



Identity and similarity in repetition blindness: no cross-over interaction[☆]

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Abstract

The difficulty in reporting both occurrences of a repeated item is a phenomenon referred to as repetition blindness (RB). RB has been proposed to result from temporal limitations in creating separate episodic tokens for a twice-activated type. Recently, Chialant and Caramazza (*Cognition* 63 (1997) 79–119) disputed the conventional view that RB for non-identical words (orthographic RB, as in *lice* and *lick*) results from the same mechanism as identity RB, and proposed that orthographic RB arises from competition for lexical selection. Supporting evidence was that identical and merely similar words showed different amounts of RB as a function of stimulus onset asynchrony (lag). Four experiments failed to replicate Chialant and Caramazza's finding that identity RB decreases, but orthographic RB increases, as a function of lag. Instead, RB for all stimuli, including homonym pairs, declined monotonically with lag. These results are consistent with a common mechanism underlying RB for identical and orthographically similar words and with prior research suggesting that RB in similar words occurs at a sublexical level. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

When two words are rapidly and sequentially displayed at stimulus onset asynchronies of approximately 100–300 ms, detection of the second word (W2) is

[☆] Experiments 2 and 4 replicate experiments presented at the 39th annual meeting of the Psychonomic Society. A report on these earlier experiments can be obtained from the first author.

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impaired if it is a repetition of the first word (W1). This deficit has come to be known as repetition blindness or RB (Kanwisher, 1987). The predominant explanation for RB put forward by Kanwisher (Kanwisher, 1987; Kanwisher & Potter, 1990; Park & Kanwisher, 1994) is a temporal limitation in distinguishing the separate occurrences of a twice-activated visual type. Kanwisher refers to this as “type activation without token individuation”.

RB is not a low-level visual effect (as could happen from retinal superposition or visual fusing) and appears to occur at the level where objects are categorized. Evidence for this is that visual identity is not required to show a repetition deficit. RB is found for words which are merely orthographically similar, such as *most post* (Bavelier, Prasada, & Segui, 1994; Harris & Morris, 2000; Hochhaus & Johnston, 1996). RB also occurs for items that share phonology, as in *nine 9* and *eight 8* (Bavelier & Potter, 1992), and even for words and pictures that share name identity, as in a picture of the sun and the word *sun* (Bavelier, 1994). In the realm of pictures, Kanwisher, Yin, and Wojciulik (1997) have shown RB for a front view and side view of an iron and for two visually distinct examples of airplanes.

The existence of non-identity RB holds forth the hope that RB can be a tool for testing theories about what kinds of abstractions mediate recognition and processing of visual objects. Our concern in this paper is with orthographic RB, the deficit in reporting non-identical but orthographically similar words. Before orthographic RB can be used to test theories about lexical and orthographic processing, an important issue to resolve is whether RB in non-identical words occurs at the level of whole words or at a sublexical level.

1.1. Sublexical accounts

Kanwisher and Potter (1990) ruled out the level of single letters as the locus of RB effects based on two pieces of evidence. First, no RB was found for words which are anagrams of each other, like *early layer* (Kanwisher, 1986). Second, no RB was found for words sharing only a single letter, even when deletion of the shared letter would create a word (for example, the letter *t* is repeated in *fault* and *heart*; deleting the *t* from *heart* would produce a legal word, *hear*; this was replicated by Harris, in press). Morphology was ruled out because RB was obtained with morphologically unrelated words such as *even* and *event*, a conclusion substantiated by additional, carefully controlled experiments in Kanwisher and Potter (1990).

Kanwisher and Potter (1990) concluded that a repeated sequence of letters was necessary and sufficient for orthographic RB. They left for future work the question of whether the perceptual system is ‘blind’ only to the repeated letters in the two words, or if orthographic similarity causes one of the words to be misperceived as the other, at which point RB at the level of whole words would apply.

We argue that the perceptual system is ‘blind’ only to the repeated letters. One type of evidence is that the amount of RB increases systematically with the number of letters repeated across the two words (Harris & Morris, 2000). Harris and Morris (2000) found that when no letters were repeated (as in *syrup AWARE*), both words were reported on 68% of trials. The percentage reporting was 54% when the first

initial letter was repeated (*about AWARE*), and 33% when the first three letters were repeated (*await AWARE*). For critical words sharing three letters, the position of the three letters in the word mattered. More RB was found for words sharing their first three letters than their middle three letters (*fancy dance*) or three alternating letters (*dense dance*).

If the perceptual system is only ‘blind’ to W2’s repeated letters, why don’t perceivers report W2’s unique letters? We have found that they frequently do (Morris & Harris, 1999). The words *band SAND* may be reported as ‘band and some word beginning with s’. The unique letters of W2 are sometimes reported as a guess of a word having the unique letters, as when *group GRAND* is reported as ‘group stand’.

These types of misreports suggested to us that the repeated letters were transiently suppressed and thus unavailable to activate W2, while the unrepeated or ‘leftover’ letters may be available to activate the set of words consistent with them. Across more than eight experiments we have systematically caused participants to report such illusory words by placing a letter fragment in the RSVP stream, as in examples (1) and (2), where we indicate report following → (Morris & Harris, 1999).

(1) *pain grain avy* → *pain gravy*

(2) *hate upstate airs* → *hate upstairs*

1.2. Whole-word accounts

Bavelier and Jordan (1992) have explained orthographic RB as a weaker form of identity RB, with the amount of RB being proportional to the degree of similarity between the two critical words.¹ The locus of orthographic RB in their theory is thus at the level of whole words, with the mechanism being the same as the mechanism for identity RB.

Chialant and Caramazza (1997) also locate orthographic RB effects at the level of whole words, but have argued that orthographic RB may not be ‘true RB’ at all. They propose that orthographic RB is the result of word-to-word inhibition resulting when similar words compete for selection during lexical access. Part of their motivation for this idea is the observation that the existence of orthographic RB is problematic for Kanwisher’s token individuation theory. RB for single letters is obtained when single letters are the unit displayed for report (*T T*), but no RB is obtained for single letters in words when words are the unit displayed for report (*fault heart*). Kanwisher and Potter (1990) explained this difference with the proposal that RB operates at the level of focused attention. Chialant and Caramazza note that extending token individuation theory to orthographic RB thus necessitates allowing RB to operate at a sublexical level even though attention is focused on the word level.

¹ Bavelier and Jordan’s computational model mainly deals with identity RB. Provisions for extensions to non-identity RB are contained in their equations, which contain a scaling parameter for the degree of orthographic similarity. They also do remark that their model accounts for the “finding of repetition blindness between orthographic neighbors” (p. 885).

Chialant and Caramazza's proposal is that theoretical reformulations may not be necessary if orthographic RB and identity RB arise from different mechanisms. Their evidence for different mechanisms comes from examining the time course of RB for identical and similar words. They conducted RSVP experiments in which critical words were embedded in sentences, separated by either one, two or three intervening words. Their first experiment found that the amount of RB for identical words decreased with lag but the amount of RB for orthographic neighbors increased with lag, reaching a maximum at lag 2. Because orthographic RB increased with lag, Chialant and Caramazza (1997) argued that it is caused by lexical competition, since such competition may result after a few hundred milliseconds delay. Their second experiment also embedded word repetitions in sentences, but the comparison here was between repetition of the same word, and repetition of a noun or verb homonym (*the groom asked us to groom his dog*). They again found an interaction of repetition type (same word versus homonym) and lag, with RB increasing as a function of lag for homonyms but decreasing for the same word condition.

Chialant and Caramazza's findings have strong implications for theories of word recognition. Lexical inhibition could be more powerful than previously assumed – powerful enough to regularly cause complete access failure at very short stimulus onset asynchronies, something which hasn't been reported using traditional methods, such as lexical decision and naming (Grainger, O'Regan, Jacobs, & Segui, 1989; Segui & Grainger, 1990).

It is unclear how word-to-word inhibition or lexical competition would predict the pattern of illusory-word report observed in our previous experiments (Morris & Harris, 1999). These mechanisms do not predict that the unique letters in W2 would be capable of activating words. Yet our findings of report of 'rock shell' given the sequence *rock SHOCK ell* suggests that the *sh* in *shock* is detected.

A reason to be skeptical of Chialant and Caramazza's claims about different time courses for identity and orthographic RB is that their Experiment 1 had several methodological weaknesses which make their findings inconclusive. Chialant and Caramazza (1997) used orthographically similar words in the 'unrepeated' condition, as in the following examples taken from their Experiment 1. The words in parentheses were intended to be the non-orthographically similar control words.

As I felt the gentle grip (grasp) my grin got bigger.
I will cut a slice (sliver) to slide under the microscope.
I often scald (scorch) my scalp when taking a shower:

Our previous experiment (Harris & Morris, 2000, Experiment 3) found strong RB for words sharing three initial letters. This suggests that a substantial report deficit would be found in these improper control conditions. In Experiment 1 of Chialant and Caramazza (1997), all of the instances of improper control words were in the orthographic-neighbor condition at the smallest lag. Because RB is measured relative to a control condition, lowered report in the control condition will reduce the amount of RB that can be measured.

A second problem comes from the possibility of more rhyme priming at short lags

than at long lags. Facilitation of a rhyming W2 at lag 1 could represent a type of rhyme priming (Lupker & Williams, 1989). In running participants in RB experiments, we have frequently observed participants' apparent sensitivity to the presence of rhyming words in the RSVP word list display, as indicated by guessing a rhyme word even when a trial contained no rhyming words. Guessing rhyming words can mean better report of orthographically similar words. Better report of both critical words means less RB. Rhyme effects may be most pronounced when the rhyme words are salient. In a sentences experiment, rhyme effects may be more salient in the short lag compared to long lag conditions, as illustrated by these examples from Chialant and Caramazza's Experiment 1:

lag 1: *When preparing to test they rest for two hours.*

lag 3: *The tank moved past a rank practicing maneuvers.*

Chialant and Caramazza's Experiment 1 also had more rhyme items at lag 1 (38%) than at lag 3 (27%). Sensitivity to rhyme items at lag 1 will result in less RB for orthographically similar items, which could contribute to the difference in lag effects between the orthographically similar and identical conditions.

The lack of item analyses and the fact that lag was only manipulated between items in Chialant and Caramazza's experiments means that the significant effects they present for analysis by subjects could be due to only a subset of their items. Even a small number of stimulus errors could produce a result that would appear significant in a subjects analysis.

In our first experiment we replicated Chialant and Caramazza's Experiment 1 using completely new sentences. Our materials manipulated lag and orthographic relatedness (identical versus orthographically similar) as within-stimulus variables.

2. Experiment 1

2.1. Method

2.1.1. Participants

Sixty Boston University students participated in exchange for course credit. All participants acquired English in the home before age 5 (seven participants acquired English simultaneously with another language).

2.1.2. Materials

Twelve versions each of 60 stimulus sentences were created. In the repeated-identity condition, the sentence contained a repeated word (*When my sister drinks beer all beer tastes awful*). The two critical words in each sentence are designated W1 and W2; an unrepeated-identity control was created by substituting an orthographically non-similar word for W1 which matched W2 in frequency (*When my sister drinks milk all beer tastes awful*). For the repeated-neighbor condition, W1 and W2 differed by only one letter and were matched in frequency (*When my sister*

eats beef all beer tastes awful). This condition also had an unrepeated control (*When my sister eats rice all beer tastes awful*). One-third of the repeated-neighbor items differed by the initial letter (*hall, wall*), one-third differed by the final letter (*chip, chin*) and one-third differed by a middle letter (*stiff, stuff*). Critical words were all three to six letters long. Each of the four main conditions (repeated-identity, unrepeated-identity, repeated-neighbor, unrepeated-neighbor) was further modified so that exactly one, two and three words intervened between W1 and W2, creating three different ‘lag’ conditions.

