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Using E-Z Reader to Examine Word Skipping During Reading

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Abstract

The question of why readers sometimes skip words has important theoretical implications for our understanding of perception, cognition, and oculomotor control during reading (Drieghe, Rayner, & Pollatsek, 2005). In this article, the E-Z Reader model of eye-movement control in reading (Reichle, 2011) was used to examine the behavioral consequences of word skipping on fixation durations. The simulations suggest that skipping “cost”, or inflated fixation durations immediately prior to skips, is modulated by the lexical properties of the upcoming word (i.e., longer fixations before skipping infrequent and/or long words; Kliegl & Engbert, 2005), but that contrary to previous claims (e.g., Reichle & Laurent, 2006), “accidental” skips due to motor error also produce skipping cost. In contrast, the cost associated with having skipped a word was not modulated by that word’s properties. These simulations suggest that skipping behavior is even more complicated than previously assumed, and that further empirical research is needed to understand the causal link between skipping and its associated cost.

Computational models of eye-movement control during reading provide quantitative accounts of how cognition (e.g., lexical processing) interacts with the visual and oculomotor systems to determine when and where the eyes move during reading (Reichle, 2006). These models often make very different assumptions about the nature of the eye-mind link, such as whether the type of attention necessary to support lexical processing is allocated to only one word at a time (e.g., Reichle, Pollatsek, Fisher, & Rayner, 1998; Salvucci, 2001) or concurrently to multiple words (e.g., Engbert, Nuthmann, Richter, & Kliegl, 2005; Reilly & Radach, 2006). Although this question about attention allocation during reading is controversial (e.g., Reichle, Liversedge, Pollatsek, & Rayner, 2009) and has generated much new research (e.g., Schotter, Angele, & Rayner, 2011), an equally important but less researched issue concerns the causes of word skipping (cf., Drieghe, Rayner, & Pollatsek, 2005; Kliegl & Engbert, 2005). The reasons why words are sometimes skipped during reading are not well understood (for a review, see Rayner, Slattery, Drieghe & Liversedge, 2011), especially why some factors differentially affect skipping rates versus fixation times (e.g. Drieghe, 2008; Fitzsimmons & Drieghe, 2011), and a better understanding of this issue is therefore likely to advance our basic understanding of the eye-mind link. This article does exactly that by using an existing model of eye-movement control, *E-Z Reader* (Reichle et al., 1998; for a review, see Reichle, 2011), to carefully examine the possible behavioral consequences of word skipping.

It is known that readers fixate the majority of the words (Brysbaert & Vitu, 1998) because the visual acuity required to identify printed words is limited to a small region of the retina, called the *fovea*. It is also known that the overall skipping rate is modulated by many variables (e.g., a reader’s age; Kliegl, Grabner, Rolfs, & Engbert, 2004; Rayner, Reichle,

Stoud, Williams, & Pollatsek, 2006) and subject to considerable local variation (for a review, see Drieghe et al., 2005). For example, short words are more likely to be skipped than long words (Brysbaert & Vitu, 1998) and words that frequently occur in printed text are more likely to be skipped than less common words (Rayner & Duffy, 1986; Schilling, Rayner, & Chumbley, 1998). Furthermore, monosyllabic words are skipped slightly more often than short disyllabic words (Fitzsimmons & Drieghe, 2011) and words that are predictable from their sentence context are more likely to be skipped than less predictable words (Ehrlich & Rayner, 1981; Rayner, Ashby, Pollatsek, & Reichle, 2004). What is not known is how these perceptual, lexical, and linguistic variables affect readers' "decisions" about whether to fixate or skip a word.

