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Eye movements while reading biased homographs: Effects of prior encounter and biasing context on reducing the subordinate bias effect

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Readers experience processing difficulties when reading biased homographs preceded by subordinate-biasing contexts. Attempts to overcome this processing deficit have often failed to reduce the subordinate bias effect (SBE). In the present studies, we examined the processing of biased homographs preceded by single-sentence, subordinate-biasing contexts, and varied whether this preceding context contained a prior instance of the homograph or a control word/phrase. Having previously encountered the homograph earlier in the sentence reduced the SBE for the subsequent encounter, whereas simply instantiating the subordinate meaning produced processing difficulty. We compared these reductions in reading times to differences in processing time between dominant-biased repeated and nonrepeated conditions in order to verify that the reductions observed in the subordinate cases did not simply reflect a general repetition benefit. Our results indicate that a strong, subordinate-biasing context can interact during lexical access to overcome the activation from meaning frequency and reduce the SBE during reading.

Keywords: Lexical ambiguity; Eye movements; Reading; Subordinate bias effect; Context.

The English language contains over 1500 homographs (orthographically identical words with multiple meanings). This doubling up of meanings can be a source of confusion and misunderstanding, but it does afford us the advantage of shorter words (unlike languages lacking lexical ambiguity such as Finnish) and the subtle humour of puns (e.g., *the knowledgeable farmer is an expert in his field*). Beyond these advantages, Piantadosi, Tily, and Gibson (2011) argued that ambiguity is, in fact, a desirable quality of language, allowing it to avoid redundancy with the sentence context and to be composed of sounds and words that are easier to produce and understand. Despite the purported desirability of lexical ambiguity, it still remains unclear exactly how we deal with activating and integrating the appropriate meaning (or in the case of puns, both meanings). A complete understanding of how we access, select, and integrate the appropriate meanings in such a seemingly effortless manner is important because, in many cases, these homographs are short, high frequency words that are used and encountered on a daily basis (e.g., *arm*, *chair*, *bill*, *coat*).

The work involved at various processing stages, can be influenced by the nature of the specific homograph in question, particularly the relative frequency of each of its meanings. Balanced

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homographs (such as *fan*) are those wherein the two primary meanings are balanced in frequency, whereas biased homographs (such as *bank*) are those with one highly frequent (dominant) meaning. Preceded by a neutral context, balanced ambiguous words are processed slower than biased ambiguous words (Rayner & Duffy, 1986) and the dominant meaning of a biased ambiguous word is accessed faster than the subordinate meaning (Simpson & Burgess, 1985).

Investigating the interaction of meaning frequency and biasing context is central to understanding how lexical ambiguity resolution is achieved, namely what cues, contextual or otherwise, lead to the successful activation and integration of the proper meaning of an ambiguous word. In many studies that have utilised eye movement data to examine homograph processing in reading, the prior context has been manipulated to instantiate different meanings of the ambiguous word (Binder, 2003; Binder & Morris, 1995, 2011; Binder & Rayner, 1998; Dopkins, Morris, & Rayner, 1992; Duffy, Morris, & Rayner, 1988; Kambe, Rayner & Duffy, 2001; Rayner, Cook, Juhasz, & Frazier, 2006; Rayner & Frazier, 1989; Rayner, Pacht, & Duffy, 1994; Sereno, 1995; Sereno, Brewer, & O'Donnell, 2003; Sereno, O'Donnell, & Rayner, 2006; Sereno, Pacht & Rayner, 1992; Sheridan & Reingold, 2012; Sheridan, Reingold, & Daneman, 2009; Wiley & Rayner, 2000). In these studies, when preceded by either a neutral or dominant-biasing context, a biased homograph was processed as fast as a control word matched for length and frequency, whereas a balanced homograph preceded by a neutral context was processed slower than a matched control word. However, when preceded by a context that instantiated the subordinate meaning, a biased homograph was processed slower than a matched control word, whereas a balanced homograph preceded by a biasing context was processed as fast as a matched control word. This reversal phenomenon has been demonstrated repeatedly and was termed the subordinate bias effect (SBE) by Pacht and Rayner (1993).

The SBE was first documented by Duffy et al. (1988) and discussed in the context of the reordered access model. According to this model, this reversal in the pattern of data – slower processing of balanced homographs in neutral contexts but not biasing contexts and slower processing of biased homographs in subordinate-biasing contexts but not neutral contexts – results from the interaction of meaning frequency and biasing context during lexical access and can be explained in the following way. In the absence of contextual information, the two meanings of a homograph are accessed in order of their meaning frequency, with the dominant meaning being accessed first. However, biasing context can interact with frequency to "reorder" access. Preceded by a neutral context, the two meanings of a balanced homograph are supported equally by the context and therefore are accessed around the same time, resulting in competition and longer *gaze durations* (the sum of all forward fixation durations on a word) because a selection process is required. However, preceded by a disambiguating context biasing either one of the balanced homograph's meanings, that meaning is accessed first and is integrated into the sentence easily with no competition. On the other hand, when a biased homograph is preceded by a neutral context (or context biasing the dominant meaning), the dominant meaning is accessed first and is integrated into the sentence easily. However, if a biased homograph is preceded by prior context instantiating the subordinate meaning, access is "reordered" and the less frequent meaning is accessed at around the same time as the dominant meaning, resulting in competition and longer gaze durations on the word (the SBE). Although this model allows for the "reordering" of lexical access, it holds that lexical access is exhaustive and not selective (i.e., all meanings receive some activation regardless of their contextual appropriateness).

It is important to note that the reordered access model does theoretically allow for reduction of the SBE (see Duffy, Kambe, & Rayner, 2001). It is possible that certain prior contexts could instantiate the subordinate meaning such that activation is reordered to the point where the subordinate meaning is accessed ahead of the dominant meaning and avoids competition. Among the previous attempts to explore the effects of context on lexical access, even the strong manipulations utilised by Rayner et al. (1994) and Binder and Morris (2011) did not reduce the SBE; they used short passages that contained two instances of a biased homograph in its subordinate meaning. The homograph occurred early in the passage and then again in the final sentence (Rayner et al., 1994) or the second to last sentence (Binder & Morris, 2011). Across both studies, no reduction in the SBE was observed on the second occurrence of the homograph, despite a previous encounter with the

homograph in its subordinate meaning earlier in the passage. Rayner et al. concluded that the activation of the subordinate meaning might not have persisted to the second encounter, therefore failing to reduce the SBE.

The results of Rayner et al. (1994) and Binder and Morris (2011), however, do not rule out the possibility that previous encounters with a biased homograph can influence processing on subsequent encounters. Binder and Morris (1995, 2011) provided evidence that a prior occurrence of a balanced homograph could influence processing on a subsequent encounter during reading. Although the processing of biased and balanced homographs in context does differ as previously discussed, there is no reason to expect that previous encounters will only affect the processing of balanced homographs. Therefore, removing the processing demands of length and time, which are present in Rayner et al. (1994) and Binder and Morris (2011), to evaluate whether a more recent occurrence of the target homograph can reduce the SBE during reading, will bolster our understanding of the extent of interactivity between context and meaning frequency during the lexical access of ambiguous words.

