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Revisiting effects of contextual strength on the subordinate bias effect: Evidence from eye movements

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Abstract In this study, we examined two issues regarding the role of context in ambiguity resolution: whether access to the contextually appropriate meaning is exhaustive or selective, and whether the contextually inappropriate meaning is inhibited. Participants read texts in which a biased ambiguous word was encountered twice while their eye movements were measured. The context preceding the first encounter varied in the extent to which the subordinate meaning was supported; the context preceding the second encounter always supported the dominant meaning. The findings suggest that lexical access is exhaustive but can be influenced by context, and that the subsequent accessibility of the contextually inappropriate meaning is unaffected by previous selection processes. The results were interpreted in terms of the assumptions of the reordered-access model and activation mechanisms that operate during reading.

Keywords Subordinate-bias effect · Lexical ambiguity · Reading

Introduction

The meanings of ambiguous words (e.g., *toast*, *bank*, *ruler*) can be balanced in frequency or biased, such that one meaning is much more frequent (i.e., dominant) than the other. For biased ambiguous words, dominant meanings are typically accessed more quickly than subordinate meanings (e.g., Rayner & Duffy, 1986; Simpson & Burgess, 1985). An issue of debate in the literature and the focus of this study is the degree to which biasing context can interact with meaning frequency to impact access to both the selected and unselected meanings of biased ambiguous words.

Most of the studies on this topic have used eyetracking to measure early lexical access processes; they have typically reported gaze durations (i.e., initial time spent processing a word prior to moving on in the text) on a biased ambiguous word embedded in either a single sentence (e.g., Dopkins, Morris, & Rayner, 1992; Duffy, Morris, & Rayner, 1988; Folk & Morris, 2003; Rayner, Cook, Juhasz, & Frazier, 2006; Rayner & Duffy, 1986; Rayner & Frazier, 1989; Sereno, 1995; Sereno, Brewer, & O'Donnell, 2003; Sereno, O'Donnell, & Rayner, 2006; Sereno, Pacht, & Rayner, 1992) or a sentence that is part of a passage (e.g., Binder, 2003; Binder & Morris, 1995, 2011; Kambe, Rayner, & Duffy, 2001; Rayner, Pacht, & Duffy, 1994; Wiley & Rayner, 2000). When the context preceding a biased ambiguous word either is neutral or reflects the dominant meaning, gaze durations on the ambiguous word tend to be fast relative to those on a control word matched for length and word frequency (see Sereno et al., 2006). In their reordered access model, Duffy et al. (1988) argued that under these context conditions, the dominant meaning of a biased ambiguous word will be accessed first. This dominant meaning is easy to integrate with the contents of active memory, and thus there is no difference from reading times on a control word. However, when the context preceding the ambiguous word supports the subordinate meaning, gaze durations on the ambiguous word are longer than those on a control word. To explain this effect, Duffy et al. argued that context and meaning frequency can interact to influence or "reorder" access to the context-appropriate meaning of an ambiguous word, without influencing access to the context-inappropriate meaning. When the preceding context supports the subordinate meaning, access to that meaning is facilitated but access to the contextually inappropriate (i.e., dominant) meaning is unaffected. Under these circumstances, both the subordinate and dominant meanings may be accessed at approximately the same rate.

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This competition between alternate meanings results in processing difficulty for the ambiguous word, as compared to a control condition. This phenomenon has been called the *subordinate-bias effect* (Pacht & Rayner, 1993; Rayner et al., 1994) and has been found to be extremely robust in the eye movement research literature.

Within the reordered-access model, it is theoretically possible for a very strong subordinate-biasing context to reorder or facilitate access to the subordinate meaning of an ambiguous word, such that it is actually accessed and integrated faster than (and thus receives no interference from) the dominant meaning. That is, with the use of very strong biasing context, it should be possible to eliminate the subordinate-bias effect. Tests of this assumption in eye movement studies, however, have typically only manipulated preceding context by providing one or two allusions to the subordinate meaning of ambiguous words, regardless of context length. Even when researchers manipulated the theme or topic sentence of the paragraph (Binder, 2003; Binder & Morris, 1995; Rayner et al., 1994), or both the global and local contexts that preceded the ambiguous word (Kambe et al., 2001), they still found effects consistent with the subordinate-bias effect.

An exception to the studies just described was conducted by Wiley and Rayner (2000). They combined ambiguous passage contexts with titles that were consistent with either the dominant or the subordinate meaning of a biased ambiguous word. That is, by changing just the title of a passage, they were able to manipulate whether the entire contents of the passage supported either the dominant or the subordinate meaning. Wiley and Rayner found that when titles supported the subordinate meaning (e.g., *Worries of a Baseball Team Manager* supports the subordinate meaning of the ambiguous word *fly*), the subordinate-bias effect was observed for ambiguous words with relatively infrequent subordinate meanings (i.e., meaning frequency < .07). However, for ambiguous words with more frequent subordinate meanings (i.e., meaning frequencies ranging from .08 to .30), the subordinate-bias effect was eliminated; reading times did not differ between the ambiguous and control words. Although Wiley and Rayner only eliminated the subordinate-bias effect for stimuli in which the frequency of the subordinate meaning more closely approximated the dominant meaning, their results are suggestive that very strong context can override effects of meaning frequency to eliminate the subordinate-bias effect.

More recently, Leinenger and Rayner (2013) demonstrated that when readers have previously encountered a biased ambiguous word in a sentence, processing difficulty on the second encounter is reduced as compared to a control no-previous-encounter condition. Importantly, they demonstrated that the processing advantage for the second encounter was much stronger when the context supported the subordinate meaning of the word than when it supported the dominant meaning. Leinenger and Rayner interpreted this finding as showing that contextual manipulations can mediate the subordinate-bias effect. In other words, context can interact with meaning frequency to influence lexical access.

In contrast to the eye movement studies on the subordinate-bias effect, Kellas, Vu, and colleagues (Kellas, Martin, Yehling, Herman, & Vu, 1995; Kellas & Vu, 1999; Martin, Vu, Kellas, & Metcalf, 1999; Vu & Kellas, 1999; Vu, Kellas, Metcalf, Herman, 2000; Vu, Kellas, Petersen, & Metcalf, 2003) provided evidence in support of selective access to contextually appropriate meanings for ambiguous words. Using word-by-word self-paced reading and probe methodologies, they found that strong context could modulate the subordinate-bias effect; the effect was present when weak context was used, but was eliminated in the presence of strong context. However, when Binder and Rayner (1998) used a subset of Kellas et al.'s (1995) materials, they found just the opposite pattern of effects: The subordinate-bias effect was actually larger in the presence of strong context. This was true whether they used eyetracking or self-paced reading to measure reading time on the ambiguous word. These findings, combined with those of Wiley and Rayner (2000), suggest that both meaning frequency and the strength of the subordinate-biasing context are critical components in determining whether context can override meaning frequency to influence lexical access.

