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Repetition blindness in sentence contexts: Not just an attribution?

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Selective "blindness" to repeated words in rapid serial visual presentation (RSVP) occurs even when omitting these words compromises sentence syntax and meaning. The contributions of lexical and contextual factors to this *repetition blindness* (RB) phenomenon were evaluated using three tasks that combined RB and ambiguity resolution paradigms. During an RSVP sentence, a repeated word and matched but incongruous control were presented simultaneously, and participants were asked to report the entire sentence, including only the appropriate word. Substantial RB was evident in impaired report of repeated targets, whereas report of nonrepeated targets was enhanced when the distractor was a repeat. Experiment 2 confirmed these results with reduced reporting requirements, and Experiment 3 demonstrated the independence of repetition and sentence congruity effects. Results across all contexts support a lexical account of RB, which assumes that reactivation and identification of rapidly repeated words are impaired due to the refractory nature of lexical representations.

Repetition blindness (RB) refers to the failure to report both occurrences of a repeated item in a series of rapidly presented visual stimuli. For instance, the sentence *When she spilled the ink there was ink all over*, presented word by word at a rate of around 100 msec/word, may be reported as "When she spilled the ink there was all over" (Kanwisher, 1987), even though the sequence is nongrammatical. RB also occurs for repeated items in lists of words and pictures (see Coltheart, 1999, for reviews), but the phenomenon is particularly striking in sentences, where its occurrence generally fails to respect the constraints of coherence or syntax. This has contributed to accounts that locate the phenomenon at the lexical level, rather than at the later stages of memory and recall. In the experiments reported here, novel variations of the standard RB sentence-processing paradigm were used to shed further light on the relative contribution of bottom-up and top-down processes to RB and, more generally, on the role of lexical activation in sentence processing.

Type–Token Accounts of RB

Kanwisher's (1987) original interpretation of RB drew upon the distinction between *types* and *tokens*. Reporting the identity of an item in a stimulus sequence requires not only activation of the existing representation of the item's type representation in memory, but also creation of a token representing the occurrence of that type in the processing episode (Kahneman & Treisman, 1984). For example, the conceptual processing required to build a coherent structure from the words of a sentence requires more than activation of word types in lexical memory; comprehension and recall depend on establishing tokens of these words and the sentential relationships between them in that specific sentence. In this framework, RB is the consequence of a perceptual limitation that impairs the rapid creation of separate tokens for two occurrences of the type.

There are two major variants of this *type–token account* that propose different sources for RB. According to the type refractoriness hypothesis, RB is due to the activation dynamics of type nodes, rather than to a problem with token formation or binding. The representation of a particular stimulus undergoes a period of reduced sensitivity immediately after firing, by analogy with the refractoriness of neurons. Accordingly, if the stimulus appears twice in close succession, the second occurrence may be unable to increase the node's activation enough to be recognized or induce a response. The second class of models attributes RB to problems in token individuation. Even though the two separate occurrences are both "recognized" at the type level, formation of a second token from a single type is briefly inhibited after the first token is individuated (e.g., Kanwisher, 1987).

The *type refractoriness hypothesis* has been formalized in dynamical models based on a signal detection approach that implement a "rudimentary form of adaptation" (Bavelier & Jordan, 1992, p. 883). Bavelier and Jordan's model assumes that the detection threshold is increased for recently detected items, whereas Luo and Caramazza's (1996) version proposes that the activation function for type nodes rises sharply following the first presentation of the critical stimulus (often labeled C1) but then falls away to below its original baseline. Both mechanisms have the same outcome: Re-presenting a word as C2 (the second critical stimulus) soon after the initial presentation will not

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result in a second detection, even if it raises the node's activation level, unless sufficient time has elapsed to allow the threshold or node activation to return to resting level. According to these accounts, "repetition blindness arises because the fluctuation due to the brief presentation of C2 is not judged significant against the background of the recent detection of the word" (Bavelier & Jordan, 1992, p. 884).

Kanwisher (1987) initially rejected the type refractoriness hypothesis because, in contrast to the repetition deficit obtained when participants were required to report a complete sentence or word list, performance for repeated words was facilitated, rather than reduced, when only the final item from a rapid serial visual presentation (RSVP) sequence was to be reported (Kanwisher, 1987, Experiment 3). She argued that the lexical locus implicated by the refractoriness hypothesis predicts equivalent RB for repeated items regardless of whether participants must recall the whole sentence or monitor for the last word. The repetition advantage observed in the final-word report task therefore led her to conclude that RB is due not to refractoriness at the type level but to impaired token individuation. The final-word report task yields facilitation, rather than RB, because the task does not require tokenization of the first occurrence.

Subsequent evidence using the final-word report task has, however, been contradictory. A number of studies have failed to replicate Kanwisher's (1987) findings and have shown, instead, that RB is relatively equivalent whether participants report all items or only the final one (Hochhaus & Marohn, 1991; Kanwisher & Potter, 1990; Luo & Caramazza, 1995). There are also conceptual problems with Kanwisher's (1987) claim that the type refractoriness hypothesis cannot accommodate facilitatory repetition effects in the final-word report task. In the signal detection implementations of this hypothesis described above (Bavelier & Jordan, 1992; Luo & Caramazza, 1995), a second presentation of an item *does* increase activation of its type node, but changes in the threshold or decay function mean that *more* activation is required to achieve identification for a second than for a first presentation. If task performance can be based simply on activation at the type level, regardless of threshold detection, refractoriness of the relevant type node to a *second* presentation will not necessarily impair performance. Instead, summation of the activation from two presentations might yield facilitation for repeated words (Luo & Caramazza, 1996). Thus, despite Kanwisher's original rejection of type refractoriness, it remains possible that this mechanism is responsible for RB effects in at least some task contexts.

Token individuation accounts are probably the dominant explanation of RB, but there are a number of variations of this general view. Kanwisher (1987) originally proposed that the formation of a second token from a single type is briefly inhibited after the first token is individuated. The subsequent discovery that RB can arise for nonidentical words, such as components of compound words (Kanwisher & Potter, 1990), and for words that are visually or phonologically similar (e.g., *reach–react*, *one–won*; Bavelier & Potter, 1992) led to elaborations of the individuation account, which assumes that the code used for registering initial information in short-term memory (STM) depends on task requirements: "RB will arise whenever the codes used in initial registration of C1 and C2 in STM are too similar, regardless of the actual stimuli the subject saw" (Kanwisher & Potter, 1990, p. 144). Park and Kanwisher (1994) attempted to distinguish whether RB was caused by a failure to create a second token for a reactivated type or a difficulty in binding it to form a new token. They cited evidence for both possibilities, depending on the nature of the task and stimuli: Sometimes an *empty* token is created, when readers know that an item appeared but cannot retrieve its identity; at other times, the item's reactivation is assimilated into the first episodic token. RB has also been attributed to later processes involved in *stabilizing* a token (Bavelier, 1994).

These different characterizations of the deficit in token individuation are not mutually exclusive. Bavelier (1999) argued that "the successful establishment of an object-specific representation is . . . a graded, dynamic process" (p. 167). RB for identical items might reflect failure to *open a token* (Bavelier, 1994), whereas those for different items that are similar only in orthography, phonology, or even semantics (Bavelier, 1994) may reflect more task-specific processes that are "important for the stabilization of information in short-term memory" (Bavelier, 1999, p. 158).

Memory and Reconstruction Accounts of RB

Type–token approaches to RB have been challenged by accounts that emphasize the role of memory processes. Failure to report an item in a full-report task does not necessarily prove that the item was not encoded or individuated. RB may, instead, be due to memory retrieval or other processes involved in short-term recall. Indeed, the full-report paradigm usually used to assess RB is essentially a test of STM but involves a faster rate of stimulus presentation than is commonly employed in that domain.

Drawing on the STM literature, Armstrong and Mewhort (1995) argued that RB is due to guessing biases and output interference similar to those underlying the Ranschburg effect (Crowder, 1968). Consistent with that view, they found that report of repeated stimuli in rapid lists was facilitated, rather than reduced, when a retrieval cue was provided. Similar findings led Fagot and Pashler (1995) to conclude that RB reflects "the operations and strategies involved in full report from RSVP displays rather than any fundamental and surprising characteristic of on-line perceptual processing" (p. 290). However, the specific mechanisms proposed as the source of the reporting deficit depend on STM's being overloaded. Demonstrations that RB occurs when memory load is minimized (e.g., Johnston, Hochhaus, & Ruthruff, 2002; Luo & Caramazza, 1995) have challenged the claim that RB is entirely due to retrieval processes.

A more complex approach that also emphasizes retrieval strategies was proposed by Whittlesea and colleagues (Whittlesea, Dorken, & Podrouzek, 1995; Whittlesea & Podrouzek, 1995; Whittlesea & Wai, 1997) and recently was expanded by Masson (2004; Whittlesea & Masson, 2005). This *constructionist account* of RB assumes that the effects are due primarily to impairments and biases in reconstructing the stimulus sequence, rather than to failures in storage, tokenization, or retrieval per se. According to this view, conscious experience of past and present events is a construction derived from production and evaluation processes that operate on the *stimulus complex* provided by the stimulus, task, and context (Whittlesea, 2003), rather than the outcome of type activation. The *mental event* of a word's meaning's coming to mind is not a direct reflection of the nominal stimulus but a production that has been filtered through memory and subjected to evaluative processes that make attributions about the source of the word (e.g., to perception, memory, or imagination) and determine its task-specific meaning. Any attempt at recall is therefore a reconstruction, rather than a readout of a veridical *memory trace*. RSVP conditions disrupt perceptual processing and lead to impoverished, fragmentary information that is more vulnerable to distortion or misattribution.