We did not include a blank condition, in which the second critical word is omitted from the RSVP sequence. The purpose of the blank condition is to detect how often subjects are likely to guess a repeated word (or a similar word) when it is not actually there. However, previous research using blank conditions reported very few intrusions (Chialant & Caramazza, 1997; Kanwisher, 1987). Our intuition from running many RB experiments is that observers more often make guesses when a stimulus is shown. That is, although observers fail to report a repeated stimulus, they are aware that a stimulus appeared, and will make remarks like, ‘and something else’. (We call the feeling that some stimulus has occurred without knowing its identity the ‘something experience’. This has also been discussed by Park and Kanwisher (1994).) Because subjects do *not* tend to guess words in the absence of a perceptual experience, we opted not to include the blank condition. This increased power by having more observations per cell in our main conditions.

Sentences ranged in length from six to ten words. Stimuli were counterbalanced such that each subject viewed five sentences in each condition at each of the three lags, for a total of 60 experimental trials. A complete set of stimulus items for Experiment 1 is shown in Appendix A.

2.1.3. Procedure

Each trial began with a row of asterisks appearing in the center of the computer screen. When the participant pressed the space bar, the sentence appeared one word at a time in the same location as the asterisks, with a 15–30 ms interval between each word due to the refresh rate of the monitor. Each word was centered on the display. Participants were instructed to report each sentence immediately after viewing it, and to report exactly what they saw, even if it seemed strange or ungrammatical. Experimenters recorded via keypresses whether participants reported both critical words, W1 only, W2 only, or neither of the critical words; omissions and substitutions were noted on the score sheet. The exposure duration for the experimental trials was set individually for each participant based on two sets of five practice sentences; each set contained two sentences containing repeated identical words, and three sentences with all non-similar words (‘unrepeated’ sentence). The exposure duration for the first set of practice sentences was set at 120 ms per word; the duration was decreased in 15 ms increments for the subsequent practice set and the experimental trials if the participant was unable to report both of the identical words in the repeated lists, but still able to report nearly all words from each unrepeated sentences. The duration was increased if the participant had difficulty with the

Table 1
Percentage of correct recall of W1 and W2 in Experiment 1, collapsing across lags^a

Word type	W1		W2	
	Repeated	Unrepeated	Repeated	Unrepeated
Identity	93	94	43	84
Neighbor	94	94	50	85

^a The standard error of the mean was less than 1% for W1, and less than 2% for W2.

unrepeated sentences. The average duration per word for the experimental trials across the 60 participants was 100 ms.

The stimuli for all experiments reported in this paper were presented on a Macintosh IICI, with the display controlled by the PsyScope experimental control software (Cohen, MacWhinney, Flatt, & Provost, 1993). The font was 48 point Chicago. Participants sat 20 inches from the screen.

2.2. Results and discussion

In this and subsequent experiments, ANOVA was performed using both participants and items as the random factor. The F statistics for these will be reported using F_1 and F_2 to indicate participants and items analyses, respectively. Following Chialant and Caramazza (1997), we first compared the percentage recall of W2 for both word types in the repeated and unrepeated conditions, collapsing across lags. As shown in Table 1, the main effect of repeatedness was very strong ($F_1(1, 59) = 430$, $F_2(1, 58) = 329$, both $P < 0.0001$), replicating findings from previous RB experiments using sentence stimuli (Bavelier, 1994; Chialant & Caramazza, 1997, Experiment 1; Kanwisher, 1987, Experiment 2).

The percentage of correct recall of W2 as a function of word type, repeatedness, and lag is shown in Table 2, and diagrammed in Fig. 1. The difference between the repeated and the unrepeated conditions decreased with increasing lag, showing that

Table 2
Percentage of correct recall of W2 in Experiment 1 as a function of lag^a

Condition	Lag		
	1	2	3
Identity, repeated	27	45	58
Identity, unrepeated	82	80	89
Neighbor, repeated	39	52	58
Neighbor, unrepeated	83	85	87

^a The standard error of the mean was approximately 2% for the unrepeated conditions, and 3–3.9% for the repeated conditions.

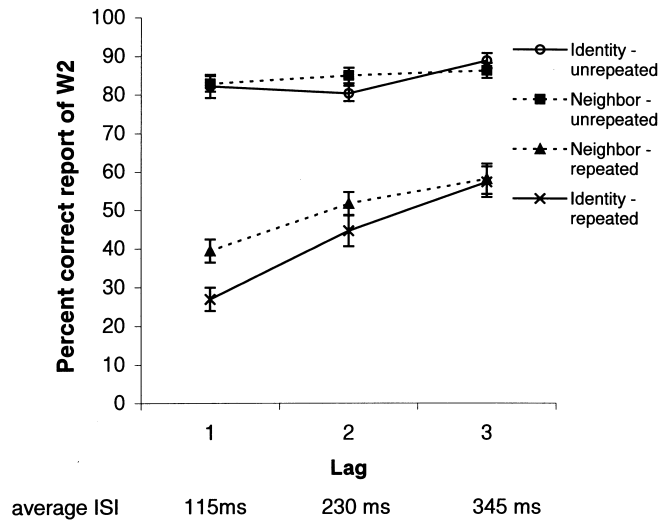


Fig. 1. Percentage correct reporting of W2 at different lags for identity and neighbor conditions, and their unrepeated control conditions in Experiment 1.

the amount of RB decreased as a function of lag. This was statistically verified by the finding that the interaction of repeatedness and lag was highly significant ($F_1(2, 118) = 14.7$, $F_2(2, 116) = 9.3$, both $P < 0.001$).

Separate ANOVAs were performed on the identity and neighbor conditions to verify that both showed a significant decrease in RB with lag. In the identity condition, the repeatedness by lag interaction yielded $F_1(2, 118) = 14.7$, $F_2(2, 116) = 9.3$, both $P < 0.001$. In the neighbor condition, the repeatedness by lag interaction yielded $F_1(2, 118) = 4.0$, $P < 0.05$, $F_2(2, 116) = 5.0$, $P < 0.01$.

RB can also be indexed by the difference between the recall of W2 in the repeated versus unrepeated conditions. To determine if the strength of the lag effect differed for the identity and neighbor conditions, we calculated difference scores and carried out an ANOVA with the factors word type and lag. The main effect of lag was significant ($F_1(2, 118) = 15.4$, $F_2(2, 116) = 13.2$, both $P < 0.001$). Most important, the condition \times lag interaction was not significant by subjects ($F_1(2, 118) = 1.1$, $P > 0.3$), or by items ($F_2(2, 116) = 0.9$, $P > 0.4$).

The amount of RB decreased with lag both for identical items and for orthographic neighbors. This finding is inconsistent with the contention by Chialant and Caramazza (1997) that RB for non-identical words has a different time course than RB for identical words. Evidence that our findings may be more reliable comes from analyzing effect size and power. We measured effect size for the main effect of repetition, and the interaction between repetition condition and lag for the identity condition, since these are effects endorsed by both sets of authors. Effect size as measured by η^2 (calculated from the degrees of freedom and F statistics) was comparable in the two experiments. Our design had more power because we used

60 sentences and 60 participants, while Chialant and Caramazza (1997) used 36 sentences and 36 participants. Their lag variable was between-item, meaning that 13 items were written for lag 1, 11 for lag 2, and 12 for lag 3, while all of our 60 items appeared in all the 12 conditions of our $3 \times 2 \times 2$ design (three levels lag, repeated/unrepeated and identity/neighbor). We thus had five items in each cell of the design while Chialant and Caramazza had only two.

3. Experiment 2

Our sentences experiment did not show the identity/neighbor \times lag interaction reported by Chialant and Caramazza (1997). Those authors mentioned an unpublished experiment which claimed to find the same interaction using lists of three words intermixed with symbols. In this unpublished manuscript (which we obtained with the kind help of Alfonso Caramazza), the interaction resulted from a flat slope for neighbors and the standard decline in RB with lag for identical words – not a cross-over interaction.

Two pilot studies using word lists (Harris & Morris, 1998) replicated this in the form of a smaller decrease in RB with lag for neighbors compared to identical words. While not a cross-over interaction, this difference in the effect of lag leaves open the possibility that RB differs in time course for identical words versus neighbors, and this requires an explanation. Our observation while running participants in these studies was that guessing biases could be responsible for the slope differences. Some participants would guess a repeated word on a neighbor trial. Participants appeared to be adopting the strategy of guessing a repeated word if they had the perception of similarity between two words. If guessing is more frequent at long lags, this will enhance the reporting of identical words at long lags and depress the reporting of neighbors. Guessing identical words is likely to be more common at longer lags for the following reason. RB in identical words declines with lag. As RB becomes weaker, participants obtain more partial evidence of W2, and more frequently have the ‘something experience’. The partial evidence of W2 can prompt guessing. Guessing of a repeated word will be common if participants are aware that the sentences contain repeated words.

Our pilot studies also suggested that some participants became sensitized to the presence of rhyming words, and thus were likely to guess a rhyming word if they had the perception of an orthographically similar word. We attempted to minimize the salience of rhyme words by using non-rhyming neighbors (e.g. *card cart*; *golf wolf*). We included 30 filler items to reduce the proportion of identical words. Given that we wanted to include 30 filler trials, we opted to use them to test an additional hypothesis: does any RB occur for a single repeated interior letter? This is important for understanding limits on what words can be used as unrepeated control items in RB experiments. Harris and Morris (2000) found that the amount of RB increased as a function of the number of repeated letters, with small but reliable RB found for a single letter at the beginning of the word (e.g. *about AWARE*). In Experiment 1, several of our control items had a repeated letter,

although it was usually in a different word position (*ring/loan*, *dozen/loan*, *lover/rang*, *coat/sale*, *guns/sale*, *crash/slip*). The 30 ‘filler’ items constituted a subexperiment in which a single interior letter was repeated in either the same or different positions across the two critical words at lags of 0, 1 or 2.

3.1. Method

3.1.1. Participants

Thirty-six Boston University students participated in exchange for course credit. All participants acquired English in the home before age 5 (five participants acquired English simultaneously with another language).

3.1.2. Materials and design

A 3×3 within-item design was used, with lag of 1, 2 or 3, and the type of relation between critical words being identical, neighbor, or unrepeated. Thirty-six of the 72 stimulus items used critical words from Chialant and Caramazza’s sentences study (Chialant & Caramazza, 1997, Experiment 1); 14 were adapted from our Experiment 1, and the remaining 22 were new. Modifications were made to avoid orthographic similarity in the unrepeated condition. Three main conditions were created: an identity condition (*GRIN grin*), a neighbor condition (*GRIP grin*), and an unrepeated condition (*BOSS grin*); in the latter condition, W1 and W2 shared no letters in common. W1 and W2 were always the same length; print frequencies were also similar across the three conditions. The mean log frequency for W1 in the identity condition was 3.02 (Francis & Kucera, 1982, log of number of occurrences per sample of 1 million words), with mean log frequencies of 3.15 and 3.18 for the neighbor and unrepeated conditions, respectively. Critical words were embedded in lists of words and symbols such that one word separated the critical words for lag 1, one word and a row of symbols separated the critical words for lag 2, and one word and two rows of symbols separated the critical words for lag 3. The filler word shared no letters with either W1 or W2. W1 was always displayed in upper case, with W2 in lower case and the filler word in upper case for half the items and lower case for the other half. Examples of the RSVP sequences for the three lag conditions are shown in Table 3.

Serial position in the word list of the critical words was considered a nuisance factor and was thus varied between items. For lag 1, in one-third of the items W1

Table 3
Examples of the three lag conditions in Experiment 2

Lag	Example
1	<p>%%%%%%%% ##### BARN HOOK barn &&&&& \$\$\$\$\$\$</p>
2	<p>%%%%%%%% ##### BARN HOOK \$\$\$\$\$\$ barn &&&&&</p>
3	<p>%%%%%%%% BARN ##### HOOK \$\$\$\$\$\$ barn &&&&&</p>

occupied position 2 and W2 occupied position 4, in another one-third W1 was in position 3 with W2 in position 5, and in the final one-third W1 was in position 4 with W2 in position 6. For lag 2, W1 and W2 occupied positions 2 and 5 or 3 and 6, with the filler word adjacent to W1 for half the items, and adjacent to W2 for the other half. For lag 3, W1 was always in position 2 and W2 was in position 6, with the filler word variably occupying positions 3, 4 or 5.