The two goals of this study were to test the reordered-access model's (Duffy et al., 1988) assumptions that (1) context effects can reorder lexical access effects, and (2) the accessibility of the unselected meaning will be unaffected. More specifically, we sought to determine (1) whether elaborated discourse contexts can override meaning frequency effects to eliminate the subordinate-bias effect and (2) whether these contextual manipulations influence, or even inhibit, the subsequent accessibility of the previously unselected (dominant) meaning. We employed eyetracking technology in order to detect the time course of effects of context on processing of ambiguous words, and we used a different manipulation of subordinate-biasing discourse context than had been used in previous studies on the subordinate-bias effect. From our examination of the subordinate-bias effect literature, even the strongest manipulations of context—those that included some thematic or topic manipulation as well as manipulation of the content that immediately preceded the ambiguous word—contained only one to two references to the subordinate meaning. In the present study, we varied the amount of elaboration consistent with the subordinate meaning in contexts preceding a biased ambiguous word. Thus, as in previous studies on the subordinate-bias effect, we used a *neutral* context condition, which had zero references to the subordinate meaning, and what we called an *unelaborated* context condition, which contained one reference to the subordinate meaning of the ambiguous word. Given that O'Brien and colleagues

(e.g., Albrecht & O'Brien, 1998; Myers, Cook, Kambe, Mason, & O'Brien, 2000; O'Brien, 1987; O'Brien, Albrecht, Hakala, & Rizzella, 1995; O'Brien, Plewes, & Albrecht, 1990) have shown that highly elaborative contexts facilitate subsequent activation and integration processes, we also created an *elaborated* context condition, which contained four references to the subordinate meaning of the ambiguous word. Using more elaborated contexts than those used in previous studies on the subordinate-bias effect might be sufficient to facilitate access to the subordinate meaning above and beyond that of the dominant meaning. So, in summary, our passage contexts contained zero, one, or four sentences that supported the subordinate meaning of a subsequent, biased ambiguous word (the neutral, unelaborated, and elaborated conditions, respectively; see Table 1 for sample passages). Importantly, these contexts varied by only a few words per sentence across conditions. The ambiguous word was presented for the first time in Sentence 5; subsequent text then switched to support the dominant meaning of the word, and the ambiguous word was presented a second time in Sentence 8. Because the predictions for the two encounters with the ambiguous word separately addressed the two critical assumptions of the reordered-access model, they will be discussed separately.

First encounter of the ambiguous word

The first goal of the present study was to test the assumption that strong context can act to reorder lexical access, such that context effects can override meaning frequency effects, with a strongly elaborated discourse context. The unelaborated context condition is comparable to the subordinate-biasing context conditions used in previous eye movement studies (e.g., Binder, 2003; Binder & Morris, 1995; Rayner et al., 1994). Thus, in the unelaborated condition, access to the subordinate meaning might be facilitated such that it would be accessed at a rate comparable to the dominant meaning, resulting in interference between the two activated meanings. As a result, processing times on the first encounter of the ambiguous word in Sentence 5 should be slower in the unelaborated than in the neutral condition; that is, the subordinate-bias effect should be observed. The elaborated context condition contained more references to the subordinate meaning of the ambiguous word than the biasing contexts that had been used in previous studies, or than the unelaborated condition in the present study. This elaborative context might therefore facilitate access to the subordinate meaning, such that it would be accessed and integrated more quickly than the dominant meaning; thus, in this condition there should be no processing difficulty due to interference from the activation of both meanings. In this case, processing times on the first encounter of the ambiguous word in the elaborated condition should be as fast as, or perhaps even faster than, in the unelaborated and neutral conditions; in other words, the subordinate-bias effect should be eliminated.

We also examined the time to process the disambiguating word, which appeared later in the target sentence. This word disambiguated the ambiguous word toward its subordinate meaning. If readers accessed (and ultimately integrated) the subordinate meaning in the unelaborated and elaborated conditions, they should process the disambiguating word faster than in the neutral condition, and we should find no difference between the unelaborated and elaborated conditions. If the contextually appropriate meaning was not selected, processing times should be longer in the unelaborated and elaborated than in the neutral condition.

Second encounter of the ambiguous word

The second goal of this study was to examine the reordered-access model's assumption that the subsequent accessibility of the initially unselected meaning of an ambiguous word would be unaffected by contextual manipulations (Duffy et al., 1988). Consistent with this view, Binder and Morris (2011; see also Binder & Morris, 1995; Kambe et al., 2001; Rayner et al., 1994) found that when the context preceding the first encounter of a biased ambiguous word supported the subordinate meaning, but then the context preceding a second encounter of the same ambiguous word switched to support the dominant meaning, there was no immediate cost of switching to the previously unselected meaning on the second encounter of the ambiguous word. However, they did find delayed processing costs associated with this meaning switch on a posttarget region. An alternative view, raised by researchers who have primarily used probe or self-paced reading methods (e.g., Gernsbacher, Robertson, & Werner, 2001; Simpson & Adamopoulous, 2001; Simpson & Kang, 1994), is that the unselected meaning would be inhibited or suppressed. Gernsbacher et al., for example, found that when meaning switched from one encounter of an ambiguous word to the next across experimental trials, processing times were slower on the second trial than in a control condition. In order to test these competing views, in the present study we extended the passages beyond the first target sentence to include a second encounter of the ambiguous word, in which the dominant meaning was intended.

In the sample passage in Table 1, the ambiguous word is encountered a second time in its previously unselected sense in Sentence 8. If the accessibility of the previously unselected (i.e., dominant) meaning was unaffected upon the first encounter of the ambiguous word, then when the reader encountered the word again later in a dominant-biasing context, the dominant meaning should be accessed quickly. This dominant meaning should be easy to integrate, and processing times on the second encounter of the ambiguous word should be faster in the unelaborated and elaborated conditions than in the neutral condition. If the previously unselected meaning was

Table 1 Sample passages used in the experiment

Neutral Condition
1. Paul's son Frank wanted to have his dad to himself.
2. Paul took him to the local playground for the day.
3. He wanted to make sure Frank was ready for anything that was present.
4. Paul decided to lecture Frank about being careful in life since he was so young.
5. Once they got to the bank, Frank ran to the shore with excitement.
6. Frank had a lot of fun hanging out with his dad that day.
7. Later in the afternoon, Paul took Frank to set up a *savings account*, which would be his first.
8. They had to wait a long time at the bank because the tellers were all busy.
9. By the time Paul and Frank got home they were very tired from the long day.
Unelaborated Condition
1. Paul's son Frank wanted to have his dad to himself.
2. Paul took him to the local playground for the day.
3. He wanted to make sure Frank was ready for anything that was present.
4. Paul decided to lecture Frank about being careful *around water* since he was so young.
5. Once they got to the bank, Frank ran to the shore with excitement.
6. Frank had a lot of fun hanging out with his dad that day.
7. Later in the afternoon, Paul took Frank to set up a *savings account*, which would be his first.
8. They had to wait a long time at the bank because the tellers were all busy.
9. By the time Paul and Frank got home they were very tired from the long day.
Elaborated Condition
1. Paul's son Frank wanted to *catch a fish for* himself.
2. Paul took him to the *local river to get one*.
3. He wanted to make sure Frank was ready for *the mud* that was present.
4. Paul decided to lecture Frank about being careful *around water* since he was so young.
5. Once they got to the bank, Frank ran to the shore with excitement.
6. Frank had a lot of fun hanging out with his dad that day.
7. Later in the afternoon, Paul took Frank to set up a *savings account*, which would be his first.
8. They had to wait a long time at the bank because the tellers were all busy.
9. By the time Paul and Frank got home they were very tired from the long day.

Biasing contexts for the different meanings of the target word are highlighted with italics in the table. Italics and underscore were not presented to participants.

inhibited or suppressed upon the first encounter of the ambiguous word, however, the dominant meaning should be difficult to access upon the second encounter of the ambiguous word, and processing times should be slower in the unelaborated and elaborated conditions than in the neutral condition.