Critically, repeated and unrepeated words are not processed differently at encoding: "Repeated presentations are encoded and represented separately . . . [and] there is no difference in the fundamental processes by which people remember single events and repetitions of events" (Whittlesea & Podrouzek, 1995, p. 1695). Indeed, it is precisely because each occurrence is processed independently that a reader may not become aware of repetition; and because words presented in RSVP are poorly integrated with their context, both instances of a repeat may be independently attributed to the same list position and, therefore, reported only once (Whittlesea et al., 1995).

Thus, the construction account emphasizes the importance of the way readers set about generating perceptions and memories to achieve particular task requirements. From this perspective, RB is not solely a function of the perceptual impairments emphasized by type–token accounts or the retrieval impairments of the memory accounts. Constructive processes influence both perception and memory to yield task-dependent constructions of perceptual events. Repetition-specific recall deficits arise because repetition increases the ambiguity of the attribution process, rather than because it directly disrupts either perceptual individuation or recall of the two occurrences.

Much of the evidence for the constructionist approach derives from demonstrations that RB effects are modulated by task demands. For example, Masson (2004) presented lists of words under RSVP conditions and asked participants to recall either the entire list or only the final word. The results showed that, consistent with Kanwisher's (1987) original finding, whole-list report showed RB, whereas final-word report was facilitated by repetition. Crucially, Masson's experiments provided the recall instruction only after the sequence had been presented, so the differences could not be attributed to changes in encoding strategies between conditions. Masson argued that these results provide strong evidence against RB's having a perceptual locus and, instead, support memory- and reconstruction-based accounts. However, this differential repetition effect occurred only for word lists. Sentences presented in the same instructional conditions showed very strong RB for whole-sentence report that was not reversed by showing facilitation in the final-word condition. RB was, however, reduced in the final-word task, and the repetition deficit was significant only when corrected for guessing. The fact that RB was modulated by reporting requirements is consistent with the constructionist claims about task specificity, but it is not clear why this should vary between list and sentence contexts. Masson suggested that the absence of facilitation in the final-word task for sentences may indicate that coherent sentence contexts enhance processing of C1 and "encourage the migration of a repeated C2 to its earlier position in the sentence" (p. 1285). But he acknowledged that "there is no basis for generating a firm prediction from the construction account" (p. 1284) as to exactly how sentence and task context combine to determine whether repetition will affect sentence recall. The differential influence of list and sentence context is particularly noteworthy given that Masson used truncated versions of the sentences from the full-report task (e.g., *The blue car and red car*). Even these fragmentary sentence contexts reduced the impact of the single-word report requirements on RB, showing that sentence contexts are, in some way, more resistant to loss of RB than are word lists when task demands are varied.

It is difficult to distinguish the constructionist account from the view that RB is due to problems with token individuation. Proponents of the individuation view acknowledge that "there is no well-defined dividing line between perception and memory . . . [or] a priori way to decide which of the . . . transformations of representations from the retinal array up through representations of recognized objects . . . should count as a 'memory'" (Park & Kanwisher, 1994, p. 502). Similarly, constructionist theorists argue that "the distinction between perception and memory as alternative bases for repetition priming is not a central issue for the [constructionist] account" (Masson, 2004, p. 1287). Thus, both views attribute RB to the interaction between perception and memory.

The critical difference lies in their assumptions about the role of abstract types in this interaction. The type–token account hinges on the distinction between an abstract level of representations of familiar stimuli and episodic representations that code the relationships between types in a particular processing context, such as items in a list or words in a sentence. The strong constructionist account argues that "there are no abstract, semantic representations to activate or inhibit" (Whittlesea & Masson, 2005, p. 54): "Memory does not work by simple registration of stimuli and later reduplication . . . but instead by construction in the moment and reconstruction on a later occasion" (Whittlesea & Hughes, 2005, p. 103). Thus, Masson (2004) claims that a critical distinguishing feature of the constructionist view from the type–token account is that it assumes that "repetition blindness is not lexically based" (p. 1287). In the present experiments, we investigated this claim directly by using a novel technique for probing the effects of repetition on sentence processing.

Bottom-Up and Top-Down Processing of Sentences

Sentences differ from lists of words in a number of important ways. They are tied together by syntax and semantics, and it is the way that words are combined, as well as the individual words' identity, that conveys the concepts or propositions of the sentence. Theories of sentence processing vary in their assumptions about how context contributes to identifying, encoding, and recalling the words within a sentence. Modular accounts of reading argue that words are identified in a purely bottom-up manner, unaffected by nonlexical information, such as sentence context and pragmatics. By contrast, interactive models assume an architecture in which bottom-up and top-down processes simultaneously contribute to word recognition. Lexical items are activated in accordance with their match to both sensory and contextual information. These parallel sources of evidence result in selection of the most highly activated word candidate. The outcome also depends on the strength or quality of information from each source: When sensory input is impoverished, as in RSVP or other degraded presentation formats, higher level processes are likely to take on a greater role.

Potter, Stiefbold, and Moryadas (1998) attempted to distinguish between the modular and the interactive models, using a *double-word selection* technique in which readers were asked to select between two words presented simultaneously within an RSVP sentence. Only one of the two words was compatible with the sentence, and the disambiguating context appeared either before or after the double-word display (e.g., *The rainbow had a bright river/color after the storm* vs. *Kate saw the river/color of the rainbow after the storm*). Participants were asked to immediately recall each sentence, completing it with the appropriate word from the double-word display, and then to recall the other word if possible. Overall, the matching word (e.g., *color*) was more likely to be reported in the sentence than was the nonmatching word (e.g., *river*), particularly when context preceded the double-word display. The bias toward the matching word was reduced as the disambiguating context moved to later positions in the sentence but remained considerable even when context was delayed by as many as six to nine words. The participants were poor at recalling the alternative word and frequently reported feeling completely unaware of it, especially when the disambiguating context preceded the double-word display.

Potter et al. (1998) interpreted these findings as supporting a hybrid *modular–interactive model* of sentence processing comprising two stages. An initial bottom-up process produces a set of weighted lexical candidates based on the perceptual evidence from the stimulus. Contextual evidence then interacts with these weights at a second stage, leading to the selection (and ultimate recognition) of the single candidate that best fits the semantic constraints while maximizing consistency with the perceptual weightings. Potter et al.'s (1998) double-word task data indicated that lexical candidates derived through bottom-up processing can remain active until context permits a selection to be made. At this point, unselected perceptual candidates are rapidly deactivated.

These results, like others reviewed by Potter (1999), suggest that semantic and syntactic structure are extracted very rapidly from sentences during initial processing, providing a basis for fast selection of the appropriate word, creation of a coherent propositional representation, and rejection of inappropriate alternatives. However, the fact that context can also be used retrospectively to select the correct item from the double-word display provides evidence for independent activation of lexical types on perceptual grounds alone.

EXPERIMENT 1

Experiment 1 combined the double-word paradigm with manipulations of stimulus repetition to provide direct evidence about the relative contribution of bottom-up activation of abstract lexical types, by comparison with top-down reconstructive processes, to RB for sentences. Stimuli consisted of RSVP sentences that incorporated a masked double-word display. The participants' task was to recall the sentence aloud, including in their report only the word that *fit* the sentence context. Unlike the straightforward recall required in typical RB tasks, the selection requirement imposed by this design encourages participants to focus on the meaning of the sentence. The technique also allows the relationship between the to-be-selected item pairs to be manipulated independently of repetition, while keeping the context equivalent. The contextual influences on attribution and construction can therefore be equated independently of the consequences of word repetition for lexical activation.

As is depicted in Table 1, three sentence conditions were compared. In the *repeated target* condition, the target word from the double-word display was a repeat of an earlier word in the sentence. In the control *no-repeat* condition, the first repeat was replaced with a different word that fitted the sentence. The *repeated distractor* condition contained repeated items identical to those in the repeated target sentences, but the repeated word was now the sentence-inappropriate *distractor* of the double-word display. Thus, the same word could be either target or distractor, depending on relatively minor variations in sentence context.

A lexical account of RB predicts that type activation and detection dynamics will make repeated words less available than nonrepeated words to construction and memory processes. This reduced availability has opposite consequences according to whether the repeated word is a target or a distractor. When the repeated word is a target, it will impair target report—that is, the standard RB effect. However, when the repeated word is the distractor, its reduced availability will decrease competition for selection between the double words, facilitating report of the target word. An additional prediction of this account is that when selection of the target word is easy—that is, when the distractor is repeated and, therefore, unavailable to compete—the reduction in resources required for selection will facilitate report of the words immediately following the double-word display, in accordance with the attentional blink effect (Raymond, Shapiro, & Arnell, 1992).

The constructionist account also predicts RB in the repeated target condition, due to the misattributions and response biases thought to be responsible for the standard

Table 1
Examples of Sentences in Each Condition

Condition	Target Position		C1	(Lag)	C2	
Repeated target	Upper	When you notice a	sale	the	sale bowl	is already over.
	Lower	When you notice a	sale	the	bowl sale	is already over.
No repeat	Upper	When you notice a	coat	the	sale bowl	is already over.
	Lower	When you notice a	coat	the	bowl sale	is already over.
Repeated distractor	Upper	At the clearance	sale	the	bowl sale	is on special.
	Lower	At the clearance	sale	the	sale bowl	is on special.