Considering that, according to the reordered access model, it is theoretically possible to reduce (or even eliminate) the SBE by instantiating a strong, subordinate-biasing context, it is surprising that the SBE has generally not been reduced via contextual manipulations during online reading. However, some studies have reported evidence for a reduced SBE for relatively frequent subordinate meanings (Wiley & Rayner, 2000), or by comparing homograph processing time to low-frequency, meaning-matched controls rather than higher frequency controls matched to the overall homograph frequency (Sereno et al., 2006). And, more recently, Colbert-Getz and Cook (2013),[1] found that the SBE was reduced following a multisentence, ''elaborated'', subordinate-biasing context. That is, when 4 subordinate-biasing sentences preceded the homograph, there was a reduction in the SBE. However, when only 1 sentence biased the homograph, they observed the traditional SBE.

In the current studies, we attempted to reduce the SBE for a biased homograph preceded by a prior context that instantiated the subordinate meaning. We varied whether the prior context contained a previous occurrence of the homograph or a control word or phrase. Unlike the Rayner et al. (1994) and Binder and Morris (2011) studies that instantiated the subordinate meaning through a prior occurrence of the homograph earlier in a passage, the current studies contained a prior occurrence within the same sentence, removing the demands of integrating across sentences and shortening both the time and content between the 2 occurrences of the subordinate homograph. In this way, we could determine whether having previously processed a biased homograph during reading could influence the processing of a subsequent presentation of the same homograph when time and length demands were removed, allowing us to test the prediction of the reordered access model – that strong, subordinate-biasing contexts can reduce the SBE.

In previous studies investigating the SBE, there are 3 generally accepted control conditions that have been used as bases for comparison. These accepted controls are word-form controls matched to the overall frequency of the homograph in question (Duffy et al., 1988), meaning frequency controls matched to the frequency of the subordinate meaning of the homograph (Sereno et al., 2006), and finally using the homograph itself as its own control (Rayner et al., 2006; Rayner & Frazier, 1989). This final option avoids the issue of deciding which frequency to match the control word to, but rather allows the reading time on the homograph in a control context to be compared to the reading time on the same homograph in a manipulated context. Because we were interested in whether the SBE could be reduced for a subordinately biased homograph after a prior occurrence of the homograph earlier in the sentence, using the homograph as its own control and manipulating the prior context (to either contain a prior occurrence of the homograph or not) was the most valid method of testing our question.

GENERAL METHODS

Apparatus

Subjects' eye movements were monitored using an Eyelink 1000 eyetracker, which sampled and recorded eye position every millisecond. Subjects were seated 61 cm away from a 19-inch ViewSonic LCD monitor. Text was displayed in

[1] The research by Colbert-Getz and Cook (2013) was carried out at the same time, and independently, of our work. We became aware of it after our research was completed.

14-point, fixed-width Consolas font, and 4 characters equalled 1° of visual angle. Viewing was binocular with eye location sampled from the right eye.

Procedure

Each subject was run individually in a session that lasted approximately 30 minutes. At the start of the experiment, subjects completed a calibration procedure by looking at a random sequence of 3 fixation points presented horizontally across the middle of the computer screen. Each trial required the subject to fixate a point in the centre of the screen before moving his/her eyes to a black square (40 pixels wide and 40 pixels tall), which appeared on the left side of the screen after the central fixation mark disappeared. This box coincided with the left side of the first character of the sentence and, once a stable fixation was detected within the box, the sentence replaced it on the screen.

Prior to the experimental portion, 10 practice sentences (with 6 comprehension questions) were presented. All sentences were randomised for each subject and presented vertically centred on the computer screen. Subjects were instructed to read silently, at their normal pace for comprehension, and to press a button on a keypad when they finished reading and were ready to proceed. When comprehension questions appeared on the screen after a sentence, subjects were required to respond *yes* or *no* via button press.

Normative data

Thirty-three native English speakers from the United States participated in online norming through Amazon's Mechanical Turk for monetary compensation. They were given a list of words, one at a time, and asked to construct sentences containing each word (1 sentence per word). Prior to the start of the norming, each subject was shown 2 examples where sentences were constructed using each word in its noun sense. In this way we hoped to covertly bias the subjects to compose sentences using the noun senses of our homographs without expressly instructing them to do so and potentially highlighting the ambiguous nature of our stimuli. The experimental homographs were included in a list of 144 words and it took subjects approximately 40 minutes to compose sentences for all of the words. Sentences were then coded for which meaning was expressed and the overall bias of each homograph was computed.

Eye movement measures

Both early and late eye movement measures for the target word and posttarget region (which extended from the end of the target word to the end of the sentence) were assessed (Rayner, 1998, 2009). For early eye movement measures on the target word we report gaze duration[2] (the sum of fixation durations on the target word before leaving it) and skipping probability (the likelihood of not fixating the target word during first pass reading). For late eye movement measures on the target word we report go-past time (the sum of all fixations on the target word and regressions to pretarget regions from the first fixation on the target until moving to the right of it), total time (the sum of all fixations on the target word), and regressions out (the probability of making a regressive saccade from the target word on first pass reading). For the posttarget region we report first pass time (the equivalent of gaze duration for a multiword region), total time, and regressions out. We do not report skipping since it is a multiword region, and we do not report go-past time because the region extends to the end of the sentence.

EXPERIMENT 1

Method

Subjects

Twenty-four native English speakers from the University of California, San Diego received course credit for their participation in the study. All subjects had normal or corrected to normal vision.

Materials

Twenty-six ambiguous words with semantically distinct noun-dominant and noun-subordinate meanings were selected from Duffy et al. (1988) and Sheridan et al. (2009) and were verified via the norms described earlier. In these norms, the

[2] First-fixation duration data trended in the same direction as gaze duration; however, in line with other papers in this domain we are not reporting first fixation because the effect is driven by gaze duration, reflecting the probability of refixating the target word.

probability of generating the subordinate meaning ranged from 0 to .39 (mean = .09).

Two sentence versions (repeated, nonrepeated) were created for each of the 26 biased homographs, resulting in a total of 52 experimental sentences. The target word never occupied the last two word positions of the sentence. In the repeated condition, the target word was preceded by an instance of the same ambiguous word earlier in the sentence. In the nonrepeated condition this prior occurrence was replaced by a control word or short phrase that also biased the subordinate meaning. The following is an example of the experimental sentence frame (for a complete list of stimuli, see the Appendix). The repeated/nonrepeated manipulation appears in parentheses with the homograph appearing first; the target word appears in italics.

1. The president began the meeting with (his cabinet and advisors/all his advisors), but only the *cabinet* was allowed to stay for the end.

Two material sets were constructed and counterbalanced such that within each set each condition appeared an equal number of times, and across material sets each sentence appeared once in each of the 2 conditions. The 26 experimental sentences were presented along with 54 filler sentences designed to mask the purposes of the experiment. Simple comprehension questions appeared after 20 of the filler items. Sentence type (repeated, nonrepeated) was tested within subjects; however, each subject saw only 1 sentence for each homograph. Context always biased the subordinate meaning of the ambiguous word and preceded the homograph. The length and content of the posttarget region was identical within items and averaged 4.2 words (21.6 characters) in length. Care was taken to ensure that the stimuli with repeated words were constructed so that they read naturally (this point will be further addressed in the Methods section of Experiment 2).