To make this issue more concrete, consider how two eye-movement models explain word skipping. According to the *E-Z Reader* model (Reichle, 2011), the completion of an early stage of lexical access called the *familiarity check* on word_N initiates a saccadic program to move the eyes to word_{N+1}. Lexical processing of word_N then continues until it is identified, causing attention to shift to word_{N+1} so that lexical processing of that word can begin. (According to the model, attention is allocated to only one word at a time, in a strictly serial manner.) In most cases, lexical processing of word_{N+1} begins before the eyes have actually moved to the word, thus affording some parafoveal processing of word_{N+1}. This parafoveal processing is occasionally sufficient to complete the familiarity check on word_{N+1}, which then initiates a saccadic program to move the eyes to word_{N+2}. If this second saccadic program is initiated rapidly enough, it cancels the (labile) saccadic program that would have moved the eyes to word_{N+1}, causing it to be skipped. This sequence of events thus explains word skipping and the general finding that easy-to-process words are skipped more often than difficult-to-process words because the familiarity check is more apt to complete in the parafovea for easy than hard words. In addition, a saccade directed towards a word might overshoot its intended target because of motor error, thereby resulting in a skip. The model thus explains two types of skips—"deliberate" skips due to parafoveal processing and "accidental" skips due to saccadic error.

Now consider an account of word skipping provided by an alternative model of eye-movement control, *SWIFT* (Engbert et al., 2005). According to this model, attention is allocated as a gradient to support parallel processing of multiple words. An autonomous timer initiates saccadic programming at random intervals, but these programs can be inhibited by lexical processing difficulty, allowing the model to explain why difficult-to-process words are recipients of longer fixations than easier-to-process words. Decisions about where to move the eyes are determined by the relative degree of lexical processing that has been completed within the attention gradient: The probability of a given word being selected as the saccade target is proportional to its activation level, with words that have already received significant processing being unlikely to be targeted and thus skipped. Of course, like *E-Z Reader*, *SWIFT* also posits that some proportion of skips will be "accidental," resulting from saccadic error.

Despite these different accounts of word skipping, however, *E-Z Reader* and *SWIFT* predict the same behavioral consequences of deliberate word skips. Because these skips entail the time-consuming cancelation of one saccadic program via the initiation of another in *E-Z Reader*, the model predicts inflated fixations on word_N prior to skipping word_{N+1}. Similarly, *SWIFT* also predicts word skipping cost, but for a different reason: Because longer fixations on word_N afford more parafoveal processing of word_{N+1}, word_{N+1} is less likely to be selected as a saccade target (i.e., more likely to be skipped) following a long fixation on word_N. The two models thus make opposite predictions about the causal "arrow" of word skipping and its associated cost: According to *E-Z Reader*, the cost is a *consequence* of

skipping, whereas according to SWIFT, the cost is the *cause* of skipping (Kliegl & Engbert, 2005).

Finally, it is important to note that both models also make similar predictions regarding the costs associated with having skipped a word—that such skips result in longer fixations. The reason for this cost is that skipping affords less parafoveal processing of the word following the skip because the eyes will have (on average) moved farther than when the eyes have simply moved from the previous word. To understand why this is true, consider what happens when the eyes move directly from word_{N-1} to word_N; when this happens, parafoveal processing of word_N from word_{N-1} reduces the time spent processing (fixating) word_N by approximately 40–50 ms (Hyönä, Bertram, & Pollatsek, 2004). Now consider what happens when the eyes move from word_{N-2} to word_N, skipping word_{N-1}; when this happens, little or no parafoveal processing of word_N is possible, resulting in a longer fixation on word_N. Because this account of the cost associated with having skipped a word is consistent with both E-Z Reader and SWIFT, this aspect of word skipping is less diagnostic for discriminating between the models. For this reason, and because the costs associated with having skipped a word are well documented (Kliegl & Engbert, 2005), the remainder of this article will largely focus on the purported costs associated with skipping an upcoming word.

Attempts to measure skipping costs have resulted in varied estimates. For example, Kliegl and Engbert (2005) indicate that estimates of such “costs” span the range from sizable penalty (e.g., 84 ms; Pynte, Kennedy, & Ducrot, 2004) to modest facilitation (e.g., –26 ms; Radach & Heller, 2000). To understand the reason for these discrepant estimates, Kliegl and Engbert examined skipping cost in the Potsdam sentence corpus (Kliegl et al., 2004) using a sampling procedure involving three types of fixation sequences. Figure 1 is a schematic diagram showing these sequences. Panel A shows the most common sequence, in which three spatially adjacent words receives one fixation each. Panel B shows a sequence in which word_{N+1} is skipped but the preceding and following words receive one fixation. Similarly, Panel C shows a sequence in which word_{N-1} is skipped but the preceding and subsequent words receives one fixation. Contrasts of these sequences thus allow one to assess the fixation-duration costs on word_N both *before* (Panel A vs. B) and *after* (Panels A vs. C) word skipping.