Stimuli were counterbalanced across nine versions of the experiment such that each participant viewed eight word lists in each condition at each of the three lags, for a total of 72 experimental trials (see Appendix B). Twelve filler trials containing only two words were also included in addition to the 30 trials of the single letter subexperiment. These can be considered ‘blank’ trials and provide an opportunity to determine if participants guessed a repeated word when they only detected two words.

Materials were prepared as follows for the subexperiment. The purpose was to examine whether RB occurs for words containing a single repeated interior letter, in order to determine if such words can safely be used in unrepeated control conditions. Four and five letter words were selected to instantiate a 3×3 within-item design. One factor was the type of orthographic similarity between the two critical words. In the ‘same position’ condition, a single letter was repeated in the same position (always position 2), as in CITY bill. In the ‘different position’ condition, the single letter appeared in position 3 of W1, as in SAID bill. In the unrepeated condition, no letter was repeated, as in SAME bill. The second factor was whether zero, one or two items (word or symbol string) intervened between the critical words. We chose to examine the case of zero lag since intervening, non-critical words in an RB experiment may sometimes repeat letters with one of the critical words. Nine material sets were constructed so that the type of orthographic similarity and lag could be counterbalanced across participants. Serial position was varied across items so that W2 appeared in each of three serial positions. All filler trials were evenly distributed among the three lag conditions.

3.1.3. Procedure

The procedure was similar to Experiment 1. Participants were informed that they would be viewing lists of words and symbols; they were instructed to report all the words but ignore the symbols. They were further instructed that if a word appeared twice, they were to report it twice. The exposure duration for the experimental trials was set individually for each participant based on four sets of five practice word lists; each set contained one ‘repeated’ word list with either two identical or two neighbor words, and four unrepeated lists. The exposure duration for the first set of practice trials was set at 150 ms per word; the duration was decreased by 15 ms for each subsequent practice set. Experimental trials were run at the shortest exposure duration where the participant reported both critical words correctly on at least 75% of the unrepeated trials. The average duration per word for the experimental trials across the 36 participants was 105 ms.

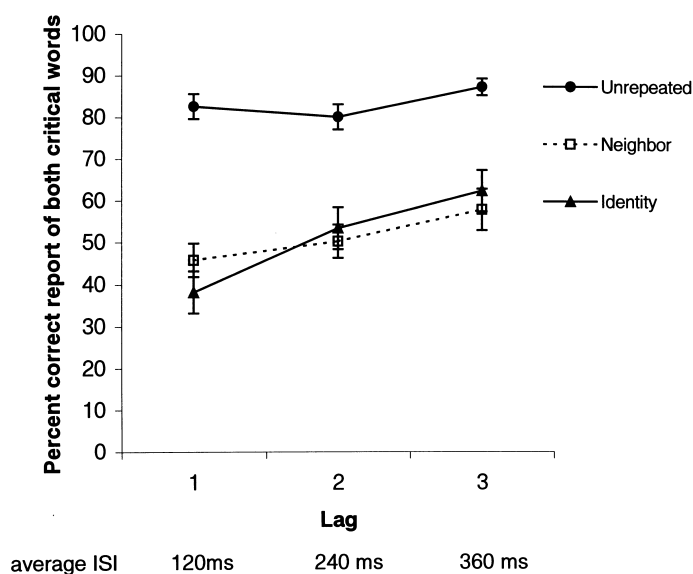


Fig. 2. Percentage correct reporting of both critical words at different lags for identity and neighbor conditions in Experiment 2.

3.2. Results and discussion

Because it is particularly difficult in word lists containing identical words to tell which of the two critical words is being reported, we calculated the percentage of trials in which both critical words were reported (joint probability or ‘both’ score) for each of the three conditions (identity, neighbor and unrepeated). The percentage of correct reports of both critical words as a function of condition and lag is shown in Fig. 2. An ANOVA revealed a significant main effect of condition ($F_1(2, 70) = 56.5$, $F_2(2, 142) = 113.6$, both $P < 0.001$), and a significant main effect of lag ($F_1(2, 70) = 18.0$, $F_2(2, 142) = 14.2$, both $P < 0.001$), as well as a significant interaction between condition and lag ($F_1(4, 140) = 4.6$, $F_2(4, 284) = 4.9$, both $P < 0.005$). When the identity and unrepeated conditions were compared, there was a significant effect of condition ($F_1(1, 35) = 70.4$, $F_2(1, 71) = 163.3$), a significant effect of lag ($F_1(2, 70) = 19.4$, $F_2(2, 142) = 14.0$), and a significant interaction between condition and lag ($F_1(2, 70) = 9.2$, $F_2(2, 142) = 9.5$) (all $P < 0.001$). Thus, the identity condition showed the expected decrease in RB with increasing lag.

A different pattern was observed when the neighbor and unrepeated conditions were compared. A significant effect of condition was found ($F_1(1, 35) = 101.1$, $F_2(1, 71) = 212.9$, both $P < 0.001$), and a significant effect of lag was found ($F_1(2, 70) = 6.1$, $P < 0.005$, $F_2(2, 142) = 5.1$, $P < 0.01$), but the interaction was not significant ($F_1(2, 70) = 1.3$, $F_2(2, 142) = 1.6$, both $P > 0.20$).

However, a complicating factor is that participants frequently reported repeated

(identical) words in place of neighbors, particularly at the longer lags. Participants erroneously reported identical words on 3% of trials at lag 1, and 7% of trials each at lags 2 and 3. ANOVA was performed on the percentage of neighbor condition trials in which identical words were reported at each lag. The result was significantly greater reports of identical words at greater lags in the subject analysis ($F_1(2, 70) = 3.3, P < 0.05$), although the effect failed to reach significance in the item analysis ($F_2(2, 142) = 2.0, P = 0.14$). Participants did not tend to intrude repeated words during the two word filler trials; similarly, reports of repeated words were practically non-existent during unrepeated trials. A bias toward reporting repeated words at longer lags in the neighbor condition would decrease the percentage of correct reports, thus increasing the measure of ‘RB’ observed in the neighbor condition at longer lags. Such a bias could also inflate the correct reports of identical words at longer lags, thus producing the different amounts of RB at different lags for the two stimulus types.

Instructions given to the participants emphasized the presence of repeated words. This may have contributed to the erroneous reports of repeated words on neighbor condition trials in Experiment 2 by changing the task to one of ‘repetition detection’ rather than strictly serial report. Alternatively, the presence of repeated words could have biased participants to guess repeated words. Experiment 3 attempted to reexamine the pattern of RB across lags for the neighbor condition, uninfluenced by identical trials. Trials were divided into two blocks. The first block consisted of neighbor and unrepeated trials, plus fillers; the second block added in identity trials. In addition, participants were not explicitly told that there would be repeated words in the experiment.

3.2.1. Results for the subexperiment on repeated interior letters

Analysis revealed no RB for these stimuli. The percentage reporting of both critical words was 71% when two words shared no letters, 71% when an interior letter was repeated in the same position, and 75% when an interior letter was repeated in a different position. The standard error for these cell means was 3%. The finding that the reporting of words was not influenced by the presence of a single repeated interior letter minimizes the concern that the results of Experiment 1 may lack validity due to the presence of isolated repeated letters in the ‘unrepeated’ condition.

4. Experiment 3

Experiment 3 tested a novel hypothesis for why orthographically similar words show smaller lag effects than identical words. Soon after observers experience identical word repetitions, they have some tendency to begin to guess repeated items on trials when they have both the ‘something experience’ (the feeling that some stimulus appeared) and an impression of similarity. The ‘something experience’ is more common at long lags because RB is weaker at long lags. This means that the reporting of identical words will be inflated at long lags compared to non-

identical words, leading to a steeper slope for identical words compared to similar words.

Our prediction was that minimizing the salience of repeated identical words would prevent observers from adopting the strategy of guessing a repeated word when they have an impression of similarity. To minimize the salience of identical repetition, we omitted the identity condition from the first half of the experiment (block 1), and did not mention identical word repeats in our instructions.

4.1. Method

4.1.1. Participants

Fifty-four Boston University students participated in exchange for course credit. All participants acquired English in the home before age 5 (eight participants acquired English simultaneously with another language).

4.1.2. Materials

The same materials were used in Experiment 3 as in Experiment 2. The 72 stimulus items were divided into two blocks; in the first block, no identity condition trials were shown. Thus, the first block consisted of four neighbor and four unrepeated condition trials at each of the three lags, plus 21 fillers, for a total of 45 trials. The second block consisted of four identity, four neighbor, and four unrepeated condition trials at each lag, plus 21 fillers, for a total of 57 trials. Stimuli were counterbalanced across 18 versions of the experiment such that each neighbor and unrepeated condition word list appeared in each block equally often. Since identity condition trials were omitted from the first block, each word list appeared twice as many times in the neighbor and unrepeated conditions as in the identity condition.

4.1.3. Procedure

The procedure was the same as that in Experiment 2, except that participants were not explicitly informed that the lists of words and symbols could contain repeated words. The average duration per word for the experimental trials across the 54 participants was 108 ms (range 100–135 ms).

4.2. Results and discussion

Not mentioning the presence of identical words and starting observers with a block of trials with no identical words achieved the intended effect of minimizing guessing of repeated words. Guesses of a repeated word were rare, totaling only 20 instances across the 54 participants, and all guesses except one occurred in block 2, the block containing identical word repeats. On debriefing, many participants expressed surprise that a substantial percentage of the trials contained repeated words.

An initial analysis compared the percentage correct recall of both critical words as a function of stimulus condition, lag, and block. Since there was no main effect of block (both $F < 1$; see Table 4) and no interactions of block with any other factor, we collapsed over block in subsequent analyses. As shown in Fig. 3, the reporting of

Table 4
Percentage of correct recall of both W1 and W2 in Experiment 3^a

Condition	Lag 1	Lag 2	Lag 3
<i>Block 1</i>			
Neighbor	47	51	64
Unrepeated	87	85	82
<i>Block 2</i>			
Identity	27	40	50
Neighbor	50	55	63
Unrepeated	84	83	82

^a The standard error of the mean was 4–5% for identity, 4% for neighbor, and 3% for unrepeated.

both critical words declined as a function of lag for both the identity and neighbor conditions. This was verified by separate ANOVAs comparing the identity condition to the unrepeated condition, and the neighbor condition to the unrepeated condition. The lag \times condition interaction was significant in both of these ANOVAs, indicating a decrease in RB with increasing lag for both word types. For the comparison of neighbors and unrepeated, this interaction yielded $F_1(4, 212) = 9.9$, $F_2(4, 284) = 9.0$, both $P < 0.001$. For the comparison of identity and unrepeated, this interaction yielded $F_1(2, 106) = 17.6$, $F_2(2, 142) = 15.1$, both $P < 0.001$. Thus, in Experiment 3, both the identity and neighbor conditions showed the expected decrease in RB with increasing lag.

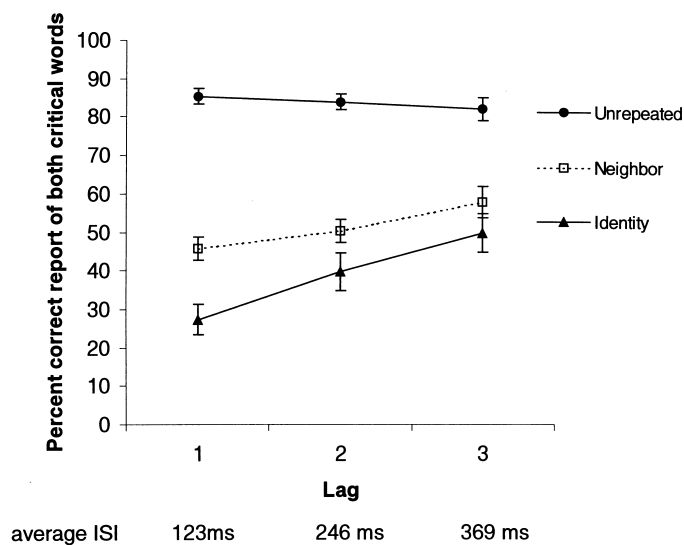


Fig. 3. Percentage correct reporting of both critical words at different lags for identity, neighbor, and unrepeated conditions in Experiment 3.