Results

Prior to analysis, fixations less than 80 ms were deleted, or pooled if they were within 1 character of another fixation. Fixations over 800 ms were deleted, as were any trials in which subjects blinked during first pass reading of the target region (exclusions resulted in the loss of less than 2% of the data). Additionally, data points that were more than 2.5 standard deviations away from a given subject's mean were removed. Data exclusions were evenly distributed across conditions. Subjects were correct on an average of 92% of the comprehension questions. To analyse fixation time data, we used the reduced maximum likelihood (REML) method for fitting analyses of variance (ANOVA) in the JMP 10 statistical package. Analyses were performed across subject ($F1$) and item ($F2$) variability, and subjects and items were specified as random effects in their respective analyses. Subject means and standard errors are presented in Table 1.

Target region

Early eye movement measures. There was a significant effect of condition (repeated vs. nonrepeated) on gaze duration, $F1(1, 23) = 5.09$,

TABLE 1
Experiment 1: Eye movement measures for the target word and posttarget region

	Subordinate				
	Repeated		*Nonrepeated*		
Measures	*M*	*SE*	*M*	*SE*	*Difference*
Target word					
Gaze duration (ms)	230	8.6	250	10.2	20
Skipping probability (%)	24.6	3.2	21.2	3.3	−3.4
Go-past time (ms)	277	15	319	20.4	42
Total time (ms)	290	16.2	317	12.8	27
Regressions out (%)	8.8	2.1	10.8	2.3	2
Posttarget region					
First pass time (ms)	719	34.4	721	43.4	2
Total time (ms)	881	51.7	945	56.6	64
Regressions out (%)	52.6	4.4	52.3	4.6	−0.3

$p = .034$, $F2(1,25) = 7.41$, $p = .012$, such that a prior encounter with the ambiguous word earlier in the sentence decreased the initial processing time on the target word. There was no effect of prior encounter on skipping probabilities; subjects were numerically more likely to skip the target word if they had encountered it earlier in the sentence, but not significantly so, $F1 < 1$, $F2(1, 25) = 2.01$, $p > .16$.

Late eye movement measures. Later eye movement measures also revealed decreased processing time from previous lexical access through repetition. Go-past times were significantly shorter by subjects and marginally shorter by items after a previous encounter with the target homograph, $F1(1, 23) = 5.58$, $p = .027$, $F2(1, 25) = 3.56$, $p = .071$, and the total time spent fixating the target word was shorter when the word had appeared earlier in the sentence, $F1(1, 23) = 4.40$, $p = .047$, $F2(1, 25) = 4.25$, $p = .049$). Lastly, there was no significant effect of repetition condition on the probability of making a regressive eye movement from the target homograph, all Fs < 1.

Posttarget region

Early eye movement measures. There was no effect of condition on first pass time in the region immediately following the target homograph; initial processing on the posttarget region did not vary as a function of whether the homograph was encountered once or twice in the sentence, all Fs < 1.

Late eye movement measures. Later eye movement measures revealed that there was a main effect of condition on the total time spent reading the posttarget region, such that readers spent longer reading the posttarget region in the nonrepeated condition, $F1(1, 23) = 8.78$, $p = .007$, $F2(1, 25) = 4.79$, $p = .038$. Finally, there was no effect of condition on the probability of making a regression out of the posttarget region to reread previous parts of the sentence, all Fs < 1.

Discussion

Readers received a significant processing advantage from having previously encountered the target homograph earlier in the sentence. Unlike the Rayner et al. (1994) and Binder and Morris (2011) studies, we found that reading times on a subordinately biased homograph were significantly shorter following a subordinate-biasing context that contained a prior occurrence of the target homograph than following a relatively weaker subordinate-biasing context that contained a control word or phrase. Additionally, readers spent less time reading the region of text following the target homograph when they had previously processed the homograph earlier in the sentence, suggesting that reducing the SBE may also have allowed for easier integration of the subordinate meaning into the sentence. According to the reordered access model, the mechanism driving this data pattern is as follows. When the preceding context biased the subordinate meaning of the target homograph, but subjects were encountering the target homograph for the first time (nonrepeated condition), the contextual information interacted in the process of lexical access, increasing the activation of the subordinate meaning so that it was accessed at the same time as the dominant meaning and resulted in competition (SBE). When the preceding context biased the subordinate meaning of the target homograph *and* a previous occurrence of the homograph in its subordinate sense appeared earlier in the sentence, this combined contextual information was able to interact in the process of lexical access, increasing the activation of the subordinate meaning so that it was able to surpass the dominant meaning and be accessed first. Because it was accessed ahead of the dominant meaning, the subordinate meaning avoided competition, thereby reducing processing time on the homograph. The reductions in both early and late reading time measures after a strong biasing context that contained a prior occurrence of the target homograph are consistent with a reduction in the SBE.

There is, however, a different interpretation that cannot be ruled out by the present experiment. Specifically, there is a well-documented and robust processing advantage from word repetition such that subjects are faster in their responses to words the second time they encounter them (e.g., Feustel, Shiffrin, & Salasoo, 1983; Rayner, Raney, & Pollatsek, 1995; Scarborough, Cortese, & Scarborough, 1977). Therefore, it could be that the reduction in processing time after a prior encounter with the target word is due (in part or in whole) to this general benefit from having just accessed the word earlier in the sentence. To tease this interpretation apart from interpretations proposing a reduction in the SBE, we ran a

second experiment that also included dominant repeated and nonrepeated conditions. In this way we could distinguish whether decreases in processing time were just the result of having a repeated word or actually reflected a reduction in the SBE.

EXPERIMENT 2

In order to distinguish between mediation of the SBE and a simple repetition benefit, we ran Experiment 2 where we included the original subordinate conditions from Experiment 1 and also both repeated and nonrepeated dominant conditions. In this way we could examine the differences between the repeated and nonrepeated conditions across meanings to determine whether there was a reduction in the SBE above and beyond a simple repetition benefit. If the differences between the repeated and nonrepeated conditions were equal across meanings, this would suggest that the processing benefit was a result of repetition. If the differences were greater for the dominant meaning, this would suggest that there was a processing benefit from having the word repeated for the dominant meaning, but that either this benefit from repetition was not observed for the subordinate meaning, or that it was somehow countered by the SBE. Lastly, if the differences were greater for the subordinate meaning, this would suggest that there was a reduction in the SBE, with or without a general benefit from repetition.

Method

Subjects

Fifty-two native English speakers from the University of California, San Diego received course credit or monetary compensation for their participation in the study. All subjects had normal or corrected to normal vision.

Materials

The materials were identical to that of Experiment 1, except in addition to the repeated and nonrepeated subordinate conditions, there were also repeated and a nonrepeated dominant conditions. The following are examples of the subordinate and dominant experimental sentence frames (for a complete list of stimuli, see the Appendix). The repeated/nonrepeated manipulation appears in parentheses with the homograph appearing first; the target word appears in italics.