Note—The target is the word that makes sense in the sentence context.

effect. It is the repeated distractor condition that yields differential predictions. Distractors do not need to be included in report, and there is therefore no need to make attributions about them during the construction process. Even if a distractor is consciously identified before the target is, it can be rejected from the construction process, because it is not congruent with the sentence. Moreover, given that "repeated representations are encoded and represented separately" (Whittlesea & Podrouzek, 1995, p. 1695), any effects of selection on the processing of subsequent words should be equivalent for repeated and nonrepeated items. There is, therefore, no obvious reason to predict any differences between the no-repeat and the repeated target conditions, because they differ only in whether or not the distractor is a repeat of an earlier item in the sentence and both repeated and nonrepeated distractors are equally incompatible with the sentence. Thus, both accounts predict RB for repeated targets, but only the lexical account explicitly predicts facilitation for targets presented with repeated distractors.

Method

Participants

A total of 41 participants were recruited from the first-year psychology participant pool at the University of Sydney and received course credit for their participation. There were 25 females and 16 males, with an average age of 19.0 years. All had normal or corrected-to-normal vision and English as their first and dominant language.

Stimuli and Design

The experimental stimuli consisted of 60 sentences, each of which appeared in three variations, as shown in Table 1. The complete list of sentences appears in Appendix A. Words appeared in a fixed central position in white on a black background, in a fixed-width font. At a typical viewing distance of 50 cm, each letter subtended a vertical visual angle of up to 0.63º. Each sentence included a critical display consisting of two words: the target (C2), which fitted the sentence context, and the distractor, which did not. Targets and distractors were unrelated and were matched pairwise on frequency and length. In repeated target sentences, the target word also appeared in an earlier position as C1, preceding the double-word display by a lag of one (24 sentences), two (31 sentences), or three (5 sentences) intervening words. The baseline no-repeat condition was created by replacing the repeated C1 word with another word, often a synonym, to preserve the coherence of the sentence but eliminate repetition. Repeated distractor sentences were created by retaining both the original words at C1 and C2 but changing the context, so that the distractor from the repeated target condition became the target, whereas the repeated item—previously the target—now rendered the sentence incoherent. These sentences were otherwise kept as similar as possible to the original versions; in particular, the position of C1 and the lag between C1 and C2 were rarely altered. Thus, there were three types of sentences, and each could be made either sensible or nonsensical, depending on whether the target or the distractor was selected from the double-word display. Matching data for sentences and critical words in each condition are presented in Table 2.

The sentences were divided into groups and rotated around conditions, so that each participant was presented with only one version of each sentence but, across all 60 trials, saw 20 examples of each of the three types of sentences. Whether the target appeared in the upper or the lower position was also counterbalanced. An additional 12 similar sentences were developed for use as practice and buffer items.

As an added manipulation check, the participants subsequently rated the plausibility of the sentences. To minimize any biases due to memory, the list of sentences shown to each participant was based on different versions of the stimuli from the list that they had seen during the RSVP task. The sentences were shown with the target word included on 50% of trials; on the other 50%, the participants viewed the sentence with either the distractor word or neither word included (in order to obtain plausibility ratings for those instances in which *classic* RB occurred). Each sentence was presented in a single line across the screen with no time restriction, and the participants indicated the sentence plausibility on a scale from 1 (*nonsensical*) to 5 (*perfectly sensible*) by pressing the appropriate key on a standard keyboard. As is shown in Table 2, sentences were reliably considered more plausible when completed with the target word than with no word or the distractor word, and these differences were relatively equivalent across conditions.

Procedure

The participants were asked to report each sentence out loud after it had been presented, including only the appropriate word from the double-word display. An example was shown very slowly to clarify the task; then 10 practice trials were presented, during which the duration of word presentation decreased across trials from 183 msec to the experimental rate of 117 msec. Two buffer sentences then preceded the 60 experimental sentences, which appeared in an individually randomized order.

The presentation sequence is illustrated schematically in Figure 1. Sentences were presented word by word, with no interstimulus interval, each word appearing for 117 msec. As in the procedure used by Potter et al. (1998), the bias toward the upper word of the double-word display was adjusted for by giving the lower word a *head start* on the upper word, so that the two words subjectively appeared si-

Table 2
Means (and Standard Deviations) of the Properties of Sentences and Critical or Control Words

Condition	P1[a]		P2[a]		Lag[b]		Sentence Length (Words)		Plausibility Rating[c] With: Target		Distractor		Neither		Word Frequency[d,e]		Word Length[e]	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Repeated target (*sale*)	4.70	1.00	7.38	1.06	1.68	0.62	9.82	1.14	4.27	0.51	1.76	0.43	2.70	0.57	49.2	36.9	4.25	0.70
No repeat (*coat*)	4.68	0.97	7.37	1.04	1.68	0.62	9.80	1.13	4.08	0.49	1.73	0.42	2.54	0.66	50.9	41.3	4.70	1.06
Repeated distractor (*bowl*)	4.67	0.97	7.35	1.07	1.68	0.62	9.85	1.16	4.52	0.39	1.60	0.43	1.98	0.55	49.1	38.7	4.33	0.66

[a]Position in sentence, in number of words, of (1) the first critical word C1 and (2) the double-word display C2. [b]Number of intervening words between C1 and C2. [c]Mean ratings on a scale from 1 (*nonsensical*) to 5 (*perfectly sensible*) of sentences completed with the target word, with the distractor, or with neither word at C2. [d]Frequency in occurrences per million words according to the CELEX database (Baayen, Piepenbrock, & Gulikers, 1995). [e]For the repeated target condition, these refer to the repeated target; for the no-repeat condition, to C1 (the target being the same word as that in the repeated target condition); and for the repeated distractor condition, to the nonrepeated target (i.e., the word that was the distractor in the repeated target condition).

multaneously. In addition, forward and backward masks were included because, unlike the other words in each sentence, the double words were not completely masked by preceding or following items. The double words and their masks appeared immediately one above the other with no overlap, each equally displaced from the center of the screen. The double-word display began with a mask of ampersands as placeholders for both words. The lower word replaced its mask after 33 msec, whereas the upper word's mask persisted for a further 33 msec. Each word was displayed for 117 msec and then replaced by its mask for either 66 msec (lower word) or 33 msec (upper word). Immediately following presentation of the final word of the sentence, it was replaced by the instruction "Please recall the sentence," which remained visible until the participant initiated the next trial by pressing a key; presentation of the next sentence began after 1 sec. The experimenter recorded responses by annotating a score sheet containing the correct sentences.

Results and Discussion

Data were cleaned to remove sentences in which fewer than 50% of the noncritical words were recalled. These constituted 5.9% of the total, and in these instances, usually no more than two words of the sentence were reported. Two participants' data were excluded, due to very low overall report. Because this resulted in unequal participant numbers in the various stimulus rotation categories, group membership was included as a factor in the analysis. A planned analysis compared each condition—no repeat, repeated target, and repeated distractor—pairwise on each response variable separately. To provide a background against which to evaluate performance for critical items, an initial set of analyses assessed several *control measures* computed from noncritical items to determine the overall accuracy of sentence recall and investigate the effects of priming and target selection. Analyses were then conducted on responses to the critical double-word display. To simplify presentation, the summarized results for critical and noncritical words in Table 3 are averaged over the position of the target word in the double-word display, because this variable did not modulate any of the critical effects. Significant main effects and interactions of target position are, however, reported in the text, and Appendix B presents the data broken down by target word location.

Noncritical Words

Overall, sentence recall was quite accurate, averaging 84.9% for noncritical words, and did not vary reliably between conditions (all Fs < 1). Report accuracy for C1 showed a small but significant report advantage for C1 words that were subsequently repeated [repeated target, $F(1,33) = 25.35$; repeated distractor, $F(1,33) = 19.68$], as compared with the matched unrepeated words from the no-repeat condition.

Recall of words following the double-word display was also analyzed to provide evidence about the processes involved in selecting between the critical words. Analysis was restricted to the first content word (i.e., excluding function words, such as articles, conjunctions, and prepositions, which are easily guessed or recreated to fit the context) following the double display. On average, 66.5% of these words were reported correctly. Performance was better in the re-

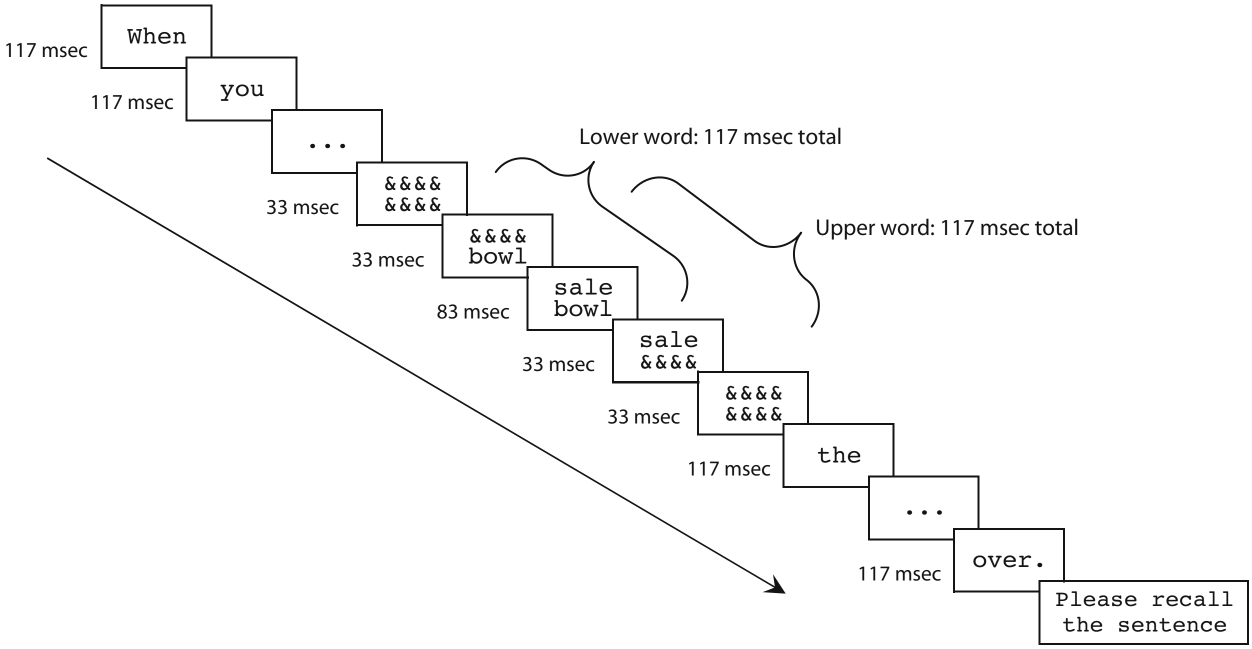

Figure 1. Schematic of a stimulus presentation sequence.

peated distractor condition than in the no-repeat [$F(1,33) = 41.37$] and repeated target [$F(1,338) = 23.71$] conditions.