A third, previously untested alternative is that meaning access could be the product of meaning frequency and contextual support, regardless of whether that meaning has been previously selected or unselected. Within this view, when the reader encounters an ambiguous word for a second time, any related information in memory has the potential to be activated; that is, both information about meaning frequency as well as any previous contextual information are signaled in parallel via some low-level memory retrieval process. If one source of information is stronger than the other, it will be activated first and drive initial processing on the ambiguous word. Given that the two sources of information are accessed in parallel, if they are comparable in strength, they may become activated at approximately the same time, and thus have competing influences on the processing of the ambiguous word. In the example in Table 1, when the preceding context supporting the subordinate meaning is limited (unelaborated condition), but more recently encountered information supports the dominant meaning, the more frequent dominant meaning might be accessed first and affect initial processing on the second encounter of the ambiguous word; in that case, there should be no slowdown in the unelaborated relative to the neutral condition. When the preceding context supporting the subordinate meaning is elaborated across multiple sentences, however, it may be facilitated, such that it is accessed concurrently with the more recently encountered contextual information supporting the dominant meaning, as well as information about meaning frequency (i.e., the dominant meaning). The concurrent activation of information supporting both meanings could result in confusion on the second

encounter of the ambiguous word; processing times should then be slower in the elaborated than in the control condition. That is, in the elaborated condition, a *dominant-bias effect* would be observed for the second encounter of the ambiguous word. If readers are accessing (and selecting) the dominant meaning in all three conditions on the second encounter of the ambiguous word, there should be no difference in the time to process the disambiguating word later in the sentence, since this is consistent with the dominant meaning.

In this study, we tested the two primary assumptions of the reordered-access model (Duffy et al., 1988). The contextual manipulations combined with the first encounter of the ambiguous word (in Sentence 5) were used to investigate whether context effects can truly "reorder" lexical access effects so as to eliminate the subordinate-bias effect. These contextual manipulations, combined with the subsequent meaning switch before the second encounter of the ambiguous word (in Sentence 8), were designed to investigate whether the accessibility of the previously unselected meaning would be unaffected. In testing these assumptions, we were specifically interested in the nature of the interaction between the context conditions and the first versus the second encounter of the ambiguous word. In short, we predicted the following patterns: For the first encounter of the word, we expected to observe processing difficulty in the unelaborated but not the elaborated condition, relative to the neutral condition; for the second encounter of the word, we expected to observe processing difficulty in the elaborated but not the unelaborated condition, relative to the neutral condition.

Although many eye movement studies on the subordinate-bias effect have primarily reported gaze durations for the ambiguous word, examining how individuals process regions of text over time can provide a more in-depth view of reading processes (see Rayner, 1998). Thus, similar to Leinenger and Rayner (2013), Rayner et al. (2006), and Sereno et al. (2006), we will report several convergent measures of reading time: first-fixation duration, gaze duration, second-pass duration, total time, regressions into and out of the word, and probability of skipping the target word. First-fixation duration and gaze duration are often assumed to be measures of lexical access, although they can also reflect early integration processes. Second-pass duration may reflect delayed processing difficulty, whereas total time provides an index of overall processing difficulty (Rayner, 1998; Rayner, Pollatsek, Ashby, & Clifton, 2012). Finally, in many previous studies of the subordinate-bias effect, researchers have compared processing times on the ambiguous word to those on a control word matched for length and frequency (for a discussion of this issue, see Sereno et al., 2006). However, in the present study, we sidestepped this issue by comparing the ambiguous word in either the elaborated or the unelaborated context conditions to itself in a neutral context condition (see also Leinenger & Rayner, 2013; Rayner et al., 2006; Rayner & Frazier, 1989). As was noted by Leinenger and Rayner, this avoids the issue of determining whether a control word should be matched to the subordinate or dominant frequency of the target word. In addition, as in the Leinenger and Rayner study, because our manipulation involved comparing processing times for two separate encounters of the same target word, it made the most sense to use the ambiguous word as its own control.

Method

Participants

The participants were 30 undergraduate students from the University of Utah. Participation fulfilled part of a course requirement for an Educational Psychology course. Participants were required to be native English speakers who were at least 18 years of age and did not have any vision problems that could not be adjusted to normal with corrective lenses. Informed consent was obtained prior to the experiment.

Apparatus

Participants' eye movements were measured with an Applied Sciences Laboratory (ASL) Model 6000 series head-mounted eyetracker. The eyetracker was interfaced and controlled via a Hewlett-Packard 1.8-GHz computer. Another Hewlett-Packard 1.8-GHz computer controlled the experiment. A Samsung 213 T 21.3-in. flat panel monitor was used for displaying the passages to the participants. The monitor was rotated 90 deg into portrait mode and placed approximately 25 in. from the eyes of the participants. The participants had free head and eye movement, and their head movements and orientation were recorded with the ASL EyeHead Integration system. The eyetracker has an accuracy range of one half of a degree of visual angle (approximately four characters of text). Stimuli were presented on the screen such that 1.75 in. separated the bottom of the characters on a line and the top of characters on the line below it. Viewing was binocular, with eye location recorded from the right eye. The position of the participant's eye was sampled at 60 Hz (approximately every 16.67 ms). Each sample was compared to the previous sample in order to determine whether the eye was fixating or moving.

Materials

Three passage versions (neutral, unelaborated, and elaborated) were created for each of 21 ambiguous words (see Table 1 for an example). All of the passages were nine sentences in length. In the neutral condition, the first four

sentences were neutral with respect to the meaning of the first encounter of the ambiguous word in the fifth sentence, but local coherence was maintained. In the unelaborated condition, the first three sentences were neutral, and Sentence 4 biased interpretation of the ambiguous word in the fifth sentence toward its subordinate meaning. In the elaborated condition, Sentences 1–4 each biased the ambiguous word in the fifth sentence toward its subordinate meaning. Importantly, passage conditions differed by only a few words in each of the first four sentences. Sentence 5, or the first target sentence, was the same for all three conditions. It contained the ambiguous target word (mean length = 4.86 characters, *SD* = 1.15), a brief posttarget region, and a word that disambiguated the target word toward its subordinate meaning; the mean number of characters that followed the ambiguous word in the first target sentence was 38.95 (*SD* = 7.55). Sentences 6–9 were held constant across conditions. Sentence 6 was neutral and served to continue the story, and Sentence 7 contained information that supported the dominant meaning of the ambiguous word presented earlier in the text. Sentence 8, or the second target sentence, contained the second encounter of the ambiguous word, a posttarget region, and a word that disambiguated the target word toward its dominant meaning; the mean number of characters that followed the ambiguous word in the second target sentence was 34 (*SD* = 4.88). Sentence 9 was neutral and ended the passage.

The ambiguous words were all biased and had both noun-dominant and noun-subordinate meanings that were semantically distinct. The ambiguous words were selected using norms collected locally, as well as norms from Rayner et al. (2006), Twilley, Dixon, Taylor, and Clark (1994), and Gorfein, Viviani, and Leddo (1982). The probabilities of generating the subordinate meaning ranged from .01 to .20 (mean = .09). Table 2 lists all of the ambiguous words used, their dominant and subordinate meanings, and the mean frequencies with which those meanings were generated.

Three material sets were constructed and counterbalanced, such that within each set each condition appeared an equal number of times, and across material sets each passage appeared once in each of the three conditions. The 21 experimental passages were presented within a larger set of 41 passages. The 20 "filler" passages were designed to mask the purposes of the experiment. A comprehension question that was not about the ambiguous word appeared after each passage.