To directly compare the strength of the lag effect in identity and neighbor stimuli, an ANOVA was performed on difference scores (unrepeated minus identity or neighbor). There was a significant effect of stimulus condition ($F_1(1, 53) = 24.6$, $F_2(1, 71) = 33.4$, both $P < 0.001$), indicating a greater amount of RB for the identity compared to the neighbor condition. There was also a significant main effect of lag ($F_1(2, 106) = 29.3$, $F_2(2, 142) = 17.6$, both $P < 0.001$), but the condition \times lag interaction was not significant ($F_1(2, 106) = 1.6$, $P > 0.20$, $F_2(2, 142) = 2.0$, $P > 0.10$). This shows that RB for both the identity and neighbor conditions decreased with lag in a similar fashion in this experiment.

We had hypothesized that more guesses of repeated words would occur in the lag 3 condition, since RB would be low here and observers would get partial evidence of similar words. Participants guessed a repeated identical when a neighbor was present 3% of the time at lag 1, 1% of the time at lag 2, and 6% of the time at lag 3. For lag 3, this was about the same as in Experiment 2 (7%). The lower rate of repeat guesses in this experiment compared to Experiment 2 thus appears to be due to the instructions, since Experiment 3 did not mention the presence of repeated identical words.

Experiment 3 may represent an accurate estimate of observers' ability to detect and recall orthographically similar words across increasing lags. The results of this experiment are consistent with the Experiment 1 results, but inconsistent with Chialant and Caramazza's claim of time course differences in RB for repeated identical words and word pairs which are orthographic neighbors.

As in Experiment 2, this experiment also contained the subexperiment on whether RB is found for words sharing a single repeated interior letter. Again, no RB was found for these stimuli, with percentages for reporting of both critical words being within one percentage point of the percentages found previously, and means all being within one standard error of the mean from each other. This confirms our prior conclusion that designers of RB experiments may freely use word pairs which share a single interior letter (as in *ball cast*).

5. Experiment 4

Does the time course of RB effects differ for repetitions of the same lexical item compared to homonyms (*the watch, to watch*)? Chialant and Caramazza (1997) found that sentences containing homonyms (*The color of matches often matches their box*) increased in the amount of RB with lag. However, in sentences repeating a single sense of the word (*The box of matches has matches painted on it*), the time course of RB showed the standard decrease with lag. Because the time course of RB for homonyms followed the same pattern that these authors had observed for orthographically similar words, they suggested that RB in homonyms is not 'true' RB, i.e. it is not caused by a time limit on the token individuation process (Kanwisher, 1987). Their findings could mean that 'true' RB only occurs "when two items share a common representation at the relevant level of processing" (p. 103). An important implication of this is that homonyms, although sharing identical word forms, have

distinct lexical entries. Chialant and Caramazza (1997) concluded that RB effects can be used as a method for investigating the nature of lexical representations.

Sublexical accounts are neutral as to whether an additional level of RB takes place at the word level, in addition to RB for orthographic units. However, orthographic RB at the sublexical level means that two words sharing some or all of their letters interfere with each other before the words are completely recognized. Therefore, information about the identity versus homonym status of the words will be at best only partially available during the time period when letter-cluster representations between the two words are interfering with each other. Our prediction is thus equally strong RB, declining as a function of lag, for homonyms and repeated identical words.

Why did Chialant and Caramazza obtain a cross-over interaction of stimulus type and lag? It is well known that in spoken language the threshold for reporting briefly displayed words is influenced by the degree of contextual fit (Miller, 1962). This appears to be also true for RSVP (Potter, 1984; Potter, Moryadas, Abrams, & Noel, 1993). The degree of fit can modulate how much RB can be measured from repeated or similar words in an RSVP display (Whittlesea, Dorken, & Podrouzek, 1995). Whittlesea and Wai (1997) displayed sentences like ‘He poured some blue ink JAR into a JAR yesterday’. The inappropriate syntactic context of the initial JAR caused it to be underreported instead of the second critical word (see Hochhaus, 2001 for further discussion). From a sublexical view of orthographic RB, the second critical word may be partially activated, especially if it contains unique letters which are unaffected by RB and thus available to activate a cohort of words. This partial activation can combine with sentence-level information to further boost its report, if W2 fits well in the sentence, or depress its report, if W2 fits poorly in the sentence (because other candidates in the cohort may have a better fit to the sentence).

Our impression from studying Chialant and Caramazza’s sentences is that sentences for the homonym and identical conditions differed in how well the critical words fit into the sentence, and that their degree of fit also depended on lag. Homonyms (which had low RB at lag 1) seemed predictable from the sentence context at lag 1, but were less predictable at lag 3. Identical words (which had high RB at lag 1) sounded odd (or usage was strained) at lag 1 but sounded more natural at lag 3. Language users generally eschew repeating a word in favor of using a pronoun or synonym. Reidentification of the referent (rather than using a pronoun) sounds more natural with increasing distance from the first usage (Ariel, 1990; Bolinger, 1979). Because homonyms have different meanings (and thus the choice of pronoun versus reidentification is a non-issue), at short lags homonyms (as in 3a) sound more natural than repeated identical words (3b).

(3a) *To pick a rose/flower she rose from her chair* (Chialant & Caramazza, 1997, Experiment 2b).

(3b) *After they stepped on my rose/flower the rose was dead.*

This suggests that the homonyms should generally sound more natural than the repeated identical words, and that naturalness need not improve with lag, while the

naturalness of sentences using repeated identical words may frequently improve with lag.

Our first study inspired by Chialant and Caramazza's homonym experiment (Harris & Morris, 1998) found that the amount of RB decreased as a function of lag for both identical words and homonyms. However, the lag effect was small and only statistically reliable when measured with the repetition blindness index (RBI; Park & Kanwisher, 1994), rather than the difference score used by Chialant and Caramazza (1997). While this experiment still counts as a failure to find a cross-over interaction, it seemed important to robustly demonstrate that both homonyms and identical words show a similar decrease in RB with lag. The 1998 study had included only lag 1 and lag 2 because this is where Chialant and Caramazza had found their cross-over interaction. In Experiment 4, we compared lag 1 and lag 3, with the idea that a longer lag would be a better test of lag effects.

5.1. Method

5.1.1. Participants

Forty Boston University undergraduates participated to receive course credit. Thirty-four of these were monolingual English speakers; six had acquired English from birth together with another language.

5.1.2. Materials and design

Forty noun–verb homonyms were selected such that natural-sounding sentences could be constructed with critical words separated by only one word (lag 1). The lag 3 condition was created by inserting adjectives or other filler words into the lag 1 sentences, or by rearranging the order of the words. (Compare the lag 1 condition, *The actress you toast had toast and eggs for breakfast*, to the lag 3 condition, *The actress you toast had eggs and toast for breakfast*; all versions of the 40 sentences appear in Appendix C.) Only two lag conditions were used, making the design $2 \times 2 \times 2$ (two levels of lag, repeated/unrepeated, homonym/identity), with all three factors within-item. Words used as W1 in the unrepeated condition were matched for length and approximate frequency to W1 of the repeated condition. Twenty-four of the 40 items were drawn from our previous study (Harris & Morris, 1998), and 16 were modified from Chialant and Caramazza (1997), although materials were edited to avoid including words in the sentence which were orthographically similar to the critical words (and were within three words of a critical word). Similarity was defined as sharing a sequence of two or more letters in any word position (e.g. a relation such as horse mi se ry). To decrease the proportion of sentences containing repeated words, 30 filler sentences were included, making the repeatedness proportion 20 of 70 or 29%. All conditions were counterbalanced across participants.

5.1.3. Procedure

The practice trials, individual titration and general procedure were similar to

Table 5
 Percentage of correct recall of W1 and W2 in Experiment 4, collapsing across lags^a

Word type	W1		W2	
	Repeated	Unrepeated	Repeated	Unrepeated
Identity	92	85	49	79
Homonym	83	87	52	83

^a The standard error of the mean was less than 2% for W1, and less than 4.5% for W2.

Experiment 1. The mean exposure duration for each word was 121 ms (range 90–135 ms).

5.2. Results and discussion

We patterned our analysis after that performed by Chialant and Caramazza (1997) in their Experiment 2b. There was a strong RB effect, demonstrated by low reporting of W2 in the repeated condition (see Table 5). However, when collapsing across lag, the RB effect, as measured by W2 reporting, did not vary for the homonym and identical conditions (note that cell means are within one standard error of the mean of each other). However, ANOVA performed on reporting of W1 revealed an interaction of stimulus type and repeatedness ($F_1(1, 39) = 10.5$, $P < 0.002$, $F_2(1, 39) = 7.2$, $P < 0.01$). Inspection of cell means suggests that this is because reporting of W1 in the identity repeated condition was higher than would be expected. This could be due to the tendency of observers to migrate a perceived W2 into the W1 position (Whittlesea et al., 1995). Because this did not interact with the lag manipulation, it may not be relevant to the question of time course differences in RB for homonyms and identical word repeats.

ANOVA was performed on reporting of W2 for the full $2 \times 2 \times 2$ design. As shown in Fig. 4, the amount of RB decreased with lag for both the homonym and identity conditions. This was verified by finding a strong interaction of lag and repeatedness ($F_1(1, 39) = 27$, $F_2(1, 39) = 32$, both $P < 0.0001$), but no hint of a three-way interaction of lag, repeatedness and homonym/identity ($F < 0.2$). We also performed an ANOVA on the difference between repeated and unrepeated conditions. There was a main effect of lag ($F_1(1, 39) = 27$, $F_2(1, 39) = 39$, both $P < 0.001$), but no main effect of stimulus type and no interaction.

This experiment failed to replicate the finding by Chialant and Caramazza (1997, Experiment 2) that RB increased with lag for noun–verb homonyms but decreased with lag for identical words. Instead, RB for homonyms decreased with lag in a fashion that was similar to identical words. This experiment replicates our previous finding (Harris & Morris, 1998) of no cross-over interaction between homonyms and identical words. These findings are consistent with the predictions of sublexical accounts, since proposals which locate the effect of orthographic RB at the level of sublexical units predict that RB occurs before words' grammatical categories.

In four experiments we failed to obtain Chialant and Caramazza's result of RB

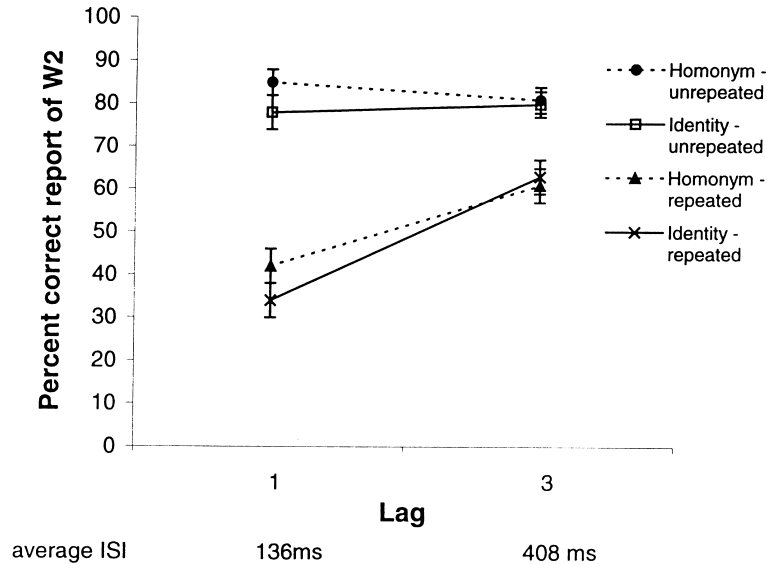


Fig. 4. Percentage correct reporting of W2 at different lags for homonym and identity conditions in Experiment 4.

increasing with lag for non-identical words. Whether critical words were lexically identical, orthographically identical (homonyms) or merely orthographically similar, RB decreased with lag.