The simplest explanation for these results is that a repeated word was functionally invisible to the parser, making selection a trivial task in the repeated distractor condition. By contrast, in the two other conditions, processing the double-word display appears to have yielded a form of attentional blink (Raymond et al., 1992), reflected in poorer processing of words following the double-word display.[1] This suggests that the repeated target and no-repeat conditions required more extensive processing of the double-word display than did the repeated distractor condition, due to continuing efforts to select between two activated types and/or to retain unstructured items in memory when no coherent structure could be formed.

Responses to Double-Word Slot

Following the method established by Bavelier, Prasada, and Segui (1994), responses to the double-word display were analyzed only for trials on which C1 was correctly reported. The retained responses were divided into several mutually exclusive categories, including only the target reported (41.9%), only the distractor reported (11.8%), complete absence of any response to the double-word display (7.2%), and various types of substitution. For 8.8% of the responses, the utterance was uninterpretable or bore

Table 3
Rates of Report for Noncritical Word Measures and Percentages of Each Type of Response to the Double-Word Display in Each Condition in Experiment 1

Type of Response	Repeated Target	No Repeat	Repeated Distractor
Noncritical Words			
Noncritical words reported (% of words)	85.3	84.7	84.7
C1 reported (% of sentences)	95.9	89.5	94.5
Post-C2 word reported (% of sentences)	66.5	61.2	77.6
Responses to Double-Word Slot (%)			
Target	17.8	44.6	64.9
Distractor	21.7	10.4	2.5
Neither	10.5	5.1	5.8
Target related	1.1	1.4	2.7
Distractor related	2.0	0.9	0.3
"Something"	15.6	8.4	8.3
Pronoun	5.2	3.1	2.1
Random/distorted	9.2	10.6	6.3
Other/combined	17.0	15.3	7.1

Note—Responses to the double-word slot are included only for sentences in which C1 was reported correctly.

no correspondence to the presented sentence; these *random* or *distorted* responses were not analyzed. A further 13.6% of the responses did not fall clearly into any of the categories, being either other variations or combinations of multiple response types (including the 1.1% of trials on which both of the words were reported). The frequencies of each possible error type within this subset were too low to enable meaningful analysis.

Target word report. Report of the correct target word from the double-word display varied considerably across conditions. The relatively low successful target report rate in the no-repeat baseline condition, as compared with the other words in the sentence, suggests that the selection requirements alone impaired performance. The target was recalled substantially less frequently in the repeated target condition than in the no-repeat condition [$F(1,33) = 77.18$], demonstrating the robust recall deficit that defines RB. By contrast, the repeated distractor condition showed a significantly enhanced report of targets, relative to the no-repeat baseline [$F(1,33) = 116.09$]. The overall advantage in target report rate for targets that occurred in the upper position (55.8% vs. 28.0% in lower position) was smaller in the repeated target condition than in either the no-repeat [$F(1,33) = 32.67$] or the repeated distractor [$F(1,33) = 14.08$] condition. Thus, the perceptual advantage for upper position words did not compensate for the factors giving rise to the RB effect. Indeed, the absolute RB effect was larger for upper than for lower position targets (20% vs. 12.8%; see Appendix B).

These results show that it was harder to select a repeated than an unrepeated target item in the double-word selection task but that it was correspondingly easier to select the correct critical word when the distractor word was a repeat. The symmetrical, opposing effect of repetition according to whether the repeated item is a target or a distractor is precisely what would be expected if lexical activation of repeated items was reduced, so that they were less available to the higher level processes responsible for sentence report.

Errors. Intrusions of distractor words showed a pattern opposite to that for target report: Distractors were reported significantly more frequently in the repeated target condition than in the no-repeat baseline condition [$F(1,33) = 38.79$] and significantly less frequently again in the repeated distractor condition [$F(1,33) = 46.17$]. Targets were recalled more frequently than distractors overall [$F(1,33) = 258.86$], especially for repeated distractor, as compared with no-repeat, sentences [$F(1,33) = 160.58$]. However, a crossover interaction revealed that the opposite occurred in the repeated target condition [$F(1,33) = 83.58$], where the distractor item was reported more frequently than the correct target word. Distractor intrusions were more frequent when the distractor was in the upper position, and the effect of position was greater in the repeated target [$F(1,33) = 19.69$] and no-repeat [$F(1,33) = 23.48$] conditions than in the repeated distractor condition.

The low intrusion rates for incongruent distractor words provide further evidence for a lexical, rather than a reconstructive, locus of the repetition effects. The low distractor intrusion rate in the baseline condition is consistent with Potter et al.'s (1998) finding that there was little or no recollection of the rejected alternative word once disambiguating context had appeared and the semantically appropriate word had been selected. Even though the distractor was equally inappropriate to the context in all the conditions, distractor intrusion rates were twice as high in the repeated target condition as in the no-repeat baseline condition; indeed, the incongruous distractor was reported more often than the congruous target in the repeated target condition. Distractor intrusions were, however, very rare in the repeated distractor condition—considerably less common than when the distractor was not a repeat. These outcomes are entirely consistent with a model that views RB as a failure to reactivate the target's lexical type: If a repeated item is not activated or identified, it is not available to be selected for the double-word slot. In the repeated target condition, the alternative distractor word is more likely to be retained, despite its incoherence, because no other word is available to be bound to that position in the sentence.

On 7.2% of the trials, both words were omitted and no substitutions made. This occurred more frequently in the repeated target condition than in either the no-repeat baseline [$F(1,33) = 17.66$] or the repeated distractor [$F(1,33) = 7.84$] condition. In the repeated distractor condition, omissions were more frequent when the target was in lower position, whereas in the no-repeat condition, there was no difference [$F(1,33) = 9.13$], and in the repeated target condition, the double-word display was omitted most often when the target was the upper word [$F(1,33) = 15.90$].

In what has been described as the "something" experience (Harris & Morris, 2001), participants occasionally feel sure that a word had been presented in a particular slot but are unable to recall its identity, leading them to report, for instance, "When you notice a sale something is over." "Something" rates averaged 10.2% of responses and, like complete omissions, were significantly more frequent in the repeated target condition than in either the no-repeat [$F(1,33) = 11.69$] or the repeated distractor [$F(1,33) = 7.07$] condition. Like omissions, "something" errors were far more frequent when the target was the lower word [$F(1,33) = 32.03$], but the effect was larger for repeated distractor sentences than for repeated target sentences [$F(1,33) = 12.83$].

Pronoun substitutions showed the same general pattern as "something" responses, although they were less common overall (3.6%) and comparisons, therefore, had less power. The only significant result was more frequent pronoun substitutions for targets in repeated target than in repeated distractor sentences [$F(1,33) = 7.51$].

Substitutions that were related (orthographically, semantically, or morphologically) to one or the other of the double words were infrequent, amounting to only 2.8% of the trials, so they could not be reliably analyzed. However, such related-word substitutions showed the same general pattern as that for the report rates for the targets and distractors to which they were related: slightly more distractor-related than target-related substitutions for no-repeat, a lot more for repeated target, and the opposite for repeated distractor sentences.

In summary, the results replicate previous investigations of the effects of stimulus repetition on sentence recall in showing robust RB for the repeated target from the double-word display. The low report rate was primarily due to increased intrusions of the incongruent distractor word, "something" errors, and omissions. The novel findings of the experiment were provided by the repeated distractor condition in which the repeated word had to be rejected, rather than selected, for report. Correct report of the congruous target word was enhanced in this condition, as compared with the no-repeat baseline, even though context provided equally strong support for the target, rather than the distractor, in both conditions. This outcome is clearly predicted by a model that locates RB at the stage of lexical activation: If the type node for the repeated word is not activated and "passed" to the system responsible for the construction of tokens, it will not act as a competitor in the ambiguity resolution process; indeed, no ambiguity arises. The reduced error rates for the next content word after the double-word display and the low intrusion rates for incongruent distractor words in the repeated distractor condition offer further support for this interpretation.

The results do provide some evidence for the attributional processes implicated by constructionist theories. Whittlesea et al. (1995) observed that participants strive for grammatical consistency when reporting sentences. They reported a tendency for the missing second occurrence of a repeated noun to be replaced with an appropriate pronoun (e.g., converting *We saw the picture although the was moved* to *We saw the picture although it was moved*). Pronoun replacements did occur in the present experiment and were more common in repeated target sentences, but the rates were low, as compared with distractor intrusions, omissions, and "something" errors. Intrusion of words related to the target or distractor were even less frequent. There is, therefore, no evidence that semantically or syntactically reconstructive errors played a major role in the RB effect observed in the repeated target condition or in the differences between the repeated target and the repeated distractor conditions.