1. The walls looked ok after the (first coat/paint) finished drying, but Katie applied a second *coat* to really make them pop. (*Subordinate*)
2. Kristen put her spring (coat/jacket) on, but she changed into her winter *coat* after she felt how cold it was. (*Dominant*)

Additionally, one homograph from Experiment 1 was replaced[3] and six additional homographs were added for a total of 32 biased experimental words. Four material sets were constructed and counterbalanced such that within each set each condition appeared an equal number of times, and across material sets each sentence appeared once in each of the 4 conditions. The 32 experimental sentences were presented along with 70 filler sentences, designed to mask the purposes of the experiment. Again, the probability of generating the subordinate meaning ranged from 0 to .39 (mean = .09). Simple comprehension questions appeared after 34 of the filler items. Sentence type (repeated, nonrepeated) and biasing context (subordinate, dominant) were tested within subject; however, each subject saw only 1 sentence for each homograph. The length and content of the posttarget region were identical across repetition conditions of a given meaning, but varied across meaning condition. For the subordinate conditions, the average posttarget region was 4 words (21.2 characters), whereas for the dominant conditions, the average posttarget region was 4.4 words (24.9 characters).

As with Experiment 1, care was taken to ensure that the stimuli with repeated words were constructed so that they read naturally. Studies investigating the establishment of coreference with repeated names have often found processing costs on the repeated noun – the repeated name penalty (e.g., Gordon, Grosz, & Gilliom, 1993; Ledoux, Gordon, Camblin, & Swaab, 2007). Our stimuli differ from those used by Gordon and colleagues in two important ways. First, the nouns repeated in our stimuli were not

[3] One homograph was removed because our norms revealed that it was not very strongly biased and in fact somewhat polysemous. Consultation of the University of South Florida Free Association Norms (Nelson, McEvoy, & Schreiber, 1998) confirmed the polysemous nature, so we excluded it from the stimuli set for Experiment 2.

proper names, and, second, the repeated nouns were not the subjects of the sentences. In light of these differences, it is unclear whether the repeated name penalty would extend to our current stimulus set. Furthermore, in other work, Gordon and colleagues (Gordon, Plummer, & Choi, 2013; Lowder, Choi, & Gordon, 2013) have demonstrated that the repeated name penalty is not observed when the sentence is constructed such that the repeated word is felicitous, as it was in our stimuli. Because the expectation is unclear, it is important to note that our experimental design is such that our results are interpretable regardless of the potential presence of the repeated name penalty. If the repeated name penalty was observed, there is no reason to expect that its magnitude would vary as a function of biasing context (dominant, subordinate). Since we compared differences in processing time between repeated and nonrepeated conditions across meanings, any presence of the repeated name penalty would be observed in both dominant and subordinate repeated conditions, and thus cancelled out.

Results

Exclusion criteria were identical to Experiment 1 and resulted in the loss of less than 5.4% of the data. Subjects were correct on an average of 95% of the comprehension questions. Once again, we report ANOVAs with analyses performed across subject ($F1$) and item ($F2$) variability, with subjects and items specified as random effects in their respective analyses.

For each fixation time measure, we report main effects of meaning (subordinate, dominant), repetition (repeated, nonrepeated), and the 2×2 interaction of meaning and repetition. For our purposes, the interaction is the critical effect because a reduction in the SBE would manifest as a differential effect of repetition across meaning conditions. In other words, we would expect the magnitude of the repetition effect to be larger for the subordinate conditions than for the dominant conditions. With this in mind, when the interaction was significant, planned contrasts were performed to analyse the differential effects of repetition condition (repeated vs. nonrepeated) on the subordinate and dominant meanings. In these instances, the critical contrasts are (1) the subordinate nonrepeated condition versus the subordinate repeated condition, as this highlights the presence of the SBE for the nonrepeated subordinate condition (measured as significantly longer reading times); (2) the dominant nonrepeated condition versus the dominant repeated condition, as a numerically smaller and nonsignificant differences between these conditions would demonstrate that the reduction observed in the subordinate repeated condition was not simply the effect of repetition; and (3) the subordinate repeated condition versus each of the dominant conditions, as these comparisons highlight a reduction of the SBE for the repeated subordinate condition (measured as subordinate repeated reading time not significantly differing

TABLE 2
Experiment 2: Eye movement measures for the target word and posttarget region

	Subordinate					*Dominant*				
	Repeated		*Nonrepeated*			*Repeated*		*Nonrepeated*		
Measures	*M*	*SE*	*M*	*SE*	*Difference*	*M*	*SE*	*M*	*SE*	*Difference*
Target word										
Gaze duration (ms)	233	5.3	247	7.5	14	223	5.6	226	5.8	3
Adjusted gaze (ms)	153	8.5	182	9.1	29	154	8.2	151	8.2	−3
Skipping probability (%)	33.2	3.3	25.7	2.5	−7.5	29.8	3.1	31.6	3.1	1.8
Go-past time (ms)	284	13.9	321	15	37	266	10.4	276	10.2	10
Total time (ms)	280	10.8	320	12.4	40	277	11.4	270	9.1	−7
Adjusted total time (ms)	212	11.7	263	13.9	51	200	10	213	12.8	13
Regressions out (%)	7.4	1.3	16.5	2.3	9.1	8.5	1.7	9.9	1.6	1.4
Posttarget region										
First pass time (ms)	626	26.2	630	29.6	4	686	29.8	694	28.1	8
Total time (ms)	744	30.2	776	33.1	32	794	40.3	826	33.8	32
Regressions out (%)	50.1	4.2	49.1	3.7	−1	42.5	3.9	47.1	3.8	4.6

from the dominant conditions). Subject means and standard errors are presented in Table 2.

Target region

Early eye movement measures. In gaze duration, there was a main effect of meaning such that readers had longer average gaze durations in the subordinate conditions than in the dominant conditions, $F1(1, 51) = 13.4$, $p < .001$, $F2(1, 31) = 8.56$, $p = .006$. There was no significant main effect of repetition in gaze duration, $F1(1, 51) = 2.23$, $p > .14$, $F2(1, 31) = 3.09$, $p > .08$, and the interaction of meaning and repetition was nonsignificant (all ps $> .22$). In skipping, there were no main effects of meaning or repetition (all ps $> .23$), but the interaction was significant by subjects, $F1(1, 51) = 2.47$, $p = .023$, and marginally significant by items, $F2(1, 31) = 4.1$, $p = .052$. Planned contrasts revealed that there was a significant effect of repetition for the subordinate conditions, such that readers were more likely to skip the ambiguous word after repetition, $F1(1, 99.53) = 5.93$, $p = .017$, $F2(1, 61.71) = 4.71$, $p = .034$. There was no significant difference between the dominant repeated and dominant nonrepeated conditions (all Fs < 1), and the subordinate repeated condition did not significantly differ from either the dominant repeated, $F1(1, 100.4) = 1.25$, $p > .26$, $F2(1, 60.14) = 1.29$, $p > .26$, or dominant nonrepeated condition (all Fs < 1).