Kliegl and Engbert’s (2005) analyses showed that the magnitude and parity of the “costs” accrued prior to word skipping varied as a function of the length, frequency, and predictability of the skipped word. To summarize their findings: Fixations were actually 11 ms shorter prior to skipping short, 2-letter words, but this facilitation turned to cost with increasing word length, with fixations being 21 ms longer prior to skipping long, 7–9 letter words. Likewise, fixations were 7 ms shorter prior to skipping the most frequent words, but 14 ms longer prior to skipping the most infrequent words. Finally, word predictability had a modest but erratic effect on cost.

Method

Three simulations were completed using the current version of E-Z Reader with its default parameters (see Table 1, Reichle et al., 2012), the Schilling et al. (1998) sentence corpus, and 10,000 statistical subjects per simulated condition. The fifth word of each sentence was designated as word_N and the length (2, 5, or 8 letters), frequency (1, 100, or 10,000 occurrences per million), and predictability (cloze probability = 0, 0.4, or 0.8) of word_N and word_{N+1} (Simulation 1) or word_{N-1} and word_N (Simulation 2) were factorially manipulated after removing the following categories of words rare in language: (1) words that are short (2 letters) and low frequency (1 per million) and/or completely unpredictable (cloze

predictability = 0); and (2) words that are long (8 letters) and high frequency (10,000 per million) and/or highly predictable (cloze predictability = 0.8). Our goal was thus to determine *if*—and if so, *how*—these lexical variables affected skipping costs on word_N using the Kliegl and Engbert (2005) sampling procedure (see Fig. 1).

Results

Simulation 1

Table 1 shows the mean proportion of simulation trials meeting the Kliegl and Engbert's (2005) selection criteria in which word_{N+1} was fixated, skipped, deliberately skipped, and accidentally skipped. Also shown are the mean fixation locations on word_N. Both dependent variables are shown as a function of the lexical properties of word_{N+1} (e.g., means for each length of word_{N+1}, collapsing across the frequencies and predictabilities of word_{N+1} and the lengths, frequencies, and predictabilities of word_N). As Table 1 shows, most instances of word skipping were deliberate rather than accidental ($M = 0.13$ vs. 0.05 , respectively). Fixation locations were also located slightly further to the right on word_N prior to skips than fixations ($M = 3.20$ vs. 2.92 characters, respectively) and this tendency was slightly more pronounced for accidental than deliberate skips ($M = 3.42$ vs. 3.23 characters, respectively).

Figure 2 shows the mean single-fixation durations (and standard errors of means¹) on word_N prior to skipping versus fixating word_{N+1}, as a function of the length (Panels A & B), frequency (Panels C & D), and predictability (Panels E & F) of word_{N+1}. The left panels show means calculated across conditions, treating each condition mean as an observation that contributes equally to the plotted means. The right panels show the means calculated with each condition weighted by its number observations. Although the overall pattern of means is qualitatively similar using un-weighted and weighted means, skipping costs were larger using the former ($M = 31$ ms) than latter ($M = 17$ ms) measure. For that reason, both means are reported here although the remaining discussion focuses primarily on un-weighted means.

An explanation of why the model predicts deliberate skipping cost is fairly straightforward. On some proportion of trials, parafoveal processing of word_{N+1} proceeds rapidly enough for the first stage of lexical processing, the familiarity check, to complete, thereby canceling the saccadic program that would have otherwise caused the eyes to fixate word_{N+1}. Because the cancelation and replacement of one saccadic program by another requires time, the fixation duration on word_N is inflated relative to when the word_{N+1} familiarity check does not cancel the saccadic program and the eyes simply move to word_{N+1}. According to the model, the mean cost associated with such deliberate skips is approximately 57 ms.

