Memory & Cognition,* online first.

Schotter, E. R., & Leinenger, M. (2016). Reversed preview benefit effects: Forced fixations emphasize the importance of parafoveal vision for efficient reading. *Journal Experimental Psychology: Human Perception & Performance, 42,* 2039–2067.

Schotter, E. R., Reichle, E. D., & Rayner, K. (2014). Rethinking parafoveal processing in reading: Serial attention models can account for semantic preview benefit and N+2 preview effects. *Visual Cognition, 22,* 309–333.

Slattery, T. J. (2009). Word misperception, the neighbor frequency effect, and the role of sentence context: Evidence from eye movements. *Journal of Experimental Psychology: Human Perception and Performance, 35,* 1969–1975.

Slattery, T. J., Angele, B., & Rayner, K. (2011). Eye movements and display change detection during reading. *Journal of Experimental Psychology: Human Perception and Performance, 37,* 1924–1938.

Veldre, A., & Andrews, S. (2016). Is semantic preview benefit due to relatedness or plausibility? *Journal of Experimental Psychology: Human Perception and Performance, 42,* 939–952.