Table 2 Dominant/subordinate meaning frequencies for ambiguous words

Ambiguous Word	Dominant Meaning		Subordinate Meaning	
	Meaning	Frequency	Meaning	Frequency
Bank	Money	.99	River	.01
Jam	Jelly	.92	Stuck	.06
Star	Sky	.85	Movie	.10
Bulbs	Light	.90	Flower	.09
Ruler	Measure	.75	King	.18
Diamond	Ring	.94	Baseball	.03
Toast	Breakfast	.90	Speech	.09
Shot	Gun	.83	Glass	.05
Cold	Hot	.77	Sick	.10
Vessel	Ship	.79	Blood	.14
Calf	Cow	.77	Leg	.20
Race	Run	.84	Color	.15
Stories	Book	.97	Two	.02
Deck	Boat	.74	Cards	.17
Table	Kitchen	.98	Report	.02
Boxer	Fighter	.87	Dog	.13
Pipe	Smoke	.70	Plumbing	.10
Scales	Weigh	.87	Fish	.04
Notes	Book	.90	Music	.07
Ball	Bat	.94	Dance	.03
Cabinet	Wood	.87	Minister	.09

Procedure

Each participant was run individually in a session that lasted approximately 40 min. Participants were randomly assigned to one of the three materials sets. Participants were then calibrated on the eyetracker with a nine-point calibration display. After calibration, participants read instructions for the experiment on the computer screen while the experimenter read them aloud. Participants were instructed that they would be reading passages at their own normal reading rate and answering comprehension questions. Once participants understood the instructions, they pressed the space bar, and the first trial began. At the beginning of each trial, a nine-point calibration screen appeared, and participants were instructed to look at the middle point, then the point directly above the middle point, and then the top leftmost point (which appeared at the same place on the screen as the beginning of each passage). The first five sentences appeared on the screen, and when participants had finished reading these, they pressed the space bar so that the final four sentences of the passage would be presented. After reading the second half of the passage, participants pressed the space bar again, and a comprehension question about the passage appeared. Participants responded by pressing a key labeled "yes" or "no" on the keyboard; this response ended the trial. To ensure that they were thoroughly familiarized with the procedure, all participants went through nine practice trials before reading the complete set of experimental and filler passages.

Results

All fixations less than 100 ms and greater than 1,000 ms, as well as all data 2.50 standard deviations beyond a participant's mean and an item's mean on a given measure for each condition, were eliminated from the analyses. This resulted in the exclusion of less than 3 % of all data. In all analyses reported, F_1 and t_1 refer to tests against error terms based on participants variability, and F_2 and t_2 refer to tests against error terms based on items variability. All analyses are significant at the standard alpha level of .05 unless otherwise indicated. The comprehension question response accuracy rates ranged from 91 %–93 %. Across context conditions, these rates did not differ as a function of conditions, Fs < 1.

To demonstrate that our effects were consistent across a wide variety of measures, for each encounter of the ambiguous word (i.e., the word itself plus the space preceding it), we report first fixation duration (the duration of the first fixation on a word), first pass duration (the duration spent initially reading a word before moving past it), second-pass duration (time spent rereading a word after having initially left it) total time (total time spent reading a word, or the sum of first- and second-pass durations), regressions into and out of the word, and probability of skipping the word. In addition to processing time measures for the ambiguous word, we also computed the total time required to read the disambiguating word that followed the ambiguous word.

In order to directly contrast the effects on the first and second encounters of the ambiguous word, we conducted a 2 × 3 (Encounter × Context) analysis of variance (ANOVA) for each measure, as well as planned comparisons among the three context conditions within each encounter of the target word. Means for the reading measures are presented as a function of encounter and context condition in Table 3.

For first-fixation durations, the main effect of encounter was marginal when based on participants variability, $F_1(1, 24) = 3.805$, $MSE = 8{,}464.99$, $p = .06$, but significant when based on items variability, $F_2(1, 18) = 6.07$, $MSE = 6{,}247.04$, $\eta_p^2 = .25$. The main effect of context was not significant, $F_1 < 1$; $F_2 = 2.22$, $MSE = 1{,}766.43$, $p > .12$. Most importantly, however, the Encounter × Context interaction was significant, $F_1(2, 48) = 4.60$, $MSE = 3{,}515.31$, $\eta_p^2 = .16$; $F_2(2, 36) = 5.74$, $MSE = 5{,}181.32$, $\eta_p^2 = .24$. For the first encounter of the target word, planned comparisons revealed that the subordinate-bias effect in the unelaborated condition was significant (but only when based on participants variability), $t_1(29) = 2.38$; $t_2(20) = 1.54$, $p = .14$. More importantly, this slowdown was eliminated in the elaborated condition, $t_1(29) = 1.18$, $p = .25$; $t_2(20) = 1.03$, $p = .32$. In contrast, on the second encounter of the target word, we observed no difference between the neutral and unelaborated conditions, $t_1(29) = 0.37$, $p = .71$; $t_2(20) = 1.65$, $p = .11$. In addition, first-fixation durations were longer in the elaborated than in the neutral condition (although only marginally when based on participants variability), $t_1(29) = 1.91$, $p = .07$; $t_2(20) = 2.36$.

The main effect of encounter was significant for gaze durations, $F_1(1, 24) = 7.07$, $MSE = 23{,}647.97$, $\eta_p^2 = .23$; $F_2(1, 18) = 7.55$, $MSE = 18{,}689.91$, $\eta_p^2 = .30$. The main effect of context was not significant when based on participants variability, $F_1 < 1.26$, and was only marginal when based on items variability, $F_2(2, 36) = 2.62$, $MSE = 5{,}237.12$, $p = .09$. The interaction of encounter and context was significant, however: $F_1(2, 48) = 4.56$, $MSE = 7{,}995.66$, $\eta_p^2 = .16$; $F_2(2, 36) = 17.06$, $MSE = 14{,}051.41$, $\eta_p^2 = .49$. On the first encounter of the target word, planned comparisons revealed significantly longer gaze durations in the unelaborated condition than in either the neutral, $t_1(29) = 3.09$, $t_2(20) = 3.44$, or the elaboration, $t_1(29) = 3.71$, $t_2(20) = 3.66$, conditions. The gaze durations in the elaborated condition were actually marginally faster than those in the neutral condition (although only when based on participants variability), $t_1(29) = 1.72$, $p = .096$; $t_2(20) = 1.46$, $p = .16$. In contrast, on the second encounter of the target word, gaze durations were longer in the elaborated condition than in either the neutral condition, $t_1(29) = 2.98$, $t_2(20) = 2.30$, or the unelaborated condition (significant for participants only), $t_1(29) = 2.19$; $t_2(20) = 1.64$, $p = .12$. We found no significant difference for gaze durations between the neutral and unelaborated conditions, both ps ≥ .17.

Table 3 Means for all reading measures (in milliseconds) as a function of encounter and context condition

	First Encounter of Ambiguous Word						Second Encounter of Ambiguous Word					
	Neutral		Unelaborated		Elaborated		Neutral		Unelaborated		Elaborated	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
First fixation duration	221	42	237	46	211	41	203	33	206	35	221	60
Gaze duration	240	44	275	74	224	46	209	38	217	42	241	61
Second pass duration	67	61	70	83	48	64	39	40	32	45	58	66
Total time	310	81	346	91	272	76	248	64	249	64	299	89
Total time disambiguating word	374	120	322	84	332	100	312	85	304	88	293	66

In second-pass durations, the main effect of encounter was significant when based on participants variability, $F_1(1, 24) = 7.56$, $MSE = 22{,}113.69$, $\eta_p^2 = .24$, and marginal when based on items variability $F_2(1, 18) = 3.37$, $MSE = 12{,}660.07$, $p = .08$. The main effect of context was not significant, Fs < 1. The interaction between encounter and context conditions was significant, $F_1(2, 48) = 3.88$, $MSE = 9{,}515.93$, $\eta_p^2 = .14$; $F_2(2, 36) = 5.51$, $MSE = 6{,}974.92$, $\eta_p^2 = .23$. For the first encounter of the target word, participants spent less time rereading the target word in the elaborated than in the neutral condition; this effect was marginally significant when based on participants variability, $t_1(29) = 1.81$, $p = .08$; $t_2(20) = 2.11$. No difference was apparent in the time spent rereading in the neutral and unelaborated conditions, both ts < 1. Second-pass times were marginally lower for the elaborated than for the unelaborated condition, but only when based on items variability, $t_1(29) = 1.14$, $p = .26$; $t_2(20) = 2.06$, $p = .05$. In contrast, for the second encounter of the target word, we found no significant differences in time spent rereading the target word across the three conditions. Participants spent more time rereading the target word in the elaborated condition than in the unelaborated condition, but this was only marginally significant when based on participants variability, $t_1(29) = 1.88$, $p = .07$; $t_2(20) = 1.45$, $p = .16$. For all other contrasts, ps > .23.