Because we observed a significant interaction in word skipping, we computed gaze duration adjusted for skipping (Gollan et al., 2011; Just & Carpenter, 1980; Rayner, Slattery, Drieghe, & Liversedge, 2011). Word skipping is often assumed to be due to words being processed and identified parafoveally, and reflects easier lexical processing (see Drieghe, Rayner, & Pollatsek, 2005, for a review). Traditionally, zeros are removed from gaze duration calculations, but when there are large and significant differences in skipping probability between conditions, removing the zeros can obscure these difference in processing ease. As a concrete example, if a reader skips a target word 4 out of 5 times and fixates it once for 250 ms, we would like the fixation data to reflect how this situation is different than a reader who fixates the word every time, with a mean gaze duration of 250 ms. Using the standard gaze duration measure, these conditions would yield identical means (250 ms), but using the adjusted gaze, the first reader's mean gaze duration would be 50 ms and the second reader's 250 ms – reflecting differential ease of processing. Therefore, to account for the large differences in skipping probability across conditions, the adjusted gaze duration measure was computed. Adjusted gaze duration revealed a main effect of meaning that was significant by subjects and marginally significant by items, $F1(1, 51) = 5.01$, $p = .03$, $F2(1, 31) = 3.7$, $p = .064$; taking skipping into consideration, readers had longer average adjusted gaze durations in the subordinate conditions. There was also a main effect of repetition that was significant by items and marginally significant by subjects, $F1(1, 51) = 3.27$, $p = .077$, $F2(1, 31) = 5.28$, $p = .028$; on average, readers had longer adjusted gaze durations on the target in the nonrepeated conditions. Finally, the interaction of meaning and repetition was significant, $F1(1, 51) = 8.02$, $p = .007$, $F2(1, 31) = 7.19$, $p = .012$. Planned contrasts revealed that there was a significant effect of repetition for the subordinate conditions, such that adjusted gaze duration was significantly longer on the ambiguous word in the nonrepeated condition, $F1(1, 96.55) = 10.05$, $p = .002$, $F2(1, 61.6) = 12.46$, $p < .001$. There was no significant difference between the dominant repeated and dominant nonrepeated conditions (all Fs < 1), and the subordinate repeated condition did not significantly differ from either the dominant repeated (all Fs < 1) or dominant nonrepeated condition (all Fs < 1).

Late eye movement measures. In go-past time, there was a main effect of meaning, $F1(1, 51) = 6.82$, $p = .012$, $F2(1, 31) = 4.76$, $p = .037$; readers had significantly longer go-past times in the subordinate conditions. Go-past time also revealed a main effect of repetition that was significant by subjects and marginally significant by items, $F1(1, 51) = 6.81$, $p = .012$, $F2(1, 31) = 3.79$, $p = .061$; readers had significantly shorter go-past times following repetition of the ambiguous word. The interaction was nonsignificant (all ps $> .23$)

Total time revealed a similar pattern of results. There was a main effect of meaning, $F1(1, 51) = 12.25$, $p = .001$, $F2(1, 31) = 6.55$, $p = .016$; readers had longer total reading times on the ambiguous word in the subordinate conditions. There was also a main effect of repetition, $F1(1, 51) = 9.05$, $p = .004$, $F2(1, 31) = 12.49$, $p = .001$; readers had significantly longer total reading times in the nonrepeated conditions. The interaction was nonsignificant (all ps $> .1$). As with the gaze duration

measure, we also computed total time adjusted for skipping. Doing so reveals the same main effects of meaning, $F1(1, 51) = 14.3$, $p < .001$, $F2(1, 31) = 5.03$, $p = .032$, and repetition, $F1(1, 51) = 10.15$, $p = .003$, $F2(1, 31) = 18.14$, $p < .001$. Additionally, the interaction of meaning and repetition was significant, $F1(1, 51) = 4.41$, $p = .041$, $F2(1, 31) = 4.73$, $p = .037$. Planned contrasts revealed that there was a significant effect of repetition for the subordinate conditions, such that readers spent significantly longer reading the ambiguous word in the nonrepeated condition, $F1(1, 100.5) = 14.27$, $p < .001$, $F2(1, 61.25) = 20.07$, $p < .001$. There was no significant difference between the dominant repeated and dominant nonrepeated conditions, $F1 < 1$, $F2(1, 61.25) = 1.61$, $p > .21$, and the subordinate repeated condition did no significantly differ from either the dominant repeated (all Fs < 1) or dominant nonrepeated condition (all Fs < 1).

Finally, regression out probability revealed a main effect of meaning that was marginally significant by subjects and nonsignificant by items, $F1(1, 51) = 3.09$, $p = .085$, $F2(1, 31) = 1.14$, $p > .29$. There was also a main effect of repetition, $F1(1, 51) = 11.68$, $p = .001$, $F2(1, 31) = 11.93$, $p = .002$; subjects were more likely to make a regressive eye movement out of the target word in the nonrepeated conditions. Lastly, there was an interaction of meaning and repetition, $F1(1, 51) = 6.68$, $p = .013$, $F2(1, 31) = 5.88$, $p = .021$. Planned contrasts revealed that there was a significant effect of repetition for the subordinate conditions, such that subjects were more likely to make a regressive eye movement out of the target region when the prior context did not contain a previous occurrence of the target homograph, $F1(1, 102) = 18.06$, $p < .001$, $F2(1, 61.97) = 17.21$, $p < .001$. There was no significant difference between the dominant repeated and dominant nonrepeated conditions (all Fs < 1), and the subordinate repeated condition did not significantly differ from either the dominant repeated (all Fs < 1) or dominant nonrepeated condition, $F1(1, 102) = 1.32$, $p > .25$, $F2 < 1$.

Posttarget region

Early eye movement measures. For completeness we present effects of meaning, repetition, and the interaction, but because the length and content of the posttarget region differed across meaning conditions, the only readily interpretable comparisons are across repetition conditions within a given meaning. First pass time in the region of text immediately following the target homograph revealed a main effect of meaning that was significant by subjects but not by items, $F1(1, 51) = 16.1$, $p < .001$, $F2(1, 31) = 1.83$, $p > .19$. There was no main effect of repetition (all Fs < 1), and the interaction was not significant (all Fs < 1).

Late eye movement measures. Total time reflected the pattern of data observed in first pass time, such that there was a main effect of meaning that was significant by subjects but not by items, $F1(1, 51) = 8.31$, $p = .006$, $F2 < 1$, and there was no main effect of repetition, $F1(1, 51) = 2.04$, $p > .16$, $F2(1,31) = 2.48$, $p > .12$, nor an interaction (all Fs < 1). Finally, regression out probability revealed a main effect of meaning such that readers were significantly more likely to regress from the region immediately following the target homograph in the subordinate conditions than in the dominant conditions, $F1(1, 51) = 5.21$, $p = .027$, $F2(1, 31) = 5.15$, $p = .03$. There was no effect of repetition (all Fs < 1) and the interaction was not significant, $F1(1, 51) = 1.24$, $p > .27$, $F2 < 1$.