Now consider why deliberate skipping cost increases with the length of the skipped word. As the length of word_{N+1} increases, so too does the mean eccentricity between the fixation location on word_N and the center of word_{N+1}. This in turn means that decreasing visual acuity slows the word_{N+1} familiarity check, making deliberate skips less likely and causing those saccadic programs that are canceled prior to deliberate skips to be further along when they are canceled, thus resulting in more cost. And in a similar manner, skipping costs increase as the frequency of the skipped word decreases because the canceled saccadic program will (on average) be further along when it is canceled prior to skipping a low-frequency word.

¹The error bars show the standard errors of mean across conditions, treating the mean of each of the conditions as an observation. The error bars are thus conservative measures and are not used for statistical inferences, but only provided as a measure of the single-fixation duration variability across conditions.

Finally, the relationship between skipping cost and predictability is more complicated because predictability can affect the time required to complete a word's familiarity check in two ways: With a probability equal to a word's cloze predictability, the word can be "guessed," resulting in the word's familiarity check duration being set equal to 0 ms; otherwise, the duration is decremented by some amount of time that is proportional to the word's predictability. This effectively means that completely unpredictable words are usually deliberately skipped if they are also short and/or frequent, whereas predictable words are also skipped because they can be "guessed" from their sentence context. In the latter case, the familiarity check completes very rapidly (i.e., its duration is set equal to 0 ms as soon as attention shifts to the word), resulting in minimal cost. The interplay of these two assumptions about how predictability affects word skipping thus reduces deliberate skipping cost markedly for words of even modest predictability.

As Figure 2 shows, accidental and deliberate skipping costs are of comparable size (57 ms vs. 39 ms, respectively). This finding is unanticipated—underscoring the importance of evaluating one's intuitions with actual model simulations—if one assumes that accidental skips reflect motor error (e.g., saccades overshooting their intended targets) that should be no more costly than when the eyes simply move from one word to the next (e.g., see Reichle & Laurent, 2006). The explanation for this finding is that prior to the eyes arriving on word_N, word_N is occasionally processed very quickly and thus subject to being skipped. However, because of motor error, the saccade falls short of its target, causing word_N to be fixated rather than skipped. When word_N processing then finishes and attention shifts to word_{N+1}, word_{N+1}'s familiarity check will take longer to complete than it otherwise would because it must be processed from word_N. Because the fixation on word_N can only terminate after word_{N+1}'s familiarity check has completed, thereby initiating a saccadic program to move the eyes forward, the fixation duration on word_N will be inflated. Moreover, because word_{N+1} is subsequently skipped due to motor error, the inflated fixation duration on word_N is correlated with the accidentally skipping of word_{N+1}. Thus, the accidental skipping of word_{N+1} does not *cause* longer fixations on word_N; both findings are instead the product of mis-located fixations.

The preceding explanation of accidental skipping cost is consistent with an analysis of word_{N+1} familiarity-check durations and skipping costs if these two variables are examined conditional upon the word_N fixation location. As Figure 3A shows, for accidental skips, word_{N+1}'s familiarity check is longest if the last letter of word_N is fixated (and thus most likely to be a mis-located fixation on word_N that was intended for word_{N+1}), and decreases monotonically for fixations on the second- and third-to-last letters. As Figure 3B shows, this also coincides with a reduction in accidental skipping cost as a function of the word_N fixation location (i.e., most cost for fixations on the last letter, least for fixations on the third-to-last letter). Furthermore, the situation in which word_N was intended to be skipped but was accidentally fixated occurred during 0–0.37 ($M = 0.04$) of simulation trials across conditions, and the propensity for this to happen also correlated ($r = 0.57$) with the magnitude of accidental skipping cost.