For total time, the main effect of encounter was significant, $F_1(1, 24) = 20.72$, $MSE = 91{,}497.61$, $\eta_p^2 = .46$; $F_2(1, 18) = 7.44$, $MSE = 62{,}114.61$, $\eta_p^2 = .29$. The main effect of context was not significant, Fs < 1.07. The interaction of encounter and context conditions was significant, $F_1(2, 48) = 8.95$, $MSE = 34{,}440.97$, $\eta_p^2 = .43$; $F_2(2, 36) = 17.52$, $MSE = 40{,}466.5$, $\eta_p^2 = .49$. On the first encounter of the target word, planned comparisons revealed marginally longer processing time in the unelaborated condition than in the neutral condition, $t_1(28) = 1.82$, $p = .08$; $t_2(20) = 1.92$, $p = .07$, and significantly longer processing times than in the elaborated condition, $t_1(29) = 3.38$, $t_2(20) = 4.19$. Most importantly, the total time to process the ambiguous word was shorter in the elaborated than in the neutral condition, $t_1(29) = 2.38$, $t_2(20) = 2.45$. However, on the second encounter of the target word, readers spent more time reading the target word in the elaborated condition than in either the neutral, $t_1(29) = 2.61$, $t_2(20) = 2.53$, or the unelaborated, $t_1(29) = 2.8$, $t_2(20) = 2.15$, condition. The difference between the neutral and unelaborated conditions was not significant, both ts < 1.

The mean probabilities of regressing into or out of the target word, along with the skipping rates, are presented in Table 4. When regressions into and out of the target word were analyzed, the main effect of neither encounter nor context was significant, nor was the interaction of the two, all Fs < 1.06. We also analyzed the probabilities of skipping the target word as a function of condition. For this analysis, the main effect of encounter was significant when based on participants variability, and marginal when based on items variability: $F_1(1, 24) = 8.29$, $MSE = .04$, $\eta_p^2 = .26$; $F_2(1, 18) = 3.36$, $MSE = .02$, $p = .08$. This effect reflected higher skipping rates for the second encounter of the target word than for the first encounter. The main effect of context was not significant when based on participants variability, $F_1(2, 48) = 1.72$, $MSE = .02$, $p > .19$, but it was significant when based on items variability, $F_2(2, 36) = 5.33$, $MSE = .01$, $\eta_p^2 = .23$. The Encounter × Context interaction was not significant, $F_1(2, 48) = 1.8$, $MSE = .02$, $p > .17$; $F_2 < 1$.

We also analyzed the total time required to read the disambiguating word in the target line. This provides insight into the degree of processing difficulty that readers experienced in ultimately integrating the contextually appropriate meaning. The main effect of encounter was significant when based on participants variability, and marginal when based on items variability, $F_1(1, 24) = 4.73$, $MSE = .01$, $\eta_p^2 = .17$; $F_2(1, 18) = 3.08$, $MSE = .01$, $p = .09$. Readers took more time to read the disambiguating word after the first than after the second encounter of the ambiguous word. The main effect of context was not significant, $F_1(2, 48) = 1.86$, $MSE = .01$, $p > .16$; $F_2 < 1$, nor was the interaction of the encounter and context conditions, $F_1(2, 48) = 1.37$, $MSE = .01$, $p > .26$; $F_2 < 1$. For the first encounter of the ambiguous word, planned comparisons based on participants variability showed that in the neutral condition, participants spent significantly more time reading the contents that followed the ambiguous word than in the unelaborated condition, $t_1(29) = 2.56$, and marginally more time than in the elaborated condition, $t_1(29) = 1.89$, $p = .06$. When based on items variability, these comparisons did not approach significance, however: t_2s < 1. For the second encounter of the ambiguous word, no significant differences were observed among the three conditions, all ts ≤ 1. The only exception was that the total time to read the disambiguating word following the second encounter was marginally longer in the elaborated than in the neutral condition, but this was only true when the analysis was based on items variability, $t_2(20) = 1.79$, $p = .08$.

Discussion

In this study, we addressed two main assumptions of Duffy et al.'s (1988) reordered-access model: (1) that context can interact with meaning frequency to reorder lexical access, and (2) that the accessibility of the previously unselected meaning of an ambiguous word is unaffected. We tested the first assumption by examining how contextual elaboration supporting the subordinate meaning of a biased ambiguous word influences processing on the first encounter of that word in text. To test the second assumption, we switched the intended meaning of the ambiguous word in subsequent text to its dominant sense and then measured processing times on a second encounter of the word. Support for both assumptions was demonstrated by

Table 4 Mean probabilities of regressing into, regressing out of, or skipping the target word as a function of encounter and context condition

	First Encounter of Ambiguous Word						Second Encounter of Ambiguous Word					
	Neutral		Unelaborated		Elaborated		Neutral		Unelaborated		Elaborated	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Probability of regressing into the target word	.19	.18	.20	.19	.19	.17	.19	.20	.20	.19	.25	.27
Probability of regressing out of the target word	.29	.17	.28	.23	.23	.19	.22	.19	.21	.20	.25	.27
Probability of skipping target word	.17	.16	.19	.18	.14	.16	.24	.20	.27	.17	.19	.19

a significant interaction of encounter with context condition across several measures. We will first discuss the evidence supporting each individual assumption, and then we will move on to their combined implications for theoretical accounts of lexical access retrieval.

Previous eyetracking studies on the interacting influences of context and meaning frequency on the processing of biased ambiguous words during reading have overwhelmingly yielded results consistent with the subordinate-bias effect (e.g., Binder, 2003; Binder & Morris, 1995, 2011; Binder & Rayner, 1998; Dopkins et al., 1992; Duffy et al., 1988; Folk & Morris, 2003; Kambe et al., 2001; Rayner et al., 2006; Rayner & Duffy, 1986; Rayner & Frazier, 1989; Rayner et al., 1994; Sereno, 1995; Sereno et al., 2003; Sereno et al., 2006; Sereno et al., 1992). Consistent with those findings, in the present study we found that the subordinate-bias effect was observed for the first encounter of the ambiguous word when the preceding context was unelaborated. Processing times on the first encounter of the ambiguous word were slower in the unelaborated than in the neutral condition for first-fixation durations, gaze durations, and total times. More importantly, when the context preceding the ambiguous word was elaborated, the subordinate-bias effect was eliminated; we observed no processing difficulty on the first encounter of the ambiguous word in the elaborated relative to the neutral condition, suggesting that the subordinate meaning was activated and integrated faster than the dominant meaning in the elaborated condition. In fact, the gaze duration, second-pass duration, and total-time measures revealed that processing times in the elaborated condition tended to be faster than those in the neutral condition. Analysis of the time spent to process the disambiguating word following the first encounter of the ambiguous word provided additional evidence that readers activated and eventually integrated the subordinate meaning in both biasing context conditions; processing times were longer in the neutral than in either the unelaborated or the elaborated condition.