Discussion

As in Experiment 1, on the target homograph readers received a significant processing advantage across both early and late eye movement measures in the subordinate repeated condition after a strong biasing context that contained a prior occurrence of the target homograph. After this stronger, repeated subordinate-biasing context readers (1) were more likely to skip the target word, (2) took less time to process the target word when they did fixate it, and (3) were less likely to make regressions from the target word to reread the preceding text, suggesting that they were able to activate and integrate the subordinate meaning of the homograph more easily and efficiently than in the nonrepeated condition. Again, according to the reordered access model, this decrease in processing time results from the strong, subordinate-biasing context containing a prior occurrence of the target word, interacting with meaning frequency during lexical access to boost the activation of the subordinate meaning such that it is accessed ahead of the dominant meaning, avoiding competition and reducing the SBE. The dominant repeated condition revealed a small numerical

processing advantage across most eye movement measures that trended in the same direction as the subordinate repeated condition (but never approached significance). This numerical advantage in the dominant repeated condition is consistent with a small general benefit from repetition. The significant interaction of meaning and repetition, where having previously processed the homograph in the prior context led to a larger decrease in processing time for the subordinate repeated condition than the dominant repeated condition (as compared to their respective nonrepeated conditions), speaks to a mediation of the SBE in the subordinate repeated condition, over and above a simple benefit from repetition.

It might be tempting to view the interaction of repetition and meaning as an interaction of repetition and frequency, where the homograph in its subordinate sense is characterised as a low frequency word and the dominant sense as a relatively higher frequency word. Since many studies investigating the repetition of individual words in nonreading tasks (e.g., word list studies and lexical decision tasks) have demonstrated larger repetition effects for low frequency words than for high frequency words (e.g., Duchek & Neely, 1989; Forster & Davis, 1984; Norris, 1984; Rugg, 1990), the present results might be seen as simply reflecting these differential effects of repetition across frequencies, and not an actual reduction in the SBE. Caution should be taken in extending the results of single-word repetition tasks to the reading of coherent sentences with repetition, as the processes underlying each activity surely differ (Raney, 1993). Indeed, Raney and Rayner (1995) investigated the processing of (nonambiguous) repeated words within a coherent context and found that the reduction in processing time after repetition did not differ as a function of a word's frequency. That is to say, word frequency did not modulate the size of the repetition effects they observed. Raney and Rayner argued that a well-developed context could eliminate differential effects of repetition across frequencies. Considering these results, we would not expect target word meaning frequency to modulate the repetition effects we observed, since our repetition manipulation was embedded within coherent sentences. In other words, since our repeated words were inserted into meaningful contexts, there is no reason to expect that the magnitude of the word repetition effect would vary as a function of the instantiated meaning of the repeated homograph (i.e., whether the context supported the low-frequency subordinate meaning or the relatively higher frequency dominant meaning). Given that we did observe an interaction of repetition and meaning, we can infer that the larger effect of repetition in the subordinate conditions arises from some processing beyond a general repetition benefit – which is assumed to be equal across meanings given the results of Raney and Rayner (1995). Therefore, it is reasonable to conclude that the greater effect of repetition that we observed in the subordinate repeated condition reflects a reduction in the SBE over and above the general benefit of repetition.

Analysis of the posttarget region did not reveal any differential processing as a function of the interaction of meaning and repetition. In both first pass time and total time there was a numerical advantage after repetition, such that readers spent less time reading the posttarget region after homograph repetition, but the numerical advantage did not reach significance. Taken in conjunction with the results of Experiment 1, the data suggest that it may be slightly easier to integrate the correct meaning of the homograph into the sentence when it has already been encountered previously, but the difference is not great nor is it statistically reliable. There was also a trend towards readers spending less time in the posttarget region in the subordinate conditions than in the dominant conditions; however, given that it was only significant by subjects and the fact that the dominant and subordinate posttarget regions were composed of completely different text, we will not speculate further.

GENERAL DISCUSSION

In the present research, we addressed the nature of lexical access through a paradigm designed to reduce the SBE. We were interested in whether previously encountering a homograph could affect lexical access for a subsequent occurrence of the same homograph during reading. Specifically, whether previously encountering a biased homograph in its subordinate meaning would reduce the SBE for a subsequent occurrence of that homograph. Although Rayner et al. (1994) and Binder and Morris (2011) were unable to reduce the SBE for the second occurrence of a homograph after it appeared earlier in a passage, their stimuli required the meaning to persist across multiple sentences. Because of the intervening material, it is possible (and Rayner et al. suggested)

that activation of the subordinate meaning may not have persisted for a long enough time or couldn't be integrated across sentences. To remove these constraints, we embedded a homograph in a single-sentence context, the beginning of which instantiated the subordinate meaning, and observed the traditional SBE that has been well documented in prior research (e.g., Duffy et al., 1988; Pacht & Rayner, 1993; Rayner et al., 1994, 2006; Sheridan & Reingold, 2012). When this prior context also contained a previous occurrence of the target homograph (using its subordinate sense), however, we observed a reduction in the SBE. After this stronger subordinate-biasing context readers took less time to process the target word across both experiments, suggesting that they were able to activate and integrate the subordinate meaning of the homograph more easily and efficiently than in the nonrepeated condition. Furthermore, after repetition in Experiment 2, they were able to activate and integrate the subordinate meaning in a way that did not significantly differ from the ease with which they were able to do so in the dominant conditions.

Taken in conjunction with the results of Rayner et al. (1994) and Binder and Morris (2011), our results suggest that, during reading, any reordering of a homograph's different meanings is either relatively short lived or does not extend across sentential boundaries (but see Colbert-Getz & Cook, 2013). Although we found effects of prior encounter on a subsequent occurrence of the homograph within the same sentence, Rayner et al. and Binder and Morris found no effect of prior encounter after multiple intervening sentences in a paragraph. Within normal discourse comprehension, it may be the case that only immediate contextual manipulations are strong enough to allow for efficient access of the subordinate meaning (but see, Martin, Vu, Kellas, & Metcalf, 1999, and Vu, Kellas, Metcalf, & Herman, 2000, for evidence that global context can extend activation across sentential boundaries to influence the processing of homographs, in non-eye movement tasks). Alternatively, the specific nature of the contextual manipulations used in these studies and previously by Rayner et al. and Binder and Morris, namely the use of repetition, may have contributed to the apparently short-lived reordering of meaning. It may be that any persistent activation of a specific meaning of a homograph may decay rapidly after access. This rapid decay hypothesis predicts that residual activation, which results from previous lexical access, will only persist for a short amount of time. Therefore, any reordering of a homograph's different meanings that is achieved through the instantiation of a strong biasing context reliant on repetition, may only occur for short intervals between the first and second occurrence of the homograph, and could explain why we observed reductions in the SBE from homograph repetition in our single-sentence stimuli, but Rayner et al. (1994) and Binder and Morris (2011) did not.