6. General discussion

What causes humans to perceive non-identical objects to be similar is one of the oldest questions about the mind (French, 1995). A plausible mechanism is that at some level of analysis, visually dissimilar objects are categorized as the same object, possibly by activating an identical type representation. RB is intriguing because it appears to offer a straightforward method of determining what objects activate identical type representations, as illustrated by the Kanwisher et al. (1997) study on pictures. At present, drawing conclusions about RB effects in words is complicated by the question of whether all observed repetition deficits are ‘true’ RB effects, where ‘true RB’ refers to deficits caused by time limitations in establishing separate tokens for a twice-activated type.

There are two categories of explanations for repetition deficits in orthographically similar words. In whole-word theories, the locus of RB effects is at the level of the whole word, either due to similarity inhibition (Bavelier & Jordan, 1992) or competition for lexical selection. Whole-word theories of orthographic RB have a number of attractive properties.

- Whole-word theories explain why RB is not found for anagrams (*early layer*).
- Whole-word theories dovetail with work demonstrating that attention modulates the degree of RB. Using a two letter display, Kanwisher, Driver, and Machado (1995) instructed observers to report either color or shape, thus making color or shape the attended dimension. Observers responded less accurately when the letters were identical on attended dimensions. Identity on the unattended dimension had no influence on reporting. This and related studies (Baylis, Driver, & Rafal, 1993) support the view that RB reflects the level on which attention is focused. For word reading, this is the level of the word.
- Whole-word theories support the intuitively plausible idea that type–token binding corresponds to stabilizing an episodic representation in short-term memory (Bavelier, 1994; Bavelier et al., 1994; Park & Kanwisher, 1994). Words are good candidates for being the unit that is stabilized in short-term memory. Letter sequences or single letters are not good candidates, because the limited capacity of short-term memory precludes storage of individuated letter tokens or tokens of letter clusters (Peterson & Peterson, 1959).

One unsatisfying aspect of whole-word approaches is how uncritically they have been accepted, as evidenced by how infrequently they have been tested and debated. The proposal by Bavelier and Jordan (1992) of similarity inhibition remains only a side note in a paper describing a computational model of repetition effects at different time scales. Chialant and Caramazza's theory of lexical competition is bolstered by empirical data, but their proposed mechanism of report failure via lexical competition lacks *prima facie* validity. Inhibition caused by lexical competition during word recognition is normally understood to be a relatively small effect, resulting in a delay of tens of milliseconds in standard word recognition experiments, using displays in which the stimulus remains visible until a response is made (Colombo, 1986; Grainger, 1990; Ziegler & Perry, 1998). It seems too coincidental that lexical competition would manifest itself as the very large effect of failure to report a word precisely when the timing of the two critical words is moved into the 'repetition blindness window' of under 300 ms between displays.

Experiments 1–4 attempted to replicate the difference in the time course of identity and orthographic RB which has been the main piece of evidence for the proposal by Chialant and Caramazza (1997). Experiment 1 failed to replicate Chialant and Caramazza's sentences experiment, and Experiments 2 and 3 failed to replicate the cross-over interaction using word lists. Experiment 4 revealed that RB decreased with lag both for identical words and homonyms.

6.1. *Guessing and context effects*

The current experiments contribute to the literature on biases and strategies which affect RB. An on-going debate is whether RB should be understood as a perceptual phenomenon (Kanwisher, 1987) or as the result of memory biasing and inference factors, such as a bias against reporting words that have already been output (Armstrong & Mewhort, 1995; Fagot & Pashler, 1995). Hochhaus (2001) has

suggested a resolution of this debate. The resolution is that in RSVP streams in which multiple words must be reported, the memory biasing and inferential factors are present *in addition to* perceptual RB. Our experiments showed that guessing effects differ for orthographically similar and identical words, and that these differences interact with lag.

Experiments with a high proportion of identical words and long lags (such that identical words are often reported) can induce participants to guess repeated words whenever they perceive a similarity. Including a ‘blank’ trial is inadequate as a corrective term for guessing since perceivers most frequently guess a word when they have evidence that a word was present (the ‘something experience’, Park & Kanwisher, 1994). According to the sublexical account, the ‘something experience’ happens more frequently with similar words because only the repeated letters are subject to blindness. Employing a strategy to guess repeated words means that measured RB is decreased for identical words and inflated for similar words. Similar words will thus show a shallower decrease in RB as a function of lag than do identical words.

Experiment 3 explicitly tested the hypothesis that guessing strategies are the cause of this shallower slope. Neighbor trials appeared first in a block with no identical words, followed by a block with identical word repeats mixed in with neighbor trials. One possible outcome was that the neighbor trials would show a shallower slope in block 2 due to incorrect guesses of repeated words at lag 3. The unexpected finding was a very low rate of guesses of repeated words at any lag, probably because we did not explicitly warn participants to be ready for repeated words. The interesting outcome of this experiment was that the decline in the amount of RB as a function of lag was the same for identical and neighbor trials. This is inconsistent with the findings of Chialant and Caramazza (1997) and supports the view that RB for both neighbors and identical words shows a similar time course.

6.2. Opportunities for studying sublexical processing

RB could be a general purpose tool for studying orthographic representations. Orthographic RB data could be matched to the predictions of different models of orthography. One important comparison is between context-dependent coding schemes (like the model by Mozer, 1991) and orthographic coding schemes which do not entail context-dependent letter clusters (Davis, 1998; Humphreys, Evett, & Quinlan, 1990; Shillcock & Monaghan, 2001). Orthographic RB could be used to investigate the importance of spelling-to-sound regularity in word naming (Plaut, McClelland, Seidenberg, & Patterson, 1996; Seidenberg & McClelland, 1989) and the role of frequency. These connectionist models imply that the networks have formed (in their weighted connections) representations that respond to letter sequences spanning three or more letters which encode deviations from regular spelling, such as the *ea* in *great* and *sweat*. A second issue is whether frequency alone determines the strength of units, or whether the mapping to phonology overrides the role of frequency. RB between and across visual hemifields could be used to probe how orthography is represented in the cerebral hemispheres.

The empirical questions mentioned above can be examined using established methods like naming and lexical decision, as well as more specialized techniques like the illusory conjunctions of letter and color in colored words (Prinzmetal, Hoffman, & Vest, 1991; Prinzmetal, Treiman, & Rho, 1986). However, new methods offer converging evidence and the opportunity to probe different parts of the system in question. Orthographic RB taps into the earliest phase of the word recognition process (60–200 ms), while other methods are more sensitive to the stage beginning 200 ms after stimulus presentation. Thus, orthographic RB has the potential to reveal unique aspects of the perceptual–cognitive interface.

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Appendix A. Experiment 1 materials

Control words for the unrepeated condition appear separated from the first critical word by a slash (/).

Condition	Lag	Sentence
1 Identity	1	When my sister drinks milk/beer all beer tastes awful.
1 Identity	2	When she drinks milk/beer all my beer tastes awful.
1 Identity	3	When she drinks milk/beer all kinds of beer taste awful.
1 Neighbor	1	When my sister eats rice/beef all beer tastes awful.
1 Neighbor	2	When she eats rice/beef all my beer tastes awful.
1 Neighbor	3	When she eats rice/beef all kinds of beer taste awful.
2 Identity	1	To keep your feet dry/cool bring cool socks.
2 Identity	2	If you want dry/cool feet bring cool socks.
2 Identity	3	If you want dry/cool feet bring those cool socks.
2 Neighbor	1	If you want to ride/cook bring cool socks.
2 Neighbor	2	If you want to ride/cook bring those cool socks.
2 Neighbor	3	When you ride/cook bring those new cool socks.
3 Identity	1	Since Jerry needs a ring/loan that loan is cheap.
3 Identity	2	Since Jerry needs a ring/loan that first loan is cheap.
3 Identity	3	Jerry needs a ring/loan and that new loan is cheap.
3 Neighbor	1	Since Jerry bought a dozen/load his loan was cheap.
3 Neighbor	2	Since Jerry bought a dozen/load his first loan was cheap.
3 Neighbor	3	Jerry bought a dozen/load and that new loan was cheap.
4 Identity	1	You won't be happy/poor in poor sections.
4 Identity	2	You won't be happy/poor in the poor sections.

(continued)

Condition	Lag	Sentence
4 Identity	3	You won't be happy/poor in the most poor sections.
4 Neighbor	1	You won't see a fight/pool in poor sections.
4 Neighbor	2	You won't see a fight/pool in the poor sections.
4 Neighbor	3	You won't see a fight/pool in the most poor sections.
5 Identity	1	Jim knew you slept/rang but rang once more.
5 Identity	2	Jim knew you slept/rang but he rang once more.
5 Identity	3	Jim knew you slept/rang but then he rang once.
5 Neighbor	1	Jim knew of his lover/rank but rang once more.
5 Neighbor	2	Jim knew of his lover/rank but then rang once.
5 Neighbor	3	Jim knew his lover/rank but then he rang once.
6 Identity	1	If you notice a coat/sale the sale is already over.
6 Identity	2	You notice a coat/sale when the sale is already over.
6 Identity	3	You notice a coat/sale when the big sale is over.
6 Neighbor	1	I noticed they had guns/salt for sale this morning.
6 Neighbor	2	I noticed the guns/salt was for sale this morning.
6 Neighbor	3	I noticed the guns/salt was not for sale today.
7 Identity	1	I try not to crash/slip and slip there anyway.
7 Identity	2	I try not to crash/slip and then slip anyway.
7 Identity	3	I try not to crash/slip and then we slip anyway.
7 Neighbor	1	When you are that bold/slim we slip through.
7 Neighbor	2	When you are bold/slim we might slip through.
7 Neighbor	3	When you are bold/slim we might often slip through.
8 Identity	1	For something new to sell/wear I wear shoes.
8 Identity	2	For something to sell/wear I can wear shoes.
8 Identity	3	For something to sell/wear I can always wear shoes.
8 Neighbor	1	When feeling brave/weak I wear shoes.
8 Neighbor	2	When feeling brave/weak I don't wear shoes.
8 Neighbor	3	When feeling brave/weak I don't often wear shoes.
9 Identity	1	When I struck the jaw/chin my chin really hurt.
9 Identity	2	I struck the jaw/chin and my chin really hurt.
9 Identity	3	I struck the jaw/chin and so my chin really hurt.
9 Neighbor	1	When I ate this nut/chip my chin really hurt.
9 Neighbor	2	I ate this nut/chip and my chin really hurt.
9 Neighbor	3	I ate this nut/chip and so my chin really hurt.
10 Identity	1	Bob liked eating fruit/corn and corn was expensive.
10 Identity	2	Bob liked fruit/corn and that corn was expensive.
10 Identity	3	Bob liked fruit/corn and that good corn was expensive.
10 Neighbor	1	Bob threw his old fruit/core and corn away.
10 Neighbor	2	Bob threw his old fruit/core and some corn away.
10 Neighbor	3	Bob threw his fruit/core and some old corn away.
11 Identity	1	Doctors need to hide/chart and chart every day.
11 Identity	2	Doctors need to hide/chart and they chart every day.
11 Identity	3	Doctors need to hide/chart and so they chart every day.