As we noted in the introduction, previous studies demonstrating support for the subordinate-bias effect have typically used biasing contexts that were similar to our unelaborated condition, which contained only a single reference to the subordinate meaning of the ambiguous word. In contrast, the elimination of the subordinate-bias effect in our elaborated condition is consistent with the results of Wiley and Rayner (2000), who showed that strong context could be used to override meaning frequency effects. However, they found that this was true only for ambiguous words with relatively frequent subordinate meanings. Note, however, that there were several differences between our "strong" elaborated contexts and those of Wiley and Rayner. Our elaborated contexts contained four references to the subordinate meaning of the word, whereas Wiley and Rayner used titles that could bias the contents of an entire passage. Wiley and Rayner's passages were also more complex, in that each of their passages contained multiple ambiguous words. Also, it is not clear whether the effectiveness of their manipulation differed as a function of whether the ambiguous word was the first one encountered in the passage, or whether it was encountered after other ambiguous words in the text. In either case, however, it may be that the "strong" context supporting the subordinate meaning resulted in a highly interconnected discourse model, such that when readers encountered the ambiguous word, they had multiple retrieval routes back to the subordinate meaning of the word, thereby facilitating access.

Combined with the results of Leinenger and Rayner (2013) and Wiley and Rayner (2000), the present findings on the first encounter of the ambiguous word support the assumption that context can influence the order in which alternate meanings are accessed (Duffy et al., 1988). A fully interactive, context sensitivity model (Kellas & Vu, 1999; Martin et al., 1999; Paul, Kellas, Martin, & Clark, 1992) assumes that strong biasing context can influence lexical access processes early on, such that only the contextually appropriate meaning is (selectively) accessed. Although this view could account for the elimination of the subordinate-bias effect on the first encounter of the ambiguous word in the elaborated condition, the observation of the effect in the unelaborated condition in the present study and the robustness of the effect in the eye movement literature suggests that the context sensitivity view may be too strong. The reordered-access model presents a more flexible view of

the interaction of context and meaning frequency that can account for the presence of the subordinate-bias effect both in the present study and in previously published studies, as well as the elimination of the effect in the present study.

Researchers have also examined how contextual manipulations affect the subsequent accessibility of the previously unselected meaning. Proponents of the reordered-access model assume that accessibility is unaffected (e.g., Binder & Morris, 1995, 2011). Others (e.g., Gernsbacher et al., 2001; Simpson & Adamopoulous, 2001; Simpson & Kang, 1994) have argued that the unselected meaning is inhibited or suppressed in memory. Consistent with the findings from previous eye movement studies (e.g., Binder & Morris, 1995, 2011), we found that when the prior biasing context was relatively weak (i.e., unelaborated), access to the previously unselected (i.e., dominant) meaning appeared to be unaffected. No difference in processing times emerged between the unelaborated and neutral conditions on the second encounter of the ambiguous word. When the prior context was strong (i.e., elaborated), however, readers accessed both the dominant meaning and the previously elaborated subordinate meaning concurrently, resulting in processing difficulty: Processing times on the second encounter of the ambiguous word were longer in the elaborated than in the neutral condition. Additional support for the idea that readers accessed the dominant meaning comes from the time spent processing the disambiguating word following the second encounter of the ambiguous word; readers were able to integrate the information that disambiguated the word toward its dominant meaning with comparable ease in all three context conditions.

On the second encounter of the ambiguous word, the failure to observe any processing cost associated with the previously unselected meaning in the unelaborated condition is inconsistent with the inhibition view. However, the observation of a processing cost for the previously unselected meaning in the elaborated condition could be viewed as consistent with an inhibition account. It is possible that previously unselected meanings are inhibited, but only in the presence of very strong contextual support for the selected meaning. In the absence of any information about the contextual strength threshold that must be exceeded in order for inhibition to occur, we argue that a simpler explanation of these effects can be provided by the reordered-access model (Duffy et al., 1988). To make this argument, it is necessary to clarify the mechanism that drives the activation of contextual and lexical (i.e., meaning frequency) information. Presumably, context influences access through some sort of low-level priming mechanism that facilitates activation of one meaning of the ambiguous word, even when the contextual "primes" do not immediately precede the ambiguous word and/or do not consist of direct lexical associates of the ambiguous word. Several studies have provided evidence for this low-level reactivation mechanism, in which activation from the current input and the passage context may converge to activate information from general world knowledge (e.g., Albrecht & O'Brien, 1993; Cook, 2013; Cook & Guéraud, 2005; Cook, Halleran, & O'Brien, 1998; Cook et al., 2012; Cook, Limber, & O'Brien, 2001; Cook & Myers, 2004; Duffy & Rayner, 1990; Garrod & Sanford, 1977; Garrod & Terras, 2000; Guéraud, Harmon, & Peracchi, 2005; Lea, Mulligan, & Walton, 2005; O'Brien & Albrecht, 1991, 1992; O'Brien, Cook, & Guéraud, 2010; O'Brien, Rizzella, Albrecht, & Halleran, 1998). One conceptualization of such a mechanism is the resonance model (Myers & O'Brien, 1998; O'Brien & Myers, 1999). According to this model, a signal to all of long-term memory is initiated when new information is encoded during reading. Any information in memory related to the newly encountered content has the potential to be activated—whether that information is semantic (lexical) or contextual in nature. Activated information may in turn signal and lead to activation of other related information from memory. Activation may be affected by factors such as elaboration, referential distance, or strength of an association. Information that is most strongly related to the current input is likely to be activated and made available for integration, regardless of its source (Cook & Myers, 2004). Importantly, the resonance process is considered "dumb" because it leads to the reactivation of any information that shares semantic associations with the current input, whether or not it is relevant to the current discourse context.

Mapping a low-level reactivation mechanism such as resonance onto the reordered-access model makes it possible to explain differences in processing costs for the previously unselected meaning of the ambiguous word without assuming that its accessibility was influenced by previously occurring meaning selection processes. In the present study, when the second encounter of the ambiguous word is encoded, a signal would be sent out to all of memory, so both lexical (meaning frequency) and contextual information would be contacted in parallel. Regardless of context condition, activation from the more recent dominant-biasing context and lexical information about meaning frequency are likely to quickly converge on and activate the dominant meaning. The extent to which the previously presented subordinate-biasing context may also affect subsequent processing, however, depends on the degree of supporting elaboration in the text. In the unelaborated condition, the subordinate context information was distant and relatively weak; it would take longer for that information to be contacted, converge with activation of lexical information, and activate the subordinate meaning. Thus, in the unelaborated condition, the dominant meaning is likely to be activated before any information about the subordinate meaning becomes available; integration of the dominant meaning with the second encounter of the ambiguous word should then be easy. Processing times on the second encounter of the ambiguous word in the unelaborated condition support this

view; no differences occurred when compared to the neutral condition. In the elaborated condition, activation from the subordinate-biasing context is expected to be strong, and when combined with activation of lexical content, these sources may converge to quickly activate the subordinate meaning, possibly concurrently with the dominant meaning. Competition between the dominant and subordinate meanings in memory would lead to processing difficulty on the ambiguous word. Consistent with this view, processing times on the second encounter of the ambiguous word were longer in the elaborated than in the neutral condition. These findings are consistent with those of O'Brien et al. (1990; see also O'Brien, 1987), who found that elaboration of content presented early in a passage could facilitate it to the degree that it competed with or was activated faster than more recent, unelaborated information.