Additionally, we have demonstrated that context can interact with meaning frequency very early to influence lexical access. We observed an interaction of meaning frequency and context in early fixation measures on the homograph (gaze duration), as well as skipping probability, providing additional evidence that context can in fact even exert its influence prior to fixation. These data demonstrate rapid integration of contextual information during lexical ambiguity resolution and are consistent with other ambiguity resolution work using ERPs (Sereno et al., 2003), distributional and survival analyses of eye movement data (Sheridan & Reingold, 2012), and eye movement studies showing an immediate effect of context (e.g., Rayner et al., 2006). This early, prelexical time course is consistent with interactive models like the reordered access model.

Our findings bring us closer to an understanding of what contexts can overcome the activation from meaning frequency and reorder lexical access. Our single-sentence repetition context did not require the activation of the subordinate meaning to persist across multiple sentences, resulting in stronger activation from the subordinate context and allowing the subordinate meaning to be accessed ahead of the dominant meaning, thereby reordering lexical access. Beyond providing further support for the notion that lexical access can be reordered, we have used eye movements to demonstrate that it is possible to create a strong enough biasing context to reduce the SBE within a single sentence through a purely contextual manipulation during reading. That is to say that, first, we have provided additional evidence that contextual information is able to interact with meaning frequency during lexical access to influence the speed and ease with which a given word or, more precisely, a specific meaning of a given word can be accessed. Second, we have provided evidence that a strong biasing context (at least one containing a prior occur-

rence of the homograph) can interact during lexical access to such an extent that it can overcome the activation from meaning frequency, reordering lexical access and reducing the SBE during reading.

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APPENDIX

Stimuli (target words appear in italics)

Subordinate	
port	The store sold many drinks including port, but Amy decided to only buy *port* because it was her favorite.
	The store sold many drinks, but Amy decided to only buy *port* because it was her favorite.
scale	The last fish Marissa caught had brown scales, but the other fish had *scales* in every color of the rainbow.
	The last fish Marissa caught was brown, but the other fish had *scales* in every color of the rainbow.
table	Data can be displayed in a graph or table, but often a *table* makes results easier to understand.
	Data can be displayed in different forms, but often a *table* makes results easier to understand.
diamond	From the stands, the new baseball diamond looked a lot larger than the old *diamond* that had been torn down.
	From the stands, the new baseball field looked a lot larger than the old *diamond* that had been torn down.
bill	Mark was told to check the duck's feet and bill for injuries and to put a tag on its *bill* if it appeared fine.
	Mark was told to check the duck's body for injuries and to put a tag on its *bill* if it appeared fine.
racket	Kara's loud neighbors made so much racket that it made the *racket* her kids were making seem like nothing.
	Kara's loud neighbors made so much noise that it made the *racket* her kids were making seem like nothing.
pen	Susan's job was to clean the stall and pen every day, which was easy except that the *pen* was a mess.
	Susan's job was to clean the barn each day, which was easy except that the *pen* was a mess.
ball	The votes between disco and ball for the dance theme were close, but in the end the *ball* won the vote.
	The votes for the dance theme were close, but in the end the *ball* won the vote.
bank	When Joe found the flooded bank, he grabbed his boots before walking along the *bank* to work.
	When Joe found the flooded river, he grabbed his boots before walking along the *bank* to work.
wire	At the museum the kids saw the machine for sending a wire and each student sent a *wire* to a friend.
	At the museum the kids saw the machine for sending a telegram and each student sent a *wire* to a friend.
horn	The hunting lodge was full of antlers and horns, but most impressive was the rhino *horn* hanging on the wall.
	The hunting lodge was full of trophies, but most impressive was the rhino *horn* hanging on the wall.
mint	Jamie wanted to go on a tour of the treasury and the mint, but on Mondays the *mint* was closed to the public.
	Jamie wanted to go on a tour of where money is made, but on Mondays the *mint* was closed to the public.
coach	Pam had to decide whether to fly first-class or coach; she decided to fly *coach* because the ticket was cheaper.
	Pam had to decide whether or not to fly in first-class; she decided to fly *coach* because the ticket was cheaper.
poker	To tend a hot fire, it's best to use a stick or a poker, but when it's really hot a metal *poker* can burn you.
	To tend a hot fire, it's best to use a stick or tool, but when it's really hot a metal *poker* can burn you.
boxer	Even though the pet store had cute huskies and boxers, John had no difficulty picking the *boxer* puppy for his son.
	Even though the pet store had many cute puppies, John had no difficulty picking the *boxer* puppy for his son.
cabinet	The president began the meeting with his cabinet and advisors, but only the *cabinet* was allowed to stay for the end.
	The president began the meeting with all his advisors, but only the *cabinet* was allowed to stay for the end.
band	Martin saw the perfect engagement ring and wedding band set, but was disappointed when the *band* was sold out.
	Martin saw the perfect engagement ring set, but was disappointed when the *band* was sold out.
notes	On the flute certain notes are hard to play, but they are not as bad as the same *notes* on the oboe.
	On the flute certain sounds are hard to play, but they are not as bad as the same *notes* on the oboe.
speaker	The sound problem could only be due to either the speaker or the cable, it turned out that the *speaker* was broken.
	The sound problem could only be due to a few things, it turned out that the *speaker* was broken.
legend	Erin knew to check the map's legend to figure out what the symbols meant, but there was no *legend* on her map.
	Erin knew to check the map to figure out what the symbols meant, but there was no *legend* on her map.
story	Kayla was hoping to get a condo on the fourth story, but the best they had was the third *story* so she didn't buy it.
	Kayla was hoping to get a condo on the fourth floor, but the best they had was the third *story* so she didn't buy it.
plant	No one wants to live near an electrical station or a plant, so the homes next to the *plant* were vacant.
	No one wants to live near manufacturing facilities, so the homes next to the *plant* were vacant.
corn	After hiking Mike had some cuts on his feet and a corn on one toe, after the walk home he had a *corn* on each foot.
	After hiking Mike had some cuts on his feet, after the walk home he had a *corn* on each foot.
habit	Paul had only seen nuns in black habits, so when he saw a group of nuns in dark blue *habits* he was very surprised.
	Paul had only seen nuns in black clothes, so when he saw a group of nuns in dark blue *habits* he was very surprised.
crown	The dentist suggested a root canal and crown, but Todd could only get a *crown* because he didn't have much money.
	The dentist suggested a few different treatments, but Todd could only get a *crown* because he didn't have much money.
suit *	His lawyer assured him that he could beat the first law suit, but the second law *suit* would be a challenge.
	His lawyer assured him that he could win the first case, but the second law *suit* would be a challenge.
coat *	The walls looked ok after the first coat finished drying, but Katie applied a second *coat* to really make them pop.
	The walls looked ok after the paint finished drying, but Katie applied a second *coat* to really make them pop.
stars *	Evan went to the movie premier in hopes of meeting his two favorite stars, but one of the *stars* didn't show up.
	Evan went to the movie premier in hopes of meeting his two favorite actors, but one of the *stars* didn't show up.

(*Continued*)

APPENDIX. Continued.