A second constructionist explanation of RB effects argues that both occurrences of the repeated word are attributed to its initial appearance as C1 (e.g., Masson, 2004; Whittlesea et al., 1995). In the present context, this account would attribute the reduced intrusions from repeated distractors to the fact that they can be identified with the word's earlier occurrence in the sentence and, therefore, compete less for report with the correct target. Consistent with this view, report of C1 was enhanced by its subsequent repetition, but this effect was equivalent for repeated target and repeated distractor sentences and was very small, suggesting that it is unlikely to provide an explanation of why these conditions differed so dramatically in both target report and distractor intrusions. However, with C1 report already approaching ceiling levels, any additional support offered by a misattribution may be redundant.

EXPERIMENT 2

Although the results of Experiment 1 provided no direct evidence that the repetition effects were due to memory biases, Experiment 2 was designed to more directly assess the influence of memory demands and reconstructive biases to the observed repetition effects by asking participants to report only one word, rather than the whole sentence.

The participants were presented with the same sentences as those in Experiment 1 in the same format. The only change was in the reporting requirements: Rather than recalling the entire sentence, the participants were asked simply to report the word from the double-word display that fitted the sentence context. Memory load has been argued to be an important determinant of RB (Armstrong & Mewhort, 1995; Fagot & Pashler, 1995). Minimizing the memory retrieval requirements allows us to tap into the *front-end* processes required by the RSVP task. This procedure has the added benefit of reducing the likelihood of positional biases in sentence reconstruction, such as the occasional pronoun replacements in Experiment 1 and the tendency to misattribute evidence for the target to C1, because participants do not have to include the C1 word in their reconstruction of the sentence. Eliminating the full-report requirement also removes many of the problems involved in directly comparing repeated and unrepeated items elaborated by Whittlesea and colleagues (e.g., Whittlesea et al., 1995). Participants know that they are supposed to report one of the items from the double-word display, reducing ambiguities associated with "detect[ing] repetition under uncertainty about what may repeat" (Whittlesea & Hughes, 2005, p. 106) and equating the selection demands for repeated and unrepeated items.

Method

Participants

Twenty-four first-year psychology students from the University of Sydney volunteered their participation in exchange for course credit. None had taken part in Experiment 1. There were 18 females and 6 males, averaging 18.9 years old. All had normal or corrected-to-normal vision and English as their dominant language.

Stimuli and Design

The stimuli and design were identical to those in Experiment 1. Only the instructions given to the participants differed. Following each sentence, rather than the instruction "Please report the sentence," the screen displayed the instruction "Please report the word that fits."

Procedure

As in Experiment 1, it was explained that sentences would be presented word by word on the screen, with the exception that at one point during the sentence, two words would appear simultaneously but only one of them would belong to the sentence; the other would be a distractor. The participants' task was to select the word that fitted the sentence and report it out loud after each sentence had been presented. They were encouraged to guess if they were not sure and to say "don't know" only if they felt unable to even guess. All other aspects of the procedure, including practice trials, were identical to those in Experiment 1.

Results and Discussion

No participants performed poorly enough to warrant exclusion. Since only one word from each sentence was to be reported, the results could not be conditionalized on successful report of C1. However, only 4% of the trials were excluded from Experiment 1 on this basis, despite its much greater memory demands. Responses were classified into the same mutually exclusive categories as in Experiment 1. Rates of each type of response are given in Table 4, averaged over target word position, and Figure 2 compares the effects of repetition on target and distractor words in Experiments 1 and 2. Appendix B presents more detailed data for each target word location. A planned analysis on report rates of targets and various error types compared sentences with repeated targets and sentences with repeated distractors against each other and pairwise against the no-repeat baseline.

Table 4
Rates (%) of Each Type of Response in Each Condition in Experiment 2

Type of Response	Repeated Target	No Repeat	Repeated Distractor
Target	36.5	53.1	64.4
Distractor	27.3	20.4	16.0
Neither	24.2	19.0	11.5
Target related	0.9	0.7	1.9
Distractor related	1.3	0.4	0.4
Transposed	5.8	3.8	2.9
Other/combined	3.1	1.9	1.0

Target Word Report

Correct report of the target word was the most frequent response (51% of the trials) and was slightly higher than in Experiment 1, suggesting that the attempt to reduce memory load was at least partly successful. As compared with the no-repeat baseline, targets were reported less frequently for the repeated target sentences [$F(1,23) = 16.40$] and more frequently for the repeated distractor sentences [$F(1,23) = 23.38$]. A strong bias toward reporting the word presented in the upper position (65.8%), as compared with that in the lower position (37.0%) [$F(1,23) = 31.30$], suggested that the participants either were unable to always read both of the words within the available time or did not always attempt to understand the entire sentence and select for meaning, as requested, and, instead, focused on extracting and recalling at least the more salient word from the double-word display. However, this bias did not interact with the variables of most interest, which were the presence and nature of repeated words (largest $F = 3.30$, $p = .082$).

Errors

The distractor was reported on 21% of the trials and showed a pattern opposite to that for the targets: It was reported more often for repeated target than for repeated distractor sentences [$F(1,23) = 7.66$]. There were also fewer reports of the distractor in the repeated distractor condition, as compared with the no-repeat baseline condition [$F(1,23) = 5.37$]. Again, distractors presented in the upper position of the display were reported more commonly than those in the lower position [$F(1,23) = 19.56$], but there were no significant interactions with condition (largest $F = 2.96$, $p = .099$).

On 18% of the trials, the participants were unable to report any word as fitting the sentence. The pattern of *don't know* responses was almost identical to that for distractors, with a greater incidence for repeated targets [$F(1,23) = 7.78$], a smaller incidence for repeated distractors [$F(1,23) = 7.79$], and more frequent omissions when the target was in the lower position [$F(1,23) = 18.50$], but no interactions between factors (all $ps > .275$).

Other possible responses included words related to the target word (2.4%), related to the distractor word (0.7%), or transposed from elsewhere in the sentence (4.0%). These frequencies were too small to enable reliable statistical analysis. A further 1.9% of the responses did not fall clearly into any single category and were also excluded from analysis.

These outcomes completely parallel those obtained in Experiment 1, in that successful report of the target word was enhanced by a repeated distractor and impaired when the target was a repeat, as compared with a baseline with no repeated words. Distractors were reported most frequently when accompanied by a repeated target and least frequently when the distractor itself was a repeat. Although this pattern of results duplicates that obtained in Experiment 1, some small differences are worth noting. As is summarized in Figure 2, the three repeat conditions do not differ from each other as sharply as in the full-report condition, even though the baseline accuracy was similar. Distractor report rates were increased overall in the single-word report task and differed less across repetition conditions, suggesting that, in the absence of the requirement to report the whole sentence, the participants paid less attention to the sentence context and were, therefore, less effective in selecting the target from the double-word display. Despite this reduced sensitivity to context, the pattern of repetition effects was identical to that observed in Experiment 1, and the baseline accuracy level demonstrates that sentence context was still used effectively on the majority of trials. The larger repeti-

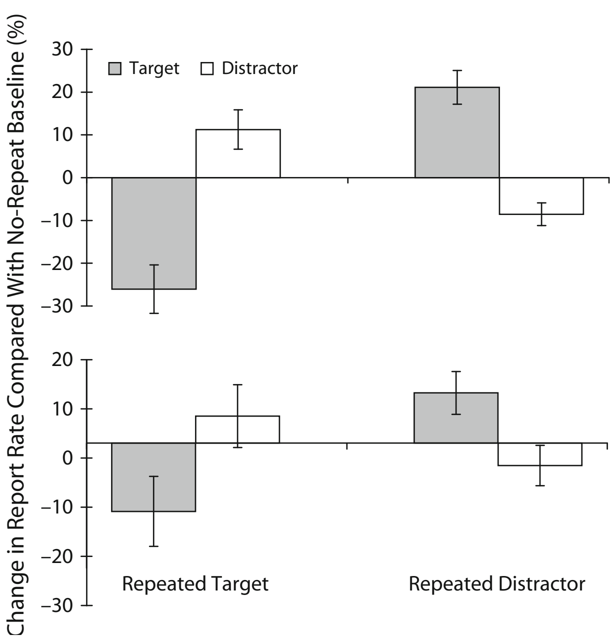

Figure 2. Repetition effects in Experiments 1 (upper panel) and 2 (lower panel). Error bars indicate 95% confidence intervals.

tion effects observed in Experiment 1 therefore seem most likely to reflect deeper processing of the sentence context, rather than report biases of the sort that Experiment 2 was designed to reduce.

The reduction in RB for the repeated target condition in Experiment 2, as compared with Experiment 1, is consistent with Masson's (2004) finding of reduced RB for sentences in a final-word report, as compared with a full-report task. However, like Masson, we did not find the facilitatory effect of repetition that both he and Kanwisher (1987) obtained in a final-word report task for word lists. Moreover, unlike Masson's sentence fragments (e.g., *The red car and blue car*), our full sentences still showed robust RB in the repeated target conditions, even though the participants had to report only a single word.

EXPERIMENT 3

The results of the experiments described so far are most parsimoniously accommodated by a model in which "blindness" to repeated items occurs early in processing—at the stage of lexical activation—and prior to the stage at which sentence context exerts an influence on selection. According to this lexical account, RB occurs because repeated words do not achieve sufficient reactivation to achieve their recognition threshold.