Taken together, the results for the first and second encounter of the word support the idea that word meaning is "highly constructive and contextual" (Kintsch, 1998, p. 133), in that it depends on both frequency of individual meanings and contextual support for those meanings. Kintsch argued that readers do not simply access a particular meaning from the lexicon and apply it to incoming text. Instead, information about meaning accessed from long-term memory combines with related information from the preceding context to construct a new "sense" of the word, which is then integrated with incoming text. The *degree* to which the "sense" of a biased ambiguous word reflects its dominant or subordinate meaning depends both on meaning frequency and on the amount of contextual support for a particular sense. The first stage of the Kintsch's construction–integration (CI) model is assumed to depend on a low-level retrieval mechanism, such as resonance (Myers & O'Brien, 1998; O'Brien & Myers, 1999). If one were to adopt a resonance-like retrieval mechanism in the reordered-access model to explain access to information about meaning on the basis of the combined influences of frequency and contextual contents, then the meaning construction process (and subsequent integration) would really be based on the product of the information retrieved. That is, not just access to dominant and subordinate meanings would be "reordered" on the basis of context. Instead, the influence that a particular meaning has on the reader's sense of an ambiguous word would be reordered by the contextual support for that particular meaning. As was demonstrated by our results for the second encounter of the ambiguous word, this occurs regardless of whether or not a particular meaning has been previously selected.

It is also important to note that the influences of context on the processing of an ambiguous word occurred very early during reading. In previous eyetracking studies on the subordinate-bias effect, researchers have typically used gaze duration on the ambiguous word as a measure of the speed of lexical access. However, as was noted by Rayner (1998; Rayner et al., 2012), this measure may also reflect initial integration processes. In the present study, we also observed an early effect of context on the processing of the ambiguous word; our first-fixation duration results showed effects of context on meaning access (see also Sheridan & Reingold, 2012; Sheridan, Reingold, & Daneman, 2009). In addition, in an event-related potential study, Sereno et al. (2003) found that contextual influences on the processing of lexical ambiguities appeared in the N1 measure (between 132 and 192 ms poststimulus). Similarly, Nieuwland and van Berkum (2006) found that discourse context could override semantic information very early on during reading; they found that N400 effects associated with semantic anomalies disappeared when words were presented in strongly supportive discourse contexts (see also van Berkum, Zwitserlood, Hagoort, & Brown, 2003). We assume that information is integrated as soon as it becomes available in memory. In most cases, semantic information will be accessed and integrated quickly, thereby dominating early processing. However, the present results, combined with previously published work, make it clear that strong context can override these effects to influence early measures of processing (e.g., Cook & Myers, 2004). Thus, it is important to be cautious about equating particular eyetracking measures with specific processes.

In conclusion, the present set of findings adds to the growing body of literature that supports an interactive view of semantic and contextual influences in reading. The results clearly show that a strong discourse context can override meaning frequency effects to the point of reordering the influences of dominant and subordinate meanings on the processing of ambiguous words. In addition, the expanded description of the reordered-access model presented here can explain differences in the accessibility of the unselected meaning without invoking an inhibition or suppression mechanism. Future studies should focus on how manipulations of discourse context can influence the accessibility of both the selected and unselected meanings of ambiguous words (e.g., Binder & Morris, 2011).

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References

Albrecht, J. E., & O'Brien, E. J. (1993). Updating a mental model: Maintaining both local and global coherence. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19,* 1061–1070. doi:10.1037/0278-7393.19.5.1061

Albrecht, J. E., & O'Brien, E. J. (1998). Updating a situation model: A memory-based text processing view. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 24,* 1200–1210.

Binder, K. S. (2003). Sentential and discourse topic effects on lexical ambiguity processing: An eye-movement examination. *Memory & Cognition, 31,* 690–702.

Binder, K. S., & Morris, R. K. (1995). Eye movements and lexical ambiguity resolution: Effects of prior encounter and discourse topic. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,* 1186–1196.

Binder, K. S., & Morris, R. K. (2011). An eye movement analysis of ambiguity resolution: Beyond meaning access. *Discourse Processes, 48,* 305–330.

Binder, K. S., & Rayner, K. (1998). Contextual strength does not modulate the subordinate bias effect: Evidence from eye fixations and self-paced reading. *Psychonomic Bulletin & Review, 5,* 271–276.

Cook, A. E. (2013). *Processing anomalous anaphors: "Good enough" or "good enough for now?"* Manuscript submitted for publication.

Cook, A. E., & Guéraud, S. (2005). What have we been missing? The role of general world knowledge in discourse processing. *Discourse Processes, 39,* 365–378.

Cook, A. E., Halleran, J. G., & O'Brien, E. J. (1998). What is readily available during reading? A memory-based view of text processing. *Discourse Processes, 26,* 109–129. doi:10.1080/01638539809545041

Cook, A. E., Lassonde, K. A., Splinter, A., Guéraud, S., Stiegler-Balfour, J., & O'Brien, E. J. (2012). The role of relevance in the activation and instantiation of predictive inferences. *Language and Cognitive Processes*.

Cook, A. E., Limber, J. E., & O'Brien, E. J. (2001). Situation-based context and the availability of predictive inferences. *Journal of Memory and Language, 44,* 220–234.

Cook, A. E., & Myers, J. L. (2004). Processing discourse roles in scripted narratives: The influence of context and world knowledge. *Journal of Memory and Language, 50,* 268–288. doi:10.1016/j.jml.2003.11.003

Dopkins, S., Morris, R. K., & Rayner, K. (1992). Lexical ambiguity and eye fixations in reading: A test of competing models of lexical ambiguity resolution. *Journal of Memory and Language, 31,* 461–477.

Duffy, S. A., Morris, R. K., & Rayner, K. (1988). Lexical ambiguity and fixation times in reading. *Journal of Memory and Language, 27,* 429–446. doi:10.1016/0749-596X(88)90066-6

Duffy, S. A., & Rayner, K. (1990). Eye movements and anaphor resolution. Effects of antecedent typicality and distance. *Language and Speech, 33,* 103–119.

Folk, J. R., & Morris, R. K. (2003). Effects of syntactic category assignment on lexical ambiguity resolution in reading: An eye movement analysis. *Memory & Cognition, 31,* 87–99.

Garrod, S., & Sanford, A. J. (1977). Interpreting anaphoric relations: The integration of semantic information while reading. *Journal of Verbal Learning and Verbal Behavior, 16,* 77–90.

Garrod, S., & Terras, M. (2000). The contribution of lexical and situational knowledge to resolving discourse roles: Bonding and resolution. *Journal of Memory and Language, 42,* 526–544.

Gernsbacher, M. A., Robertson, R. W., & Werner, N. K. (2001). The costs and benefits of meaning. In D. S. Gorfein (Ed.), *On the consequences of meaning selection: Perspectives on resolving lexical ambiguity* (pp. 119–137). Washington, DC: American Psychological Association.

Gorfein, D. S., Viviani, J. M., & Leddo, J. (1982). Norms as a tool for the study of homography. *Memory & Cognition, 10,* 503–509.

Guéraud, S., Harmon, M. E., & Peracchi, K. A. (2005). Updating situation models: The memory-based contribution. *Discourse Processes, 39,* 243–263.

Kambe, G., Rayner, K., & Duffy, S. A. (2001). Global context effects on processing lexically ambiguous words. *Memory & Cognition, 29,* 363–372.

Kellas, G., Martin, C., Yehling, K., Herman, R., & Vu, H. (1995, November). *Contextual strength as a determinant of the subordinate bias effect.* Poster presented at the annual meeting of the Psychonomic Society, Los Angeles.