Subordinate	
toast *	As best man, Kurt's jobs were to hold the rings and give a toast, which was fine except the *toast* made him nervous.
	As best man, Kurt's jobs were to say a few words at the reception, which was fine except the *toast* made him nervous.
bulb *	In early spring Lara plants tulip bulbs and by the middle of spring the *bulbs* begin to sprout.
	In early spring Lara plants tulips and by the middle of spring the *bulbs* begin to sprout.
staff *	When the shepherd lost his supplies and staff, he had to use a stick as his *staff* that day on the trail.
	When the shepherd lost his supplies, he had to use a stick as his *staff* that day on the trail.
chair *	Although the election for department chair was usually very close, this year the *chair* was elected unanimously.
	Although the election for department head was usually very close, this year the *chair* was elected unanimously.
pit †	Emily hated eating food with seeds or a pit, so she was upset to find a *pit* in the exotic fruit she tried.
	Emily hated eating food with inedible parts inside, so she was upset to find a *pit* in the exotic fruit she tried.
Dominant	
port	The ship docked at the port, but the sailors didn't want to stay in the *port* that evening.
	The ship docked at the harbor, but the sailors didn't want to stay in the *port* that evening.
scale	The food could be weighed with a balance or scale, but Marcy chose a *scale* because it was more precise.
	The food could be weighed a few different ways, but Marcy chose a *scale* because it was more precise.
table	The waitress offered them seats at the bar or a table, but the couple chose a *table* because it was private.
	The waitress offered them seats at the bar, but the couple chose a *table* because it was private.
diamond	Paul had to decide between an emerald or diamond ring, he picked the *diamond* because his wife liked them best.
	Paul had to decide between many different rings, he picked the *diamond* because his wife liked them best.
bill	Mark was shocked to discover that although he paid his bills on time, this month his water *bill* contained a late fee.
	Mark was shocked to discover that although he paid on time, this month his water *bill* contained a late fee.
racket	Anne was excited because she got a new tennis net and racket for Christmas, but the *racket* was the wrong size.
	Anne was excited because she got new tennis equipment for Christmas, but the *racket* was the wrong size.
pen	The form could be filled out in pencil or pen, but Kelly used *pen* so her answers couldn't be accidentally erased.
	The form could be filled out with any utensil, but Kelly used *pen* so her answers couldn't be accidentally erased.
ball	Carl brought a frisbee and a ball to the park, but his dog only wanted to play with the *ball* that day.
	Carl brought many toys to play fetch in the park, but his dog only wanted to play with the *ball* that day.
bank	When he saw that the bank was closed, Peter went to get coffee before going to the *bank* to cash his check.
	When he saw that the teller line was long, Peter went to get coffee before going to the *bank* to cash his check.
wire	Carly was trying to connect the battery to the proper wire, but she grabbed the wrong *wire* and got shocked.
	Carly was trying to connect the battery properly, but she grabbed the wrong *wire* and got shocked.
horn	In the city you hear many car alarms and horns, but the car *horns* are less annoying because they are quieter.
	In the city you hear many loud sounds, but the car *horns* are less annoying because they are quieter.
mint	Shannon offered him candy or a mint, but he picked a *mint* because his breath was terrible.
	Shannon offered him multiple candies, but he picked a *mint* because his breath was terrible.
coach	Eric gave permission slips to both his teacher and coach, but his strict *coach* refused to let him miss practice.
	Eric gave permission slips to his school authorities, but his strict *coach* refused to let him miss practice.
poker	The teens knew how to play rummy or poker, but they decided to play *poker* because they wanted to win money.
	The teens knew how to play a few card games, but they decided to play *poker* because they wanted to win money.
boxer	Scott was a wrestler and a boxer when he was young, but being a *boxer* gave him arthritis.
	Scott was a wrestler and a fighter when he was young, but being a *boxer* gave him arthritis.
cabinet	The builder was supposed to put in the new kitchen counter and cabinets, but the selected *cabinet* style was sold out.
	The builder was supposed to put in the new kitchen, but the selected *cabinet* style was sold out.
band	Mark's favorite band was playing in his town, but back stage passes to meet the *band* members were sold out.
	Mark's favorite music group was playing in his town, but back stage passes to meet the *band* members were sold out.
notes	Maddy always paid attention and took notes, but when she was sick she had to get a copy of the *notes* from her friend.
	Maddy always paid attention in class, but when she was sick she had to get a copy of the *notes* from her friend.
speaker	Marge was responsible for finding a graduation speaker, so when the *speaker* canceled last minute she was fired.
	Marge was responsible for organizing the graduation ceremony, so when the *speaker* canceled last minute she was fired.
legend	For class the kids had to write a poem or a legend, but everyone wrote a *legend* because it was easier.
	For class the kids had to write some kind of tall-tale; everyone wrote a *legend* because it was easier.
story	At night Sue's mom reads her a story before bed, but last night they didn't read a *story* since she was in trouble.
	At night Sue's mom reads her a book before bed, but last night they didn't read a *story* since she was in trouble.
plant	The students forgot to water the flowers and plant, so when they returned from break the *plant* was dead.
	The students forgot to take care of the garden, so when they returned from break the *plant* was dead.
corn	The farmer grew potatoes and corn, but he only sold his *corn* at the local market.
	The farmer grew many crops, but he only sold his *corn* at the local market.
habit	Addictions and bad habits are hard to overcome because people often don't even realize what bad *habit* they have.
	Addictions and bad traits are hard to overcome because people often don't even realize what bad *habit* they have.

(*Continued*)

APPENDIX. Continued.

Dominant	
crown	The costume looked good with a tiara or crown, but Pam bought a *crown* because it was really cheap.
	The costume looked good with a tiara, but Pam bought a *crown* because it was really cheap.
suit	The saleswoman recommended that Gabe try a different suit, but he liked the *suit* he had on too much to listen.
	The saleswoman recommended that Gabe try something different, but he liked the *suit* he had on too much to listen.
coat	Kristen put her spring coat on, but she changed into her winter *coat* after she felt how cold it was.
	Kristen put her spring jacket on, but she changed into her winter *coat* after she felt how cold it was.
stars	Cal hoped to see the moon and stars with his telescope, but he couldn't see the *stars* because of the city lights.
	Cal hoped to see something with his telescope, but he couldn't see the *stars* because of the city lights.
toast	Joyce's breakfast was supposed to come with toast, but she substituted potatoes for the *toast* because of her diet.
	Joyce's breakfast was supposed to come with bread, but she substituted potatoes for the *toast* because of her diet.
bulb	Roger rewired the light and changed the bulb, but it still didn't turn on because the *bulb* he used was wrong.
	Roger rewired the light, but it still didn't turn on because the *bulb* he used was wrong.
staff	Although the managers and staff were worried about potential job cuts, it turned out that none of the *staff* were let go.
	Although the managers were worried about potential job cuts, it turned out that none of the *staff* were let go.
chair	The patio had one very comfortable chair that Christa wanted because the only other *chair* was old and broken.
	The patio had one very comfortable seat that Christa wanted because the only other *chair* was old and broken.

Note: For the subordinate sentences, † indicates stimuli used only in Experiment 1, * indicates stimuli used only in Experiment 2.