One final aspect of Simulation 1 warrants discussion—the degree to which these results are similar to those observed by Kliegl and Engbert (2005). One obvious discrepancy was that, contrary to what was observed with humans, the simulated mean fixations prior to skipping were usually longer prior to fixating, not shorter². This difference is important because it reflects a constraint of the model's architecture: Deliberate skipping requires the time-

²However, it should be noted that, despite the large number of simulated observations (i.e., 48 sentences $\times$ 10,000 statistical subjects per sentence = 480,000 observations), the model occasionally predicted *shorter* fixations prior to deliberate skipping, resulting in up to 8 ms of facilitation in 20 of the 289 conditions. Such facilitation was never evident, however, prior to accidental skipping.

consuming cancellation and replacement of one saccadic program by another. Despite this discrepancy, however, there are several important similarities between the simulated and observed patterns of skipping costs. In both cases, skipping cost increases in magnitude with increasing length and decreasing frequency of the skipped word, with the former relationship being more pronounced than the latter. And the relationship between skipping cost and predictability is more erratic and smaller in magnitude than the previous two relationships.

These correspondences between the simulated and observed (Kliegl & Engbert, 2005) patterns of skipping costs are even closer if one considers the weighted means (i.e., right panels of Fig. 2). The skipping cost is now negligible for 2-letter words ($M = 7$ ms) but still large for 8-letter words ($M = 16$ ms). Similarly, skipping cost is reduced for high-frequency words ($M = 12$ ms) but still large for low-frequency words ($M = 17$ ms). And except for completely unpredictable words (which by definition are skipped for reasons other than being predictable), skipping cost is largely unaffected by cloze predictability, being modest for moderately and highly predictable words ($M = 11$ ms and 12 ms, respectively).

Simulation 2

As indicated earlier, cost associated with having skipped word_{*N*-1} on the fixation on word_{*N*} is less controversial than cost before skipping and is thus reported for completeness rather than theoretical significance. Table 2 shows the mean proportion of simulation trials meeting Kliegl and Engbert's (2005) selection criteria for each condition involving lexical properties of word_{*N*-1} (e.g., means for each length of word_{*N*-1}, collapsing across the frequencies and predictabilities of word_{*N*-1} and the lengths, frequencies, and predictabilities of word_{*N*}), along with mean fixation locations on word_{*N*}. As indicated, there were more deliberate than accidental skips ($M = 0.17$ vs. 0.05, respectively), and fixations were located closer to the beginnings of word_{*N*} following a skip than a fixation ($M = 2.15$ vs. 2.96 characters, respectively), with this trend being larger for accidental than deliberate skips ($M = 1.12$ vs. 2.63 characters, respectively).

Figure 4 shows the single-fixation durations on word_{*N*} after skipping versus fixating word_{*N*-1}, as a function of the length (Panels A & B), frequency (Panels C & D), and predictability (Panels E & F) of word_{*N*-1}. As with Simulation 1, both un-weighted (left panels) and weighted (right panels) means are reported for completeness.

As Figure 4 shows, moderate skipping costs were evident in all of the conditions and these costs were not modulated by the lexical properties of the skipped words. The explanation for this cost is that it reflects a reduction in parafoveal processing: Whenever the eyes move directly from word_{*N*-2} to word_{*N*}, any parafoveal processing of word_{*N*} must be completed from word_{*N*-2}, so that less processing of word_{*N*} will be completed until the eyes actually move to word_{*N*}, inflating the fixation durations on word_{*N*}.

Figure 4 also shows that single fixations on word_{*N*} were modulated by the lexical properties of word_{*N*-1}, even when word_{*N*-1} was fixated. This reflects the well-documented *spillover effect*, or the finding that processing difficulty associated with one word often "spills over" onto the next, inflating the fixation duration on that word (Kliegl, Nuthmann, & Engbert, 2006; Rayner & Duffy, 1986; Rayner, Sereno, Morris, Schmauder, & Clifton, 1989). In cases where word_{*N*} is difficult to process, lexical processing of word_{*N*} consumes more time, leaving less time for parafoveal processing of word_{*N*+1}. This then results in longer fixations on word_{*N*+1} when it is eventually fixated. However, because these effects are less controversial and have also been simulated using the SWIFT model (see Engbert & Kliegl, 2011), they are reported here for completeness. We therefore return to our discussion of the fixation-duration costs that precede word skipping.