This is consistent with the modular–interactive framework for word recognition (Potter, Moryadas, Abrams, & Noel, 1993), which assumes that the initial stage of word recognition is purely stimulus driven. This stage is the locus for lexical RB: Repeated words that do not achieve their recognition threshold would fail to be included among the output of candidate words. During the second stage, the weighted candidates determined by bottom-up processes are evaluated with respect to the sentence context. It is at this stage that mismatching words may be rejected, although they may sometimes be retained in the absence of visually similar but more contextually appropriate competitors. According to additive factors logic (Sternberg, 1969), if repetition and congruency exert their influence at different stages, they should produce additive effects—that is, RB should be equivalent for congruous and incongruous sentences. Indirect support for this prediction was provided by the symmetry of the effects in Experiments 1 and 2 for repeated target and repeated distractor conditions, relative to the baseline. Experiment 3 was designed to provide a more direct test of this prediction by manipulating congruence and repetition orthogonally. An interaction between the two factors would be difficult to accommodate under the lexical account and would, instead, support the construction account, which assumes a simultaneous locus for congruity and repetition.

The design was a modification of Experiment 1 that simplified the task for the participants by removing the need to select for the appropriate word and brought the requirements into accordance with typical RSVP sentence-reading tasks. Extracting the target from the double-word display is clearly quite a challenging task. Even when there was no repetition, selection and report of the correct target word was successful on only about half of trials, even in Experiment 2, in which only a single word was reported. The words following the double display failed to be recalled on at least one third of the trials in Experiment 1, indicating ongoing processing demands from attempts to select the target. The bias toward reporting the upper word also suggests that, independently of any issues relating to repetition, the participants were not always able to take in both of the words. This experiment removed the selection requirement by retaining only one of the two words from the double display and presenting all the words centrally in a standard RSVP format. The retained word could be either a target or a distractor and either a repeat or a nonrepeat of C1, producing the independent factors of sentence congruity and critical word repetition.

Method

Participants

The participants were 30 first-year psychology students from the University of Sydney who had not taken part in Experiment 1 or 2. They received course credit for their participation. There were 18 females and 12 males, averaging 18.9 years old. All had normal or corrected-to-normal vision and English as their dominant language.

Stimuli and Design

The stimuli and design were identical to those in Experiments 1 and 2, except that the sentences no longer contained the double-word display. Instead, they were presented in normal RSVP format throughout, with every word appearing centrally for 117 msec. The double-word display was replaced either by the word that had been the target or by the word that had been the distractor. Half of the resulting sentences (those that retained the target word) made sense and will be referred to as *congruous*, whereas the other half (those that retained the distractor word) did not make sense and will be referred to as *incongruous*. Sentences derived from the no-repeat and repeated distractor conditions were equivalent when the target was retained, both being congruous sentences without a repeat, and were therefore collapsed into a single *nonrepeat congruous* condition. Similarly, when the distractor was retained, sentences derived from both the no-repeat and the repeated target conditions became incongruous sentences without a repeat and were collapsed into a single *nonrepeat incongruous* condition. In this way, the repetition and sentence congruity factors were independent, but only one third of the sentences involved a repetition.

Each participant saw a total of 60 experimental sentences, with the sentences rotated through conditions across participants. Practice items from Experiment 1 were converted in a similar way, so that half the sentences were congruous and half incongruous.

Procedure

The participants were asked to report each sentence out loud after it had been presented and were advised that they should attempt to report exactly what they saw even if not all the sentences made sense. All other aspects of the procedure, including practice trials, were identical to those in Experiment 1.

Results and Discussion

The data were cleaned in the same way as for Experiment 1, to remove sentences in which fewer than 50% of the noncritical words were recalled. These constituted 3.9% of the total. Three participants' data were excluded due to very poor overall report, leading to unequal participant numbers across categories, so group membership was included as a factor in the planned analysis. The same noncritical measures were computed and analyzed as in Experiment 1, and the results are summarized in Table 5.

Table 5
Noncritical Word Measures From Sentences in Experiment 3 and Rates of Each Type of Response to the Critical Word in Each Sentence

Type of Response	Congruous Repeat	Congruous Nonrepeat	Incongruous Repeat	Incongruous Nonrepeat
Noncritical Words				
Noncritical words (% of words)	89.6	89.9	85.0	84.8
C1 reported (% of sentences)	97.6	96.6	94.7	95.4
Post-C2 word reported (% of sentences)	89.9	83.3	86.7	73.0
Responses to Critical Word Slot (%)				
Reported correctly	57.2	86.8	42.8	66.8
Omitted	23.8	4.8	21.1	13.0
Related word substituted	0.3	2.0	2.7	5.9
"Something" substituted	2.8	2.1	8.5	6.1
Pronoun substituted	9.6	0.7	10.0	2.2
Other	6.2	3.5	14.9	6.0

Note—Responses to the critical word slot are included only for sentences in which C1 was reported correctly, and their classifications are mutually exclusive (columns sum to 100%).

Noncritical Words

Overall, recall was 5% greater in congruous than in incongruous sentences [$F(1,21) = 49.58$], but there were no effects of repetition (all Fs < 1). Report of C1 was close to ceiling, with a trend toward improved accuracy for repeats [$F(1,21) = 3.136$, $p = .091$] but no congruity effects (all Fs < 1). Congruity improved report of the word following the critical word [$F(1,21) = 31.55$], which was also more accurately recalled for sentences with repeated words than for those with nonrepeated critical words [$F(1,21) = 20.66$]. The effect of repetition was reliable for incongruous sentences [$F(1,21) = 15.73$], but not for congruous sentences [$F(1,21) = 1.69$], although their interaction did not reach significance [$F(1,21) = 3.068$, $p = .094$].

Responses to Critical Word Slot

As in Experiment 1, the analysis of responses to the critical word (C2) excluded the 4% of trials on which C1 was not correctly reported. The retained responses were divided into the same mutually exclusive categories as in Experiment 1, apart from 6.3% of utterances considered *random* or *distorted* and a further 0.4% that were either other variations or combinations of multiple response types. Rates of each type of response are given in Table 5.

Critical word report. The critical word was reported 20% more frequently when it was meaningful in the sentence context [$F(1,21) = 54.50$]. An RB effect of 29.6% emerged for congruous sentences [$F(1,21) = 30.84$]. The effect for incongruous sentences was also substantial at 24.0% [$F(1,21) = 21.97$]. Repetition and congruity did not interact [$F(1,21) = 1.55$, $p = .227$]. The absence of a reliable interaction[2] between the individually substantial RB and congruity effects is a key finding, indicating that they appear to be independent, additive effects, potentially arising at different stages of processing. Rates of RB were very similar in Experiments 1 and 3. The additional contextual information provided by the double-word display in Experiment 1 therefore did not contribute to evidence for perceiving and recalling two distinct occurrences of the repeated word, contrary to the constructionist argument that contextual distinctiveness can reduce the chance of the misattributions that induce RB (Whittlesea & Wai, 1997).

Errors. Complete omission of the critical words occurred on 13.4% of the trials, more commonly when the critical word was a repeat, both for congruous sentences [$F(1,21) = 26.78$] and for incongruous sentences [$F(1,21) = 6.56$]. The effect was larger for congruous than for incongruous sentences [$F(1,21) = 14.10$]. Pure omissions were the most frequent errors in this experiment, whereas they amounted to only 7.2% of the responses in Experiment 1, in which substitutions of various sorts were more common. This reflects the visual salience of the double-word display. When the double-word displays are included, the task instructions draw attention to them and the need to extract one or the other word from the display. In Experiment 3, there was nothing distinctive or salient about the critical word slot, either visually or in terms of the instructions given to the participant. The lack of distinctive context is also reflected in comparatively low "something" rates in Experiment 3, as compared with Experiment 1. At 4.6%, this was the next largest category of responses and was more common for incongruous than for congruous sentences [$F(1,21) = 16.48$] but did not vary reliably with repetition status [$F(1,21) = 1.393$], nor was there an interaction ($F < 1$). Pronoun substitutions, although constituting almost the same proportion of overall responses (4.2%), were equally frequent for congruous and incongruous sentences but were more common in both cases for repeated than for nonrepeated critical words [$F(1,21) = 16.82$ and 13.67, respectively; interaction, $F < 1$]. Substitutions of words related to the critical word were significantly less frequent for congruous (1.2%) than for incongruous (4.3%) sentences [$F(1,21) = 19.54$] and were less frequent for repeated (1.5%) than for nonrepeated (4.0%) targets [$F(1,21) = 7.79$], but there was no hint of an interaction ($F < 1$).

The error analysis, on the whole, corroborates the independence of the repetition and congruence factors. Although several of the error types varied with repetition, with congruity, or with both, the two effects interacted only for omission scores. In this case, though, it is worth noting that the baseline (no-repeat) omission rates may be biased, because congruous sentences become less plausible if the critical word is omitted, whereas incongruous sentences become more plausible (see Table 2). The frequency of omissions of a critical repeated word was numerically almost identical (23.8% vs. 21.1%), regardless of sentence congruity.

GENERAL DISCUSSION

Overall, the present results suggest that the repetition effects observed for our RSVP sentences have an early, lexical locus. They are entirely consistent with the view that, when presented rapidly, repeated words fail to achieve threshold lexical activation and, thus, never even enter into the processes required for consolidation and subsequent regeneration.

In Experiment 1, repetition not only impaired target selection, but also facilitated distractor rejection, implying that it exerts its influence prior to the selection process—that is, on perceptual or lexical processing of the items from the double-word display. This conclusion was confirmed by the difference in distractor intrusion rates across the three conditions and by the reduced attentional blink when the repeated word was a distractor, whose loss from the sentence would be expected to facilitate processing. The constructionist account does not provide an obvious account of this pattern of findings.