(continued)

Condition	Lag	Sentence
11 Neighbor	1	Jane's help/charm will chart our future.
11 Neighbor	2	Jane's help/charm will help chart our future.
11 Neighbor	3	Jane's help/charm will help to chart our future.
12 Identity	1	If they want to drink/share you share with us.
12 Identity	2	If they drink/share water you share with us.
12 Identity	3	They drink/share water and you share with us.
12 Neighbor	1	The bright/sharp ones share drinks with their friends.
12 Neighbor	2	The bright/sharp ones always share with their friends.
12 Neighbor	3	The bright/sharp ones can always share with friends.
13 Identity	1	While buying honey/sheep those sheep might run.
13 Identity	2	While buying honey/sheep those little sheep might run.
13 Identity	3	While buying honey/sheep all those little sheep run.
13 Neighbor	1	If you wave a finger/sheet those sheep may run.
13 Neighbor	2	If you wave a finger/sheet those little sheep run.
13 Neighbor	3	You wave a finger/sheet and those little sheep run.
14 Identity	1	When police looked for a bomb/trace no trace remained.
14 Identity	2	Police looked for a bomb/trace after no trace remained.
14 Identity	3	Police looked for a bomb/trace well after no trace remained.
14 Neighbor	1	Of the former barn/track no trace remained.
14 Neighbor	2	Of the former barn/track no clear trace remained.
14 Neighbor	3	Of the former barn/track at first no trace remained.
15 Identity	1	Although I saw your magic/worst his worst came later.
15 identity	2	I saw your magic/worst but his worst came later.
15 Identity	3	I saw your magic/worst but his very worst came later.
15 Neighbor	1	Although that is crazy/worse your worst comes later.
15 Neighbor	2	Although that is crazy/worse your very worst comes later.
15 Neighbor	3	That is crazy/worse but your very worst comes later.
16 Identity	1	As he sat on the desk/chair Fred's chair broke.
16 Identity	2	As he sat on the desk/chair Fred's green chair broke.
16 Identity	3	He sat on the desk/chair and Fred's green chair broke.
16 Neighbor	1	She tried to join/chain Fred's chair to his desk.
16 Neighbor	2	She tried to join/chain Fred's green chair to his desk.
16 Neighbor	3	Try to join/chain Fred's new green chair to his desk.
17 Identity	1	I have to choose/guess and guess right.
17 Identity	2	I have to choose/guess and better guess right.
17 Identity	3	I will choose/guess and had better guess right.
17 Neighbor	1	I recall/guess my guest may leave soon.
17 Neighbor	2	I recall/guess my house guest may leave soon.
17 Neighbor	3	I recall/guess my new house guest leaves soon.
18 Identity	1	I know weddings are formal/grand but grand parties are boring.
18 Identity	2	Weddings are formal/grand but those grand parties are boring.
18 Identity	3	Weddings are formal/grand but all those grand parties are boring.
18 Neighbor	1	We have no liquor/grant but grand parties are ahead.

(continued)

Condition	Lag	Sentence
18 Neighbor	2	We have no liquor/grant but some grand parties are ahead.
18 Neighbor	3	We have no liquor/grant but there are grand parties ahead.
19 Identity	1	When I bought a hen/cat my cat was nice.
19 Identity	2	I bought a hen/cat and my cat was nice.
19 Identity	3	I bought a hen/cat and my black cat was nice.
19 Neighbor	1	I found the old pipe/cap my cat had stolen.
19 Neighbor	2	I found the pipe/cap that my cat had stolen.
19 Neighbor	3	I found the pipe/cap that my old cat stole.
20 Identity	1	Be sure to plow/dig and dig carefully.
20 Identity	2	Be sure to plow/dig and you dig carefully.
20 Identity	3	You should plow/dig and try to dig carefully.
20 Neighbor	1	Those old woods are pine/dim so dig carefully.
20 Neighbor	2	Those woods are pine/dim so you dig carefully.
20 Neighbor	3	Those woods are pine/dim so try to dig carefully.
21 Identity	1	If you paint my floor/wall the wall might look better.
21 Identity	2	Paint my floor/wall and the wall might look better.
21 Identity	3	Paint my floor/wall and the new wall might look better.
21 Neighbor	1	If you paint my floor/hall the wall might look better.
21 Neighbor	2	Paint my floor/hall and the wall might look better.
21 Neighbor	3	Paint my floor/hall and the new wall might look better.
22 Identity	1	When I saw her kids/fate my fate was sealed.
22 Identity	2	I saw her kids/fate but my fate was sealed.
22 Identity	3	I saw her kids/fate but knew my fate was sealed.
22 Neighbor	1	When I saw the kids/gate my fate was sealed.
22 Neighbor	2	I saw the kids/gate but my fate was sealed.
22 Neighbor	3	I saw the kids/gate but knew my fate was sealed.
23 Identity	1	If Beth loves cash/gold John's gold is cheap.
23 Identity	2	If Beth loves cash/gold John's best gold is cheap.
23 Identity	3	Beth loves cash/gold and John's best gold is cheap.
23 Neighbor	1	Beth hates dirt/mold but gold she likes.
23 Neighbor	2	Beth hates dirt/mold but John's gold she likes.
23 Neighbor	3	Beth hates dirt/mold but John's cheap gold she likes.
24 Identity	1	Too much loss/pain causes pain for everyone.
24 Identity	2	Too much loss/pain causes some pain for everyone.
24 Identity	3	Too much loss/pain causes some more pain for everyone.
24 Neighbor	1	A big rock/rain causes pain for everyone.
24 Neighbor	2	A big rock/rain causes some pain for everyone.
24 Neighbor	3	A big rock/rain causes some more pain for everyone.
25 Identity	1	Since Wayne needs a cabin/tent Sue's tent will do.
25 Identity	2	Since Wayne needs a cabin/tent Sue's new tent will do.
25 Identity	3	Wayne needs a cabin/tent and Sue's new tent will do.
25 Neighbor	1	I heard Wayne may pack/rent Sue's tent in July.
25 Neighbor	2	I heard Wayne may pack/rent Sue's new tent in July.

(continued)

Condition	Lag	Sentence
25 Neighbor	3	Wayne may pack/rent Sue's brand new tent in July.
26 Identity	1	Kim was much too busy/slow for slow traffic.
26 Identity	2	Kim was too busy/slow for Maine's slow traffic.
26 Identity	3	Kim was too busy/slow for Maine's bad slow traffic.
26 Neighbor	1	Kim tried to coast/flow with slow traffic.
26 Neighbor	2	Kim tried to coast/flow with Maine's slow traffic.
26 Neighbor	3	Kim tried to coast/flow with Maine's bad slow traffic.
27 Identity	1	When going to jump/lift please lift carefully.
27 Identity	2	When going to jump/lift off please lift carefully.
27 Identity	3	When going to jump/lift will you please lift carefully.
27 Neighbor	1	When buying a tire/gift please lift carefully.
27 Neighbor	2	When buying a tire/gift you should lift carefully.
27 Neighbor	3	When buying a tire/gift you should please lift carefully.
28 Identity	1	All of us cried/sang and sang for hours.
28 Identity	2	All of us cried/sang and we sang for hours.
28 Identity	3	All of us cried/sang and we just sang for hours.
28 Neighbor	1	Since Joe didn't laugh/hang we sang all night.
28 Neighbor	2	Since Joe didn't laugh/hang we just sang all night.
28 Neighbor	3	Joe didn't laugh/hang so we just sang all night.
29 Identity	1	If you get a key/jack the jack could work.
29 Identity	2	If you get a key/jack maybe the jack could work.
29 Identity	3	You get a key/jack and maybe the jack could work.
29 Neighbor	1	I'm afraid we built/lack the jack for this car.
29 Neighbor	2	I'm afraid we built/lack the right jack for this car.
29 Neighbor	3	We built/lack the kind of jack for this car.
30 Identity	1	At work I smile/pick and pick some more.
30 Identity	2	At work I smile/pick and then pick some more.
30 Identity	3	At work I smile/pick and then you pick some more.
30 Neighbor	1	When Ron gets cross/sick I pick his medicine.
30 Neighbor	2	When Ron gets cross/sick I may pick his medicine.
30 Neighbor	3	When Ron gets cross/sick I may not pick his medicine.
31 Identity	1	I bet Dan will throw/catch or catch next year.
31 Identity	2	Dan should throw/catch Monday or catch next year.
31 Identity	3	Dan should throw/catch Monday or he'll catch next year.
31 Neighbor	1	I fear the old grass/match will catch on fire.
31 Neighbor	2	The old grass/match will not catch on fire.
31 Neighbor	3	The old grass/match surely will not catch on fire.
32 Identity	1	I try not to suffer/faint and faint very often.
32 Identity	2	I try not to suffer/faint and don't faint very often.
32 Identity	3	I try not to suffer/faint and I don't faint often.
32 Neighbor	1	I can smell bread/paint and faint very often.
32 Neighbor	2	I can smell bread/paint and not faint very often.
32 Neighbor	3	I smell bread/paint and I won't faint very often.

(continued)

Condition	Lag	Sentence
33 Identity	1	That wall is marble/brick yet brick is strong.
33 Identity	2	That wall is marble/brick and yet brick is strong.
33 Identity	3	That wall is marble/brick and yet the brick is strong.
33 Neighbor	1	Show us a clue/trick about brick later today.
33 Neighbor	2	Show us a clue/trick about new brick later.
33 Neighbor	3	Show a clue/trick about this new brick later.
34 Identity	1	I promise not to agree/worry but worry for hours.
34 Identity	2	I promise not to agree/worry but still worry for hours.
34 Identity	3	Promise not to agree/worry but you still worry for hours.
34 Neighbor	1	You can be silent/sorry but worry about the children.
34 Neighbor	2	You can be silent/sorry but never worry about the children.
34 Neighbor	3	You can be silent/sorry but I never worry about children.
35 Identity	1	If you touch a candle/flame the flame will burn.
35 Identity	2	Touch a candle/flame and the flame will burn.
35 Identity	3	Touch a candle/flame and the hot flame will burn.
35 Neighbor	1	I really can't blow/blame the flame on you.
35 Neighbor	2	I can't blow/blame the hot flame on you.
35 Neighbor	3	I can't blow/blame the hot smoky flame on you.
36 Identity	1	Debbie had speed/youth but youth was not enough.
36 Identity	2	Debbie had speed/youth but her youth was not enough.
36 Identity	3	Debbie had speed/youth but her fading youth was not enough.
36 Neighbor	1	They liked Debbie's style/mouth but youth was enough.
36 Neighbor	2	They liked Debbie's style/mouth but her youth was enough.
36 Neighbor	3	They liked Debbie's style/mouth but her fading youth was enough.
37 Identity	1	When I lost all touch/sight my sight meant nothing.
37 Identity	2	I lost all touch/sight and my sight meant nothing.
37 Identity	3	I lost all touch/sight and then my sight meant nothing.
37 Neighbor	1	When I had that battle/fight my sight was lost.
37 Neighbor	2	I had that battle/fight and my sight was lost.
37 Neighbor	3	I had that battle/fight and then my sight was lost.
38 Identity	1	The steak is rare/tough but tough meat is better.
38 Identity	2	The steak is rare/tough but some tough meat is better.
38 Identity	3	Steak is rare/tough but meat that's tough is better.
38 Neighbor	1	The ship was dirty/rough and tough meat was served.
38 Neighbor	2	The ship was dirty/rough and some tough meat was served.
38 Neighbor	3	The ship was dirty/rough and they served tough meat.
39 Identity	1	Since I need a baby/hat my hat must look cute.
39 Identity	2	I need a baby/hat and my hat must look cute.
39 Identity	3	Get a baby/hat and make your hat look cute.
39 Neighbor	1	Since I am wild/fat my hat looks funny.
39 Neighbor	2	I am wild/fat so my hat looks funny.
39 Neighbor	3	I am wild/fat and so my hat looks funny.