Kellas, G., & Vu, H. (1999). Strength of context *does* modulate the subordinate bias effect: A reply to Binder and Rayner. *Psychonomic Bulletin & Review, 6,* 511–517.

Kintsch, W. (1998). *Comprehension*. New York, NY: Cambridge University Press.

Lea, R. B., Mulligan, E. J., & Walton, J. L. (2005). Accessing distant premise information: How memory feeds reasoning. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31,* 387–395.

Leinenger, M., & Rayner, K. (2013). *Eye movements while reading biased homographs: Effects of prior encounter and biasing context on reducing the subordinate bias effect*. Manuscript submitted for publication.

Martin, C., Vu, H., Kellas, G., & Metcalf, K. (1999). Strength of discourse context as a determinant of the subordinate bias effect. *Quarterly Journal of Experimental Psychology, 52A,* 813–839.

Myers, J. L., Cook, A. E., Kambe, G., Mason, R. A., & O'Brien, E. J. (2000). Semantic and episodic effects on bridging inferences. *Discourse Processes, 29,* 179–199. doi:10.1207/S15326950dp2903_1

Myers, J. L., & O'Brien, E. J. (1998). Accessing the discourse representation during reading. *Discourse Processes, 26,* 131–157. doi:10.1080/01638539809545042

Nieuwland, M. S., & van Berkum, J. J. A. (2006). When peanuts fall in love: N400 evidence for the power of discourse. *Journal of Cognitive Neuroscience, 18,* 1098–1111.

O'Brien, E. J. (1987). Antecedent search processes and the structure of text. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13,* 278–290.

O'Brien, E. J., & Albrecht, J. E. (1991). The role of context in accessing antecedents in text. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17,* 94–102.

O'Brien, E. J., & Albrecht, J. E. (1992). Comprehension strategies in the development of a mental model. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18,* 777–784. doi:10.1037/0278-7393.18.4.777

O'Brien, E. J., Albrecht, J. E., Hakala, C. M., & Rizzella, M. (1995). Activation and suppression of antecedents during reinstatement. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,* 626–634.

O'Brien, E. J., Cook, A. E., & Guéraud, S. (2010). Accessibility of outdated information. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 36,* 979–991. doi:10.1037/a0019763

O'Brien, E. J., & Myers, J. L. (1999). Text comprehension: A view from the bottom up. In S. R. Goldman, A. C. Graesser, & P. van den Broek (Eds.), *Narrative comprehension, causality, and coherence: Essays in honor of Tom Trabasso* (pp. 35–53). Mahwah, NJ: Erlbaum.

O'Brien, E. J., Plewes, P. S., & Albrecht, J. E. (1990). Antecedent retrieval processes. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16,* 241–249.

O'Brien, E. J., Rizzella, M. L., Albrecht, J. E., & Halleran, J. G. (1998). Updating a situation model: A memory-based text processing view. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 24,* 1200–1210. doi:10.1037/0278-7393.24.5.1200

Pacht, J. M., & Rayner, K. (1993). The processing of homophonic homographs during reading: Evidence from eye movement studies. *Journal of Psycholinguistic Research, 22,* 252–271.

Paul, S., Kellas, G., Martin, M., & Clark, M. (1992). Influence of contextual features on the activation of ambiguous word meanings. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18,* 703–717.

Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin, 124,* 372–422. doi:10.1037/0033-2909.124.3.372

Rayner, K., Cook, A. E., Juhasz, B. J., & Frazier, L. (2006). Immediate disambiguating of lexically ambiguous words during reading: Evidence from eye movements. *British Journal of Psychology, 97,* 467–482.

Rayner, K., & Duffy, S. A. (1986). Lexical complexity and fixation times in reading: Effects of word frequency, verb complexity, and lexical ambiguity. *Memory & Cognition, 14,* 191–201.

Rayner, K., & Frazier, L. (1989). Selection mechanisms in reading lexically ambiguous words. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15,* 779–790.

Rayner, K., Pacht, J. M., & Duffy, S. A. (1994). Effects of prior encounter and global discourse bias on the processing of lexically ambiguous words: Evidence from eye movements. *Journal of Memory and Language, 33,* 527–544.

Rayner, K., Pollatsek, S., Ashby, J., & Clifton, C. (2012). *Psychology of reading* (2nd ed.). New York, NY: Psychology Press.

Sereno, S. C. (1995). Resolution of lexical ambiguity: Evidence from an eye movement priming paradigm. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,* 582–595.

Sereno, S. C., Brewer, C. C., & O'Donnell, P. J. (2003). Context effects in word recognition: Evidence for early interactive processing. *Psychological Science, 14,* 328–333. doi:10.1111/1467-9280.14471

Sereno, S. C., O'Donnell, P. J., & Rayner, K. (2006). Eye movements and lexical ambiguity resolution: Investigating the subordinate-bias effect. *Journal of Experimental Psychology. Human Perception and Performance, 32,* 335–350.

Sereno, S. C., Pacht, J. M., & Rayner, K. (1992). The effects of meaning frequency on pprocessing lexically ambiguous words: Evidence from eye movements. *Psychological Science, 3,* 296–300.

Sheridan, H., & Reingold, E. M. (2012). The time course of contextual influences during lexical ambiguity resolution: Evidence from distributional analyses of fixation durations. *Memory & Cognition, 40,* 1122–1131. doi:10.3758/s13421-012-0216-2

Sheridan, H., Reingold, E. M., & Daneman, M. (2009). Using puns to study contextual influences on lexical ambiguity resolution: Evidence from eye movements. *Psychonomic Bulletin & Review, 16,* 875–881.

Simpson, G. B., & Adamopoulous, A. C. (2001). Repeated homographs in word and sentence contexts: Multiple processing of multiple meanings. In D. S. Gorfein (Ed.), *On the consequences of meaning selection: Perspectives on resolving lexical ambiguity* (pp. 105–117). Washington, DC: American Psychological Association.

Simpson, G. B., & Burgess, C. (1985). Activation and selection processes in the recognition of ambiguous words. *Journal of Experimental Psychology. Human Perception and Performance, 11,* 28–39.

Simpson, G. B., & Kang, H. (1994). Inhibitory processes in the recognition of homograph meanings. In D. Dagenbach & T. H. Carr (Eds.), *Inhibitory processes in attention, memory, and language* (pp. 359–378). San Diego, CA: Academic Press.

Twilley, L. C., Dixon, P., Taylor, D., & Clark, K. (1994). University of Alberta norms of relative meaning frequency for 566 homographs. *Memory & Cognition, 22,* 111–126.

van Berkum, J. J. A., Zwitserlood, P., Hagoort, P., & Brown, C. M. (2003). When and how do listeners relate a sentence to the wider discourse? Evidence from the N400 effect. *Cognitive Brain Research, 17,* 701–718.

Vu, H., & Kellas, G. (1999). Contextual strength modulates the subordinate bias effect: Reply to Rayner, Binder, & Duffy. *Quarterly Journal of Experimental Psychology, 52A,* 853–856.

Vu, H., Kellas, G., Metcalf, K., & Herman, R. (2000). The influence of global discourse on lexical ambiguity resolution. *Memory & Cognition, 28,* 236–252.

Vu, H., Kellas, G., Petersen, E., & Metcalf, K. (2003). Situation-evoking stimuli, domain of reference, and the incremental interpretation of lexical ambiguity. *Memory & Cognition, 31,* 1302–1315.

Wiley, J., & Rayner, K. (2000). Effects of titles on the processing of text and lexically ambiguous words: Evidence from eye movements. *Memory & Cognition, 28,* 1011–1021.