Experiment 2 replicated the key results of the first experiment with a task that vastly reduced the demands placed on memory and on sentence regeneration processes. The results confirmed that reconstructive biases in sentence recall are not responsible for the differential effects of repetition of targets and distractors, implying that the obtained effects of repetition arose during perception and/or encoding. Finally, the third experiment directly tested the relationship between repetition and sentence congruity and showed them to have independent, additive effects on critical word report. Taken together, the data are completely compatible with an account that assumes that repeated words in RSVP displays are not activated to threshold during early lexical processing and are, therefore, less available to the selection process imposed by the double-word selection task.

The results of Experiments 1 and 2 converge with those in Potter et al.'s (1998) original double-word study in suggesting that sentences are parsed and words integrated on the fly. That study also manipulated the position of the biasing context—before or after the double-word display—and showed that both words are initially processed in parallel. As soon as it becomes available, context is used to rapidly select for the appropriate word, with concomitant rejection and forgetting of the inappropriate item.

Potter (1993, 1999) attributed the processes involved in early access to semantic and syntactic information to a conceptual STM (CSTM) system that yields rapid but transient activation of relevant conceptual information, which persists just long enough for new scenes and sentences to be comprehended or for targets to be selected for attention, depending on the goal. In the case of reading, where the skills for extracting structure are highly practiced, CSTM draws on linguistic knowledge retrieved from long-term memory (such as word meanings and syntactic structure) to generate a structured conceptual representation of the sentence. After individual words have been identified, concurrently active items are linked into a more stable propositional structure, which may then be consolidated further in longer term memory. However, any information that is not or cannot be incorporated into a structure is rapidly forgotten, often before it enters awareness. The present results help to refine this account of the processing sequence that leads to RB.

When the congruent target word occurred in the perceptually optimal upper position in Experiment 1, it was recalled 62% of the time when it was not repeated, but only 25% of the time when it was. Conversely, distractor words hardly ever intruded when they were repeats, even when they occurred in the upper position, but they were reported more often than the correct congruent word when that target word was a repeat. Similar results were obtained in Experiment 2. The fact that "blindness" to repeated words can override the powerful semantic constraints of the sentence suggests that the repeated word was often not even a candidate in the semantically driven competition for the double-word slot. This interpretation supports Potter's (1999) proposal that failure to create a token for a stimulus prevents it from entering into CSTM. She argued that the structure-building process operates on tokens, not merely on activated types: "Failure to create a token for the second occurrence of a word prevents it from entering into the structuring process, . . . [making] it invisible to the parser" (Potter, 1999, pp. 23–24). Her conclusion was based largely on the observation that RB arises even when loss of the repeated word renders the recalled sentence nonsensical or agrammatical. The present study provides more direct evidence that repeated words are not available to structure-building processes. Repeated distractors seem to effectively disappear so early that they do not even enter CSTM, and they therefore make it easier to select the target. Conversely, the failure to perceive a repeated target allows the simultaneously presented distractor word to remain active, increasing its chance of being included in report. The higher rate of "something," pronoun, and other substitution errors in the repeated target condition in Experiment 1 illustrates what happens when such integration is not possible because no candidates fit the sentence context.

This is not to say that sentence report is not also influenced by constructive and attributional processes that are modulated by stimulus properties and task demands. Clear evidence of the influence of such factors is provided by discrepancies between the present results for incongruent sentences and those reported by Whittlesea and Wai (1997). In Experiment 3, on two thirds of the trials, the participants successfully reported an anomalous word that did not fit the rest of the sentence. By contrast, Whittlesea and Wai found that anomalous words embedded in sentences were correctly reported on only 28% (Experiment 2) to 51% (Experiment 1) of trials. A key difference is that their anomalous words were additions to the sentence (e.g., *He poured some blue ink TAX into a JAR yesterday*), so that their omission produced a coherent sentence. When the anomalous word was a repetition (e.g., *He poured some blue ink JAR into a JAR yesterday*), participants usually omitted the first, anomalous occurrence, an outcome argued to be incompatible with the type–token account, which predicts impairment only for the second occurrence. In our sentences, the anomalous word replaced the congruent word, and its omission left an empty slot in the sentence. In the absence of any competitor for this slot, the incongruent word was often recalled. Experiment 1 shows that when there is a more appropriate candidate for that slot of the sentence, other things being equal, the incongruent word is reported much less frequently: only on around 11% of the trials.

Thus, the structure of the sentences and the availability of alternative responses clearly influences sentence report, as is predicted by the constructionist account. Abrams, Dyer, and MacKay (1996) have also demonstrated that RB is sensitive to the syntactic structure of sentences when words are presented in groups. However, this sensitivity to stimulus and task context is also compatible with Potter's (1999) elaboration of how CSTM influences the processes involved in converting activated types into structured tokens. Individuation is seen not as an all-or-none process, but as a graded, dynamic one that operates at multiple levels: visual, orthographic, phonological, and so forth. As Bavelier (1999) explained it, individuation may fail at any one of these levels, but the task must prioritize the use of information at that level for RB to occur. An important feature of the CSTM hypothesis is that it provides an account of how type and token activation interact in task-specific ways (Potter, 1999) that can potentially account for some of the task variation emphasized by the constructionist approach.

Indeed, it is difficult to distinguish between the two views. Whittlesea and Wai (1997) "conclude that report of rapid sentence should be thought of as a reconstructive activity, a process of deciding what words occurred and where they occurred, rather than detection and report of traces" (p. 177). This account bears a remarkable similarity to Potter and Lombardi's (1990) description of the function of CSTM in sentence recall: "Memory is (nearly) verbatim . . . because the regenerative process of recall makes use of recently activated but unordered entries in the lexicon to express the ideas in the sentence, using the normal mechanisms of sentence production" (p. 650). At this level, the accounts are almost indistinguishable. Both *reconstruction* as proposed by Whittlesea and colleagues and *regeneration* following processing in CSTM predict that a word in the wrong place in an RSVP sentence may be rationalized to a more coherent position or even omitted altogether. The critical difference between the two views is that the constructionist account eschews the need to assume the abstract lexical representations on which Potter and Lombardi's regeneration process operates and, consequently, must assume that repeated and nonrepeated words are encoded in the same way (Whittlesea & Podrouzek, 1995), because there is no abstract lexical representation to "record" the previous occurrence (Whittlesea & Hughes, 2005). The constructionist account therefore locates the loss of a repeated word (from whichever sentence position is least disruptive to meaning) at the same processing stage as construction: As words "come to mind" during perception or for recall, they must be attributed to their having been seen in the sentence. In the elaborated type–token account offered by Potter and Lombardi, RB arises when a repeated word fails to activate its lexical type sufficiently to make it available for use in regeneration.

The present findings—that repeated targets are hard to report, regardless of memory demands or sentence congruity, whereas repeated distractors are easy to ignore—are exactly as predicted by the assumption that repeated words often fail to achieve lexical threshold on their second encounter. Although it is difficult to falsify the constructionist account, we believe that it has to stretch considerably harder to accommodate the results. Essentially, it must explain why, even though repeated words are encoded in the same way as nonrepeated words, they are simultaneously easier to reject as being incompatible with the sentence context and harder to identify as being compatible with the context when presented in a double-word display but produce additive effects of context in a single-word RSVP task. Although it may be possible to account for this pattern through a combination of task and context-specific attributional processes, it seems more parsimonious to accept that there are abstract lexical representations that are somewhat refractory under rapid presentation conditions.

Conclusions

The novel combination of RB and double-word selection paradigms in these experiments has yielded results that speak to both the reading process and the mechanism of RB. Effective sentence processing is supported by an initially stimulus-driven activation mechanism, followed by rapid, online integration of words into their context. Under RSVP conditions, rapidly repeated words do not effectively reactivate their lexical representations, regardless of their fit with sentential context. These results provide strong support for a theory of RB that locates the phenomenon in early lexical processes.

AUTHOR NOTE

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NOTES

1. For the majority of sentences in all the conditions, the next content word occurred with a lag of one or more intervening function words after the double-word display, the lag at which the attentional blink effect is greatest (Chun, 1997).

2. A null interaction can never provide definitive evidence for additivity. However, the present finding of a nonsignificant interaction occurs in the context of main effects that were both large (in excess of 1.1 *SD* units) and extremely statistically robust ($ps < .0001$). By contrast, the interaction was small (0.26 *SD*) and statistically very weak. Power analyses using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) showed that 118 participants would be needed to obtain power of .8 for the observed size of the interaction effect—a considerably larger sample than those used in published RB research. In other words, even if the effect is a real one, it is quite small and, certainly, too small to be detected in typical RB experiments.

(*Continued on next page*)

APPENDIX A
List of Stimuli

C1 is in italics; the double words (C2) are separated by a slash, with the target in bold. The first sentence of each pair shows the repeated target condition (and no-repeat condition, C1 in parentheses). The second sentence shows the repeated distractor condition.

When my sister drinks *beer* (*milk*) some kinds of **beer/**roof taste awful.
My sister drinks *beer* up on the beer/**roof** of the house.

To keep yourself *cool* (*dry*) bring some **cool/**ice clothes.
To keep yourself *cool* eat an cool/**ice** cream.

It's Jerry's first *loan* (*ring*) so the **loan/**crash is cheap.
Jerry needed a *loan* after the loan/**crash** in stock prices.

Most people are *poor* (*happy*) in **poor/**job suburbs.
If people are *poor* any poor/**job** will do.

Jim knew you *rang* (*applied*) but he **rang/**hated again anyway.
Jim knew you *rang* but he rang/**hated** missing out.

When you notice a *sale* (*coat*) the **sale/**bowl is already over.
At the clearance *sale* the sale/**bowl** is on special.

I try not to *slip* (*crash*) but I usually **slip/**pool up there anyway.
I try not to *slip* but around the slip/**pool** it's always wet.