(continued)

Condition	Lag	Sentence
40 Identity	1	Julie was very curt/mad but mad is unhealthy.
40 Identity	2	Julie was curt/mad but staying mad is unhealthy.
40 Identity	3	Julie was curt/mad but staying so mad is unhealthy.
40 Neighbor	1	Julie was very calm/sad because mad is unhealthy.
40 Neighbor	2	Julie was calm/sad because staying mad is unhealthy.
40 Neighbor	3	Julie was calm/sad because staying so mad is unhealthy.
41 Identity	1	I usually don't like clubs/golf because golf is hard.
41 Identity	2	I don't like clubs/golf because playing golf is hard.
41 Identity	3	I don't like clubs/golf because you play golf too much.
41 Neighbor	1	I visit the coach/gulf for golf in the summer.
41 Neighbor	2	I visit the coach/gulf for some golf in the summer.
41 Neighbor	3	I visit the coach/gulf to play some golf this summer.
42 Identity	1	Jeff wanted ham/soup and soup was on the menu.
42 Identity	2	Jeff wanted ham/soup and his soup was ready.
42 Identity	3	Jeff wanted ham/soup and his favorite soup was ready.
42 Neighbor	1	Jeff wanted candy/soap but soup is what he got.
42 Neighbor	2	Jeff wanted candy/soap but his soup was there instead.
42 Neighbor	3	Jeff wanted candy/soap but his favorite soup was there.
43 Identity	1	You have a good break/term next term or else.
43 Identity	2	Have a good break/term the next term or else.
43 Identity	3	Have a good break/term in the next term or else.
43 Neighbor	1	I hope our judge/team next term is pretty good.
43 Neighbor	2	I hope our judge/team the next term is pretty good.
43 Neighbor	3	I hope our judge/team in the next term is good.
44 Identity	1	I like to save/buy and buy things often.
44 Identity	2	I like to save/buy things and buy often.
44 Identity	3	I like to save/buy many things and buy often.
44 Neighbor	1	I drove near the shop/bay to buy groceries.
44 Neighbor	2	I drove near the shop/bay area to buy groceries.
44 Neighbor	3	Drive near the shop/bay in order to buy groceries.
45 Identity	1	I'll eat fish eggs/raw but raw chicken is bad.
45 Identity	2	I'll eat fish eggs/raw but not raw chicken.
45 Identity	3	I'll eat fish eggs/raw but won't have raw chicken.
45 Neighbor	1	On the first bench/row the raw carrots sat.
45 Neighbor	2	On the first bench/row sat the raw carrots.
45 Neighbor	3	On the first bench/row sat the nice raw carrots.
46 Identity	1	When I saw your lion/fox that fox ran away.
46 Identity	2	I saw your lion/fox and that fox ran away.
46 Identity	3	I saw your lion/fox when that other fox ran.
46 Neighbor	1	You need to fix/fix the fox right away.
46 Neighbor	2	You need to fix/fix the injured fox right away.
46 Neighbor	3	Please fix/fix the poor injured fox right away.
47 Identity	1	When leaving a tip/pen the pen must have ink.

(continued)

Condition	Lag	Sentence
47 Identity	2	Leave a tip/pen and the pen must have ink.
47 Identity	3	Leave a tip/pen only if the pen has ink.
47 Neighbor	1	I want you to seal/pin a pen on that door.
47 Neighbor	2	You may seal/pin a nice pen on that door.
47 Neighbor	3	You may seal/pin a nice blue pen on that door.
48 Identity	1	This group had better dream/score and score big.
48 Identity	2	This group better dream/score and really score big.
48 Identity	3	This group will dream/score and they must score big.
48 Neighbor	1	It's time to visit the beach/shore and score big.
48 Neighbor	2	Time to visit the beach/shore and really score big.
48 Neighbor	3	Visit the beach/shore and then really score big.
49 Identity	1	Since I wore this crown/skirt my skirt fell apart.
49 Identity	2	I wore this crown/skirt and my skirt fell apart.
49 Identity	3	I wore a crown/skirt and then my skirt fell apart.
49 Neighbor	1	Bring either a jersey/shirt or skirt to the party.
49 Neighbor	2	Bring either that jersey/shirt or a skirt to the party.
49 Neighbor	3	Bring either that jersey/shirt or a red skirt tonight.
50 Identity	1	Chris had so much fear/stuff his stuff was everywhere.
50 Identity	2	Chris had so much fear/stuff he had stuff everywhere.
50 Identity	3	Chris had so much fear/stuff that he had stuff everywhere.
50 Neighbor	1	Chris was bent/stiff from stuff he moved on Tuesday.
50 Neighbor	2	Chris was bent/stiff from that stuff he moved yesterday.
50 Neighbor	3	Chris was bent/stiff from moving that stuff on Tuesday.
51 Identity	1	If we feel guilty/shame then shame is great.
51 Identity	2	If we feel guilty/shame then more shame is great.
51 Identity	3	We feel guilty/shame but then more shame is great.
51 Neighbor	1	You lie in the cellar/shade and shame his family.
51 Neighbor	2	You lie in the cellar/shade and then shame his family.
51 Neighbor	3	Lie in the cellar/shade and then you shame his family.
52 Identity	1	Lisa had debts/fame but fame was a serious problem.
52 Identity	2	Lisa had debts/fame but her fame was a problem.
52 Identity	3	Lisa had debts/fame but yet her fame was a problem.
52 Neighbor	1	Lisa tried to boost/fake her fame all those years.
52 Neighbor	2	Lisa tried to boost/fake her mild fame all those years.
52 Neighbor	3	Lisa tried to boost/fake her level of fame before.
53 Identity	1	Since I have a dog/boat this boat can be yours.
53 Identity	2	I have a dog/boat so this boat can be yours.
53 Identity	3	I have a dog/boat so this new boat is yours.
53 Neighbor	1	I doubt you will clean/beat this boat in five hours.
53 Neighbor	2	You will clean/beat this new boat in five hours.
53 Neighbor	3	You will clean/beat this fancy new boat after lunch.
54 Identity	1	The old room was dusty/neat and neat places work.
54 Identity	2	The room was dusty/neat and more neat places work.

(continued)

Condition	Lag	Sentence
54 Identity	3	The room was dusty/neat so find a neat place.
54 Neighbor	1	The lawn/nest is neat and birds love it.
54 Neighbor	2	The lawn/nest is really neat and birds love it.
54 Neighbor	3	The lawn/nest you have is neat and birds love it.
55 Identity	1	My sister is very angry/wise but wise people know.
55 Identity	2	My sister is angry/wise but most wise people know.
55 Identity	3	She is angry/wise but then most wise people know.
55 Neighbor	1	Don't forget your code/wire because wise people might know.
55 Neighbor	2	Don't forget your code/wire because most wise people know.
55 Neighbor	3	Forget your code/wire because most truly wise people know.
56 Identity	1	That was made of fiber/bone since bone is sturdy.
56 Identity	2	That was made of fiber/bone since only bone is sturdy.
56 Identity	3	That was made of fiber/bone since only the bone lasts.
56 Neighbor	1	His humor is a crime/bore and bone dry too.
56 Neighbor	2	His humor is a crime/bore and yet bone dry too.
56 Neighbor	3	His humor is a crime/bore and yet also bone dry.
57 Identity	1	When you clean the fur/boot my boot feels better.
57 Identity	2	Cleaning the fur/boot helps my boot to feel better.
57 Identity	3	Cleaning the fur/boot helps my old boot feel better.
57 Neighbor	1	Please get the coin/bolt your boot kicked away.
57 Neighbor	2	Please get the coin/bolt that your boot kicked away.
57 Neighbor	3	Please get the coin/bolt that your old boot kicked.
58 Identity	1	I love juice/cake but cake is too fattening.
58 Identity	2	I love juice/cake but their cake is too fattening.
58 Identity	3	I love juice/cake but their good cake is fattening.
58 Neighbor	1	I see a drum/cane and cake way over there.
58 Neighbor	2	I see a drum/cane and some cake over there.
58 Neighbor	3	I see a drum/cane and pieces of cake over there.
59 Identity	1	Our foods are extra/prime but prime items cost money.
59 Identity	2	Our foods are extra/prime but those prime items cost money.
59 Identity	3	Our foods are extra/prime but all those prime items cost.
59 Neighbor	1	We stock with safety/pride but prime items cost money.
59 Neighbor	2	We stock with safety/pride but those prime items cost money.
59 Neighbor	3	We stock with safety/pride but all those prime items cost.
60 Identity	1	His face was looking tragic/grave and grave was correct.
60 Identity	2	His face was tragic/grave and looking grave was correct.
60 Identity	3	His face was tragic/grave looking and yet grave was correct.
60 Neighbor	1	I know his terrible mood/grade had grave consequences.
60 Neighbor	2	His terrible mood/grade had some grave consequences.
60 Neighbor	3	His mood/grade had some really grave consequences.

Appendix B. Stimuli for Experiments 2 and 3

On half of the trials, the filler word was capitalized, and on half it was lower case. Sequencing of items, and position of critical words in the symbol sequences varied as described in Experiment 2.

W1				W2
Identity	Neighbor	Unrepeated	Filler	
BARN	YARN	DICE	HOOK	barn
GRATE	GRAVE	LUNCH	SWISS	grate
GRIN	GRIP	BOSS	face	grin
REST	TEST	MAIN	cold	rest
SLAP	SNAP	REEF	kick	slap
CLEAN	CLEAR	SOUTH	VIVID	clean
GREED	BREED	AWFUL	spoon	greed
BLADE	BLAME	SWIFT	YOUNG	blade
SCALP	SCALD	FROWN	quiet	scalp
DUST	BUST	OVEN	fair	dust
SLIDE	SLICE	PATCH	rumor	slide
HURL	HURT	FOAM	GIVE	hurl
RENT	TENT	LOUD	camp	rent
FISH	DISH	JEEP	club	fish
DUCK	DOCK	BOOM	half	duck
IDIOM	IDIOT	BRAKE	SUNNY	idiom
CLING	FLING	TRASH	MOODY	cling
LIFT	LIST	ARMY	week	lift
CURL	CURB	PINT	GAME	curl
HUNCH	PUNCH	SWAMP	DRIVE	hunch
CRAZE	CRAVE	PUPPY	FIGHT	craze
LEAF	LEAP	MIST	door	leaf
FLIP	CLIP	CORD	BATH	flip
POSE	POLE	TRAY	mind	pose
GRAB	GRAM	COIN	left	grab
RANK	TANK	PLOW	SIDE	rank
DRAFT	DRIFT	SPELL	cough	draft
SHRUB	SHRUG	CLICK	TODAY	shrub
FLOW	BLOW	SING	READ	flow
SHADE	SHAVE	FUZZY	COLOR	shade
SPIN	SPIT	DRUM	coal	spin
HEEL	PEEL	TICK	gray	heel
GLAZE	GLARE	BOOTH	MUSIC	glaze
THUMB	THUMP	CLOWN	river	thumb
SHAPE	SHAME	LUCKY	BROWN	shape
SLIP	SLIT	GOAT	KNEE	slip
TIGHT	EIGHT	SPEAK	CLOUD	tight
GRASS	GLASS	TEETH	KNOCK	grass
CHAIR	CHAIN	DOZEN	BLUFF	chair
CAKE	CANE	HUNT	ROOM	cake
MOOD	WOOD	BUSY	FREE	mood

(continued)

W1				W2
Identity	Neighbor	Unrepeated	Filler	
SLEEP	SHEEP	THICK	WRONG	sleep
POOR	POOL	WISH	bank	poor
WISE	WIRE	MOLD	junk	wise
SIGHT	LIGHT	POWER	candy	sight
STUFF	STIFF	CRACK	money	stuff
BEER	BEEF	CALM	SHOW	beer
DART	DIRT	SELL	bump	dart
BONE	NONE	STAY	girl	bone
GRAPE	GRIPE	HUMID	STOCK	grape
COOL	COOK	RIDE	fast	cool
NEAT	NEST	JUMP	LOOK	neat
WORSE	HORSE	PLANT	QUICK	worse
PRIME	PRIDE	CLOTH	BUGGY	prime
CHIN	CHIP	SEAL	food	chin
SNOW	SLOW	BABY	high	snow
FOUR	HOUR	DEAL	SIGN	four
POINT	PAINT	HURRY	smell	point
BREAK	BREAD	FUNNY	GHOST	break
RICE	RACE	WALK	shop	rice
SORRY	WORRY	THEME	cliff	sorry
SHIRT	SHORT	LEAVE	MUDDY	shirt
LOAD	LOAN	PINK	tree	load
ITCH	INCH	FOOL	BEAR	itch
BOOT	FOOT	DESK	HAIR	boot
BEAT	BOAT	ROCK	WILD	beat
BRAIN	DRAIN	FLOOD	STUCK	brain
BLACK	BLOCK	DRESS	night	black
WOLF	GOLF	CASH	bird	wolf
TERM	TEAM	LOSS	find	term
COMB	BOMB	GATE	pill	comb
SCORE	STORE	BUILD	happy	score
SCORE	STORE	BUILD	happy	score