Discussion

Our simulations demonstrate that fixation-duration cost prior to skipping is a direct consequence of the E-Z Reader architecture. Our simulations also indicate why this cost is modulated by word length and frequency, and to a lesser degree, predictability (Kliegl & Engbert, 2005). The one discrepancy between the simulated and observed results is that observed fixations were shorter prior to skipping short and/or common words, producing skipping benefit rather than cost. However, it is important to note that, although the most recent version of the SWIFT model can simulate this pattern of skipping cost and benefit for word length by dynamically modulating the model's perceptual span (consistent with a zoom-lens model of attention; e.g., Eriksen & St. James, 1986), an explicit, "mechanistic" account of this simulation result is not provided (see Schad & Engbert, 2012, p. 412).

Although we cannot definitively explain this discrepancy, existing accounts of skipping cost presuppose that it reflects how visual and oculomotor constraints affect lexical processing. This assumption is probably incomplete because higher-level (post-lexical) language processing also rapidly affects readers' decisions about when and where to move their eyes (for a review, see Clifton, Staub, & Rayner, 2007). Analyses that only attribute skipping benefit to lexical variables are probably missing important contributions of other linguistic variables (e.g., differences between content and function words; Kliegl, 2007). Although this "explanation" admittedly only substitutes one mystery (how lexical processing might produce skipping benefit) for another (e.g., how post-lexical might produce skipping benefit), it is important to consider the possible role of all variables affecting readers' eye movements. For example, although Schad and Engbert (2012) do not explain why skipping benefit occurs their simulation of normal reading, the effect is notably absent in their simulation of the reading of "shuffled" text (Schad, Nuthmann, & Engbert, 2010), suggesting that post-lexical processing (which is presumably only occurring during normal reading) may contribute to skipping benefit.

Earlier discussions of accidental word skipping (e.g., Reichle & Laurent, 2006) suggest that it should not produce cost because it does not entail the cancelation and replacement of saccadic programs. However, our simulations show that such cost can be generated via sequences of events that produce both inflated fixations *and* accidental skips. This underscores the importance of running simulations rather than relying upon intuitions to understanding models of eye movements in reading—even with relatively simple phenomena like the ones investigated in this article.

Finally, the simulations also demonstrate how the inclusion of mis-located fixations can contribute to theoretically important effects (e.g., costs associated with accidental skipping). For example, our simulations validate one account of *parafoveal-on-foveal effects*, or the purported finding that lexical processing of word_{N+1} can influence fixation durations on word_N (Kennedy & Pynte, 2005; Kliegl et al., 2006; see Drieghe, 2011). Although such effects are seemingly at odds with serial-attention models like E-Z Reader because of their assumption that the time spent looking at a word should only reflect its processing difficulty (Reichle, 2011), one account for these effects is that they reflect mis-located fixations (Drieghe, Rayner, & Pollatsek, 2008). By this account, the eyes are directed towards word_{N+1} but occasionally fall short, landing on word_N and resulting in word_{N+1} being processed from word_N so that the processing difficulty associated with word_{N+1} affects when the eyes move from word_N (Rayner, White, Kambe, Miller, & Liversedge, 2003). Our demonstration that E-Z Reader generates such an effect mitigates claims that parafoveal-on-foveal effects provide evidence against the serial-attention hypothesis (e.g., Kennedy & Pynte, 2005), and again underscores the importance of running simulations to test model predictions because of the inherent complexity of eye-movement behavior.

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Figure 1. Schematic diagram of the three types of fixation sequences used by Kliegl and Enbert (2005) in their analyses of skipping costs. Panel A shows the sequence of fixations used to estimate the fixation duration on word_N when word_{N+1} is fixated. Panel B shows the sequence of fixations used to estimate the fixation-duration costs on word_N when word_{N+1} is skipped. Panel C shows the sequence of fixations used to estimate the fixation-duration costs on word_N when word_{N-1} is skipped.