To show off what I *wear* (*sell*) I **wear/**lips brightly colored clothes.
To show off what I *wear* my wear/**lips** are bright red.

I bumped my *chin* (*jaw*) and my **chin/**sink really hurt.
I bumped my *chin* on the chin/**sink** at work.

Bob likes eating *corn* (*fruit*) but apples and **corn/**mess are expensive.
Bob likes eating *corn* apart from the corn/**mess** it makes.

Sailors relied on *charts* (*maps*) but the **charts/**storms were often wrong.
Sailors relied on *charts* but the charts/**storms** blew them off course.

When it's your turn to *share* (*spend*) you **share/**empty with everybody.
When it's your turn to *share* you share/**empty** your pockets.

If you scare one *sheep* (*animal*) all those **sheep/**track might run.
If you find a *sheep* on this sheep/**track** walk carefully.

The police searched for a *trace* (*bomb*) but no **trace/**tests was found.
The police searched for a *trace* but the trace/**tests** were negative.

I thought I had seen your *worst* (*temper*) but your **worst/**fixed came later.
The window damage was the *worst* but we worst/**fixed** it later.

As he sat on the *chair* (*desk*) Fred's **chair/**visit broke.
As he got up from the *chair* Fred's chair/**visit** ended.

I have to *guess* (*choose*) and my **guess/**laugh had better be right.
I have to *guess* so don't guess/**laugh** at me if I'm wrong.

It looks very *grand* (*formal*) but **grand/**dust parties are boring.
It looks very *grand* but grand/**dust** builds up quickly.

When I bought a new *cat* (*hen*) my **cat/**yard was upset.
When I bought a new *cat* my cat/**yard** was overgrown.

It is hard to *dig* (*locate*) so **dig/**pond the hole carefully.
Because it's hard to *dig* our dig/**pond** will be shallow.

If I paint my *wall* (*floor*) the **wall/**fire might look better.
After I painted my *wall* a wall/**fire** burnt it down.

Once I knew about her *fate* (*kids*) my **fate/**joke was sealed.
Nobody who knows her *fate* would fate/**joke** about it.

APPENDIX A (Continued)

If Beth loves *gold* (*rings*) this **gold/**team is cheap.
If Beth wins *gold* the gold/**team** will celebrate.

Watching his *pain* (*loss*) caused some **pain/**risk she could hardly bear.
To ease his *pain* she would pain/**risk** almost anything.

Wayne hasn't got a *tent* (*cabin*) but Sue's **tent/**lake will do.
Wayne sleeps in a *tent* by the tent/**lake** in summer.

Kim was too *slow* (*busy*) to drive in **slow/**kill traffic.
Kim was too *slow* to hit and slow/**kill** mosquitoes.

If you need to *lift* (*jump*) please **lift/**seek the box carefully.
If you need to *lift* please lift/**seek** some assistance.

None of us *sang* (*cried*) but they **sang/**hired for hours.
None of us *sang* so they sang/**hired** a band.

If you find the right *jack* (*tool*) I will **jack/**teach up the car.
If you find the right *jack* I will jack/**teach** you to use it.

If I let you *pick* (*save*) one I **pick/**meat the next.
If I let you *pick* it the pick/**meat** will be tasty.

Dan can either *catch* (*throw*) from here or **catch/**prove from over there.
Dan needs to *catch* from here to catch/**prove** he's good enough.

I try not to *faint* (*panic*) but I **faint/**drugs quite often.
I try not to *faint* but the faint/**drugs** don't help.

That wall is only *brick* (*thin*) but **brick/**frame is strong.
Unless the wall is *brick* the brick/**frame** is too heavy.

I try hard not to *worry* (*agree*) but still **worry/**safe for hours.
There is no need to *worry* when you're worry/**safe** at home.

Touch a *flame* (*candle*) and the **flame/**saint will burn you.
Light a *flame* for the flame/**saint** in his memory.

Debbie had *youth* (*speed*) but her **youth/**noise was not enough.
Despite Debbie's *youth* all the youth/**noise** was too loud.

When I began to lose my *sight* (*touch*) my **sight/**issue became everything.
It's vital not to lose *sight* of the sight/**issue** in question.

The steak was *tough* (*rare*) and **tough/**proud meat is awful.
The boss is *tough* and tough/**proud** of it.

I need to wear a *hat* (*coat*) and my **hat/**pair must look cute.
I need to wear a *coat* and a hat/**pair** of sturdy shoes.

Julie was very *mad* (*curt*) but staying **mad/**fun is unhealthy.
Julie was very *mad* but having mad/**fun** is healthy.

I've given up *golf* (*sport*) because **golf/**knee is too hard.
Before I played *golf* my golf/**knee** used to hurt.

Jeff wanted *soup* (*ham*) and **soup/**host was on the menu.
Besides his *soup* the soup/**tray** held bread and butter.

If you work hard this *term* (*break*) and next **term/**mark you will do well.
If you work hard this *term* your test term/**mark** will be better.

I like to *buy* (*save*) and I **buy/**wish things often.
I like to *buy* so I buy/**wish** I was richer.

I'll eat fish *raw* (*uncooked*) but **raw/**egg chicken is bad.
If it is *raw* the raw/**egg** might go bad.

At the sight of the *fox* (*lion*) that **fox/**oak ran away.
After a branch fell on a *fox* that fox/**oak** was cut down.

APPENDIX A (Continued)

You can't give a *pen* (*tip*) if the **pen/**deck has no ink.
Please don't write in *pen* on the pen/**deck** of cards.

This group had better *score* (*pray*) and really **score/**solve big.
This group had better *score* to really score/**solve** our problem.

Since I last wore this *skirt* (*dress*) the **skirt/**waist has started fraying.
Since I last wore this *skirt* my skirt/**waist** has grown fatter.

Chris had so much *stuff* (*gear*) his **stuff/**brain was everywhere.
Chris knew so much *stuff* his stuff/**brain** was full.

If we feel *shame* (*guilty*) then **shame/**prize is appropriate.
It is a *shame* the shame/**prize** was stolen.

Lisa loved her *fame* (*role*) but her **fame/**owed was a serious problem.
Lisa loved her *fame* but she fame/**owed** it to her mother.

Since I have a *boat* (*canoe*) this **boat/**hole can be yours.
When I bought the *boat* a boat/**hole** made it leak.

The old room was as *neat* (*shiny*) as a **neat/**damp new pin.
The old room was so *neat* that the neat/**damp** barely showed.

My granny is as *wise* (*sharp*) as a **wise/**dull old owl.
My granny was once *wise* but grew wise/**dull** with age.

It was made of *bone* (*fibre*) since most **bone/**tail is sturdy.
Our dog broke a *bone* in his bone/**tail** last night.

Cleaning the *boot* (*fur*) made my **boot/**pins look better.
Wearing this *boot* gives me boot/**pins** and needles.

I love *cake* (*sweets*) but that **cake/**host is too fattening.
I love *cake* but our cake/**host** only served fruit.

Our foods are *prime* (*special*) and **prime/**rates items cost money.
Our services are *prime* and prime/**rates** are very reasonable.

His face was *grave* (*tragic*) and looking **grave/**fever was appropriate.
The doctor looked *grave* as the grave/**fever** grew worse.

APPENDIX B

Table B1
Results of Experiment 1 by Target Word Location: Rates of Report for Control Measures and Percentages of Each Type of Response to the Double-Word Display in Each Condition

	Repeated Target		No Repeat		Repeated Distractor	
Type of Response	Upper	Lower	Upper	Lower	Upper	Lower
Control Measures						
Prime reported (% of sentences)	95.2	96.5	88.6	90.3	93.3	95.7
Postcritical word reported (% of sentences)	69.5	63.5	67.0	55.3	80.5	74.7
Noncritical words (% of words)	86.3	84.2	85.6	83.7	84.9	84.4
Responses to Double-Word Slot (%)						
Target reported	25.1	9.9	62.8	24.3	79.4	49.9
Distractor reported	13.5	30.8	1.9	19.9	0.3	4.4
Omitted	12.3	8.9	4.6	5.4	2.3	10.0
Target-related word substituted	1.0	1.3	1.0	1.6	1.9	3.5
Distractor-related word substituted	2.2	1.7	0.3	1.6	0.0	0.6
"Something" substituted	14.3	14.9	5.3	10.3	2.6	14.0
Pronoun substituted	5.8	4.8	2.3	4.5	1.4	3.0
Random/distorted	9.8	8.7	7.0	15.1	6.7	5.7
Other/combined	16.0	19.1	15.0	17.2	5.4	8.9

Note—Responses to the double-word slot are included only for sentences in which the prime word was reported correctly, and their classifications are mutually exclusive (columns sum to 100%).

Table B2
Results of Experiment 2 by Target Word Location: Rates (%) of Each Type of Response

	Repeated Target		No Repeat		Repeated Distractor	
Type of Response	Upper	Lower	Upper	Lower	Upper	Lower
Target	47.9	25.0	67.9	37.8	81.5	48.2
Target related	2.5	1.3	2.1	0.8	3.8	3.8
Distractor	20.8	33.8	10.2	31.5	4.2	26.7
Distractor related	0.4	2.1	0.4	0.4	0.4	0.4
Omitted ("don't know")	17.9	30.8	13.7	24.2	7.6	15.8
Transposed	7.5	4.2	3.8	4.0	1.7	3.8
Other	2.9	2.9	2.0	1.2	0.8	1.3

Note—"Upper"/"Lower" refer to the position of the target word in the double-word display. Recall that for the repeated target and no-repeat conditions, the target was *sale*; for the repeated distractor condition, the target was *bowl*.

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