B.1. Subexperiment on single interior repeated letter used in Experiments 2 and 3

W1				W2
Identity	Neighbor	Unrepeated	Filler	
CITY	SAID	SAME	HOW	bill
FIVE	UNIT	PAST	CRY	hill
WELL	OVER	YOUR	BAT	mess
SUCH	THUS	PART	ODD	june
MUCH	TRUE	THAT	LIP	fund
COVER	BROKE	SHEET	AIM	found
LARGE	FRAME	EVERY	BUS	watch

(continued)

W1				W2
Identity	Neighbor	Unrepeated	Filler	
MODEL	GROUP	KNIFE	WHY	coast
TABLE	IMAGE	BEGIN	HOP	carry
WORTH	DROVE	EVENT	PIG	local
FULL	BLUE	MEAN	ZOO	suit
TALK	HEAR	VIEW	BUY	mass
TOLD	KNOW	KEEP	CAR	body
TOWN	DROP	PAIR	FLY	nose
SEND	GREW	DARK	BOX	felt
WHEEL	OTHER	MOTOR	JUG	china
MARCH	CLAIM	PRIOR	FUN	taste
EARLY	LEARN	BELOW	DUG	faith
MAJOR	SMALL	MOOTH	IVY	dance
NORTH	FRONT	MEANT	CUP	solid
BACK	YEAR	ODOR	FIX	sang
LIVE	THIN	TYPE	ROW	miss
CARE	ROAD	HOLD	INK	last
NICE	PAIN	WORE	SKY	fill
MOVE	FROM	WALL	BIT	song
HUMAN	CAUSE	DRAWN	FOG	built
MONTH	ALONG	PARTY	SUB	voice
TRUCK	BIRTH	CIVIL	MAD	green
VALUE	DEATH	TRUTH	WOW	basic
BRIEF	AGREE	EMPTY	NUN	crowd

Appendix C. Stimuli for Experiment 4

The words which varied between the repeated and unrepeated condition are indicated using the / character. H, homonym condition; I, identity condition; 1, lag 1; 3, lag 3.

-
- H 1 After we leave/rest the rest of your team will arrive.
H 3 After our teams leave/rest more of the rest will arrive.
I 1 Although we paused/rest our rest break was skipped.
I 3 Although we paused/rest our early morning rest break was skipped.
- H 1 Our van bounced/rocks when rocks fell on it.
H 3 Our van bounced/rocks every time new rocks fell on it.
I 1 I compared her large wet stone/rocks to rocks from the lake.
I 3 I compared her stone/rocks to large wet rocks from the lake.
- H 1 Eventually the motion to discuss/second was second on the agenda.
H 3 The motion to discuss/second finally ended up second on the agenda.
I 1 My team finished first/second but second was desired.

Table 9 (continued)

I 3 My team finished first/second place even though second was desired.

H 1 After examining his bag/sack please sack the employee.

H 3 After examining his bag/sack they refused to sack the employee.

I 1 After they lost your big red bag/sack my sack was stolen.

I 3 After they lost your bag/sack only my red sack remained.

H 1 I'll kiss my pet duck/seal and seal the box where she'll live.

H 3 I'll kiss my pet duck/seal and then carefully seal the box.

I 1 We saw wild fish/seals and seals living in captivity.

I 3 We saw wild fish/seals but no adult seals in captivity.

H 1 To open the door/spell please spell the four magic words.

H 3 To open the door/spell three people must spell correctly.

I 1 The phrases you can't spell/spell they spell correctly.

I 3 The phrases you spell/spell wrong they could spell easily.

H 1 Please report/state the state in New England where you were married.

H 3 Please report/state which New England state you were married in.

I 1 Everything you could report/state I state in the bulletin.

I 3 Everything you report/state I managed to state already.

H 1 The actress you saw/toast had toast and eggs for breakfast.

H 3 The actress you saw/toast had eggs and toast for breakfast.

I 1 The person who asked for more/toast had toast before leaving his room.

I 3 The person who asked for more/toast doesn't need his toast now.

H 1 Doctors (from that school)/(of that type) don't type very well.

H 3 Doctors (from that school)/(of that type) usually do not type well.

I 1 Doctors who always publish/type reports type well.

I 3 Doctors who publish/type many reports usually type well.

H 1 Put on Mary's shirt/dress then dress the boy for school.

H 3 Put on Mary's shirt/dress before starting to dress the boy.

I 1 After you help/dress Mary dress the boy for school.

I 3 After you help/dress Mary please go dress the child.

H 1 Take the baby's arm/hand but hand Luke our toys.

H 3 Take the baby's arm/hand before the girls hand out toys.

I 1 Next to my uncle's finger/hand your hand is tiny.

I 3 Next to my uncle's finger/hand your baby girl's hand is tiny.

H 1 The firm my uncle bought/heads sold heads for movie star dolls.

H 3 The firm my uncle bought/heads sold movie star heads for dolls.

I 1 The firm sold animal fur/heads and heads for movie star costumes.

I 3 The firm sold animal fur/heads and movie star heads for costumes.

H 1 Under the animal skin/hide we'll hide from the others.

H 3 Under the animal skin/hide the boys can hide from the others.

I 1 If you decide to leave/hide don't hide near the freezer.

I 3 When you leave/hide don't try to hide on top of the freezer.

(continued)

H 1 The open fires we start/light provide light for metal working.

H 3 The fires we start/light didn't provide enough light for working.

I 1 Although the room needed sun/light the light was blocked by curtains.

I 3 The room needed sun/light because all the light was blocked.

H 1 They will take the item/change and change the sales slip.

H 3 They took the item/change in order to change the sale.

I 1 People who try to improve/change will change their learning easily.

I 3 People who try to improve/change will learn to change easily.

H 1 I don't care/mind if mind reading is your hobby.

H 3 I don't care/mind if reading her mind amuses them.

I 1 Open your heart/mind to mind reading instead of doubting it.

I 3 Open your heart/mind instead of doubting mind reading.

H 1 The instructions on that form/page say page your supervisor.

H 3 The instructions on that form/page say you should page the supervisor.

I 1 The instructions on this form/page correct pages that follow.

I 3 The instructions on this form/page improve on the pages that follow.

H 1 The guests at my swimming club/pool will pool their money.

H 3 My swimming club/pool attracts guests who pool their money.

I 1 I avoided swimming/pool clubs because pools are usually dirty.

I 3 I avoided swimming/pool clubs because so many pools are dirty.

H 1 When herding cattle on the open plains/range our range of food was limited.

H 3 Herding cattle on the open plains/range seriously limited our range of food.

I 1 Compared to the partner's vocal ability/range your range is limited.

I 3 Compared to her vocal ability/range your partner's singing range is limited.

H 1 I used a toy house/block to block the soldier.

H 3 A toy house/block was used to block the soldier.

I 1 The first cars you halt/block will block the others.

I 3 The cars you halt/block will soon enough block the others.

H 1 I bet that lock/can opener can do the machine system job.

H 3 That lock/can opening machine system can do the job.

I 1 The trash/can bags held cans of birthday wrapping paper.

I 3 The trash/can bags held large metal cans of scraps.

H 1 The teacher who Jane admired/bugs caught bugs and spiders for class.

H 3 The teacher who Jane admired/bugs caught spiders and bugs for class.

I 1 The scientist hunted lice/bugs wherever bugs could be found.

I 3 We hunted lice/bugs wherever Mark said bugs lived.

H 1 After we return from skiing/break let's break open the wine.

H 3 After the skiing/break we can all break open the wine.

I 1 When BU starts its vacation/break your break will already be over.

I 3 BU starts its vacation/break when your school's break is already over.

H 1 The men she knew/dates remember dates and people easily.

H 3 The men she knew/dates remember people and dates easily.

(continued)

- I 1 We prefer (a new time slot)/(new dates) to dates from last year.
- I 3 We prefer (a new time slot)/(new dates) rather than old dates now.

- H 1 Paper boats in the lake/sink will sink quickly.
- H 3 Paper boats in the lake/sink will not always sink quickly.
- I 1 Paper boats will usually flip/sink and sink quickly.
- I 3 Paper boats will flip/sink but won't always sink quickly.

- H 1 They hope the bee/fly will fly off.
- H 3 They hope the bee/fly will decide to fly off.
- I 1 They hate to travel/fly but fly they must.
- I 3 They hate to travel/fly and never will fly alone.

- H 1 Please sign/check your check before going to the bank.
- H 3 Please sign/check your last pay check before going to the bank.
- I 1 After they got my gift/check your check to your daughter was stolen.
- I 3 After they got my gift/check your daughter's refund check was stolen.

- H 1 They design it so the color of paint/matches often matches the box.
- H 3 The color of paint/matches they sell often matches the box.
- I 1 The box of tobacco/matches has matches painted on it.
- I 3 The box of tobacco/matches was painted with matches on it.

- H 1 Some workers can hammer/pound a pound of nails.
- H 3 Some workers can hammer/pound more than a pound of nails.
- I 1 Some workers can hammer/pound and pound well.
- I 3 Some workers can hammer/pound but they don't pound well.

- H 1 To pick a flower/rose she rose from the general's chair.
- H 3 To pick a flower/rose the general's daughter rose from her chair.
- I 1 After they stepped on my plants/rose the rose was dead.
- I 3 Stepping on my plants/rose could mean the rose was dead.

- H 1 The rangers could not bear/stand Smokey Bear living far away.
- H 3 The rangers can't stand/bear having their Smokey Bear live away.
- I 1 Whenever people reported seeing one/(a bear) the bear was far away.
- I 3 Whenever they saw one/(a bear) people reported the bear was moving away.

- H 1 While he lay sleeping on the floor/ground you ground coffee.
- H 3 He lay on the floor/ground sleeping while you ground coffee.
- I 1 The coffee Paul prepared/ground was ground too fine for me.
- I 3 The coffee Paul prepared/ground had to be ground very fine.

- H 1 Every time we fight/box the box of red gloves is used.
- H 3 Every time we fight/box Mark uses the box of gloves.
- I 1 Although a carpenter made this new chest/box your box is sturdier.
- I 3 A carpenter made this chest/box although your new box is sturdier.

- H 1 They (needed time)/(picked up a watch) to watch the order of his play.
- H 3 They (needed time)/(picked up a watch) in order to watch him play.
- I 1 All you need is a (timer)/(stop watch) or watch with a second hand.
- I 3 You need a (timer)/(stop watch) or any good watch with a second hand.

(continued)

- H 1 The officers recruit/evaluate and train new train conductors regularly.
 H 3 The officers recruit/train and evaluate new train conductors regularly.
 I 1 The officers we evaluate/train and recruit can train others.
 I 3 The officers we recruit can evaluate/train and train others.
- H 1 John originally missed the (electric drill)/(chain saw) but saw the other tools.
 H 3 John noticed the (electric drill)/(chain saw) right after he saw the other tools.
 I 1 After we lost John's (electric drill)/(chain saw) my saw proved useful to the team.
 I 3 After losing John's (electric drill)/(chain saw) they used my saw for the job.
- H 1 The nobles of the French palace/court would court any person they desired.
 H 3 The French palace/court nobles would often court any person they desired.
 I 1 After appeal to the supreme judge/court no court will review the evidence.
 I 3 We appealed to the supreme judge/court because no other court would listen.
- H 1 When (alarms go off)/(store alarms ring) the ring and other diamonds are in danger.
 H 3 When (alarms go off)/(store alarms ring) the large diamond ring is in danger.
 I 1 Although I wanted a diamond pendant/ring this ring of plain gold is fine.
 I 3 Although I wanted a diamond pendant/ring the plain gold ring is fine.
- H 1 The thieves used a broken coffee jar/mug to mug the old lady.
 H 3 A broken coffee jar/mug was used to mug the old lady.
 I 1 After you spilt Jane's glass/mug your mug of coffee arrived.
 I 3 After you spilt Jane's glass/mug of coffee your mug arrived.
- H 1 The rich old king/count will count his money.
 H 3 The rich old king/count may refuse to count his money.
 I 1 The old man/count is count of Ashby no longer.
 I 3 The old man/count is no longer count of Ashby.
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