Figure 2.

Simulation 1: Fixation durations on word_N associated with fixating versus skipping word_{N+1} as a function of three lexical properties of word_{N+1}: (Panels A & B) its length in character spaces; (Panels C & D) its frequency of occurrence; and (Panels E & F) its within-sentence cloze-task predictability. (The left-hand panels are un-weighted means, averaged across conditions, and the right-hand panels show means weighted by the number of observations per condition.)

Figure 3. Simulation 1: Panel A shows the familiarity check durations for word_{N+1} as a function of whether it is fixated versus skipped, and as a function of the fixation position on word_N; Panel B shows the fixation-duration costs on word_N associated with skipping word_{N+1} as a function of the fixation position on word_N.

Figure 4.

Simulation 2: Fixation durations on word_N associated with fixating versus skipping word_{N-1} as a function of three lexical properties of word_{N-1}: (Panels A & B) its length in character spaces; (Panels C & D) its frequency of occurrence; and (Panels E & F) its within-sentence cloze-task predictability. (The left-hand panels are un-weighted means, averaged across conditions, and the right-hand panels show means weighted by the number of observations per condition.)

Table 1

Simulation 1: Mean fixation positions on word_N as a function of the lexical properties of word_{N+1} and the mean proportion of simulation trials (*M*) that word_{N+1} was fixated, skipped, and accidentally or deliberately skipped.

Lexical Properties of Word _{N+1}		Word _{N+1} Fixated		Word _{N+1} Skipped		Word _{N+1} Deliberately Skipped		Word _{N+1} Accidentally Skipped	
		Fixation Position	<i>M</i>	Fixation Position	<i>M</i>	Fixation Position	<i>M</i>	Fixation Position	<i>M</i>
Length (characters)	2	2.83	0.64	3.17	0.36	3.04	0.23	3.39	0.13
	5	2.95	0.86	3.20	0.14	3.34	0.12	3.40	0.02
	8	2.98	0.95	3.22	0.05	3.20	0.05	3.47	0
Frequency	1	2.97	0.90	3.20	0.10	3.20	0.09	3.48	0.01
	100	2.93	0.83	3.19	0.17	3.25	0.13	3.41	0.05
	10,000	2.88	0.77	3.20	0.23	3.25	0.17	3.35	0.07
Cloze Predictability	0	2.98	0.98	3.46	0.02	3.77	0	3.44	0.01
	0.4	2.93	0.83	3.10	0.17	3.01	0.12	3.42	0.05
	0.8	2.88	0.68	3.07	0.32	3.01	0.26	3.38	0.06

Table 2

Simulation 2: Mean fixation positions on word_N as a function of the lexical properties of word_{N-1} and the mean proportion of simulation trials (*M*) that word_{N-1} was fixated, skipped, and accidentally or deliberately skipped.

Lexical Properties of Word _{N-1}		Word _{N-1} Fixated		Word _{N-1} Skipped		Word _{N-1} Deliberately Skipped		Word _{N-1} Accidentally Skipped	
		Fixation Position	<i>M</i>	Fixation Position	<i>M</i>	Fixation Position	<i>M</i>	Fixation Position	<i>M</i>
Length (characters)	2	3.12	0.56	2.24	0.44	2.69	0.30	1.01	0.14
	5	2.95	0.82	2.12	0.18	2.59	0.16	1.10	0.02
	8	2.81	0.93	2.16	0.07	2.61	0.07	1.24	0
Frequency	1	2.90	0.87	2.11	0.13	2.61	0.12	1.21	0.01
	100	2.95	0.78	2.16	0.22	2.62	0.17	1.09	0.05
	10,000	3.03	0.71	2.20	0.29	2.64	0.22	1.05	0.07
Cloze Predictability	0	2.89	0.98	1.65	0.02	2.72	0	1.20	0.02
	0.4	2.96	0.79	2.32	0.21	2.56	0.16	1.10	0.06
	0.8	3.02	0.60	2.43	0.40	2.60	0.35	1.04	0.06