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Identity and similarity factors in repetition blindness: implications for lexical processing

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Abstract

The influence of identity and similarity of repeated items on repetition blindness (RB) was investigated in two rapid-serial-visual processing (RSVP) tasks. In Experiment 1, the difference between correct recall for sentences containing repeated identical items and their controls was contrasted with the difference between correct recall for sentences containing pairs of orthographically similar items (fish – dish) and their controls. In Experiment 2 the same comparison was made between sentences containing repeated identical items and sentences containing pairs of orthographically identical items (the watch – to watch). The amount of RB elicited by the two conditions was measured at three different temporal lags. The results show that the function that describes performance over time for the repeated-identical (R-I) condition is different from that for the condition in which the items are orthographically similar (repeated-neighbor: R-N) or orthographically identical (repeated-homonym: R-H). The results are interpreted as suggesting that the decrements in performance observed for recall of the second occurrence of the repeated item in the R-I and the R-N and R-H conditions have different underlying causes. ©1997 Elsevier Science B.V.

1. Introduction

In a series of experiments Kanwisher (1987) has shown that in a rapid-serial-visual processing (RSVP) task subjects are less accurate in reporting the second occurrence of a repeated item presented in a given serial position than in reporting the same item in the same position when it has not been presented before. This

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phenomenon has been named ''repetition blindness'' (RB) (Kanwisher, 1986). The effect was shown to occur even in a condition in which the repeated item appeared in a sentence context, thus resulting in the production of ungrammatical sentences (e.g., The brown *couch* and black *couch* were stolen → The brown *couch* and black were stolen). This effect was shown to be sensitive to exposure duration (which ranged from 117 to 250 ms per word) and number of items intervening between the first and the second appearance of the repeated item (one to four words). The effect is stronger (i.e., greater RB) at shorter time exposures and at shorter lags.

RB was originally reported to occur with repeated identical items, such as ''couch'' in the example above, but not their semantically related controls (e.g., 'The brown *sofa* and black *couch*' were stolen failed to induce RB). In later work (Kanwisher and Potter, 1990), RB was shown to occur with pairs of items that are lexically dissimilar: RB has been shown to occur with pairs of homonyms (e.g., When she saw the *rose* she quickly *rose* from the chair), but not for the semantically related controls (e.g., When she saw the *tulip* she quickly *rose* from the chair); it has also been found with orthographically similar words (We need a *car* not a *cart* to move the beds), but not their controls (We need a *truck* not a *cart* to move the beds). Analogous findings for lexical items which are similar along other dimensions have also been reported (Bavelier and Potter, 1992; Bavelier et al., 1994). Finally, RB has been shown to occur for letters, for pictures, for words and their corresponding pictures, and for words and their translation in another language (Bavelier, 1994; Kanwisher and Potter, 1990; MacKay and Miller, 1994). Phonology has also been reported to play a role in RB but phonological similarity by itself has been shown not to be a sufficient factor (Bavelier and Potter, 1992; Kanwisher, 1991; but see Miller and MacKay, 1994).

Kanwisher and her colleagues (Kanwisher, 1987; Kanwisher and Potter, 1990; Park and Kanwisher, 1994) interpreted these results to indicate a distinction during visual recognition between a process of type (category) recognition and a process of token (instance) formation. According to the type–token interpretation, a node representing a type (the mental representation for that type) is first activated by the visual input, indicating that an instance of that type is present in the visual field. In order to preserve information relative to spatial location, temporal order, or other features of the visual input, the activated node is linked to the appropriate token. This latter process is called token individuation or type–token binding. In this framework, RB is thought to result from the failure to bind a type to more than one token within a short time interval. This interpretation also assumes that the input item successfully activates the type node on both occurrences.

Other interpretations of RB have been suggested. Another class of perceptually-based explanations of RB attributes the effect to the reduced responsiveness of the type node during a refractory period, resulting in the failure to encode the second occurrence of the repeated item. This interpretation was originally dismissed by Kanwisher (1987) on the basis of her findings of priming instead of RB when subjects were required to identify only the last item in a sequence of words which,

for the critical trials, corresponded to the second occurrence of the repeated item (Kanwisher, 1987, Exp. 3). The finding of a priming effect was interpreted to indicate that in the case where both items of a repeated set must be reported the second item is ''recognized'' but is not identified as a distinct token. However, the priming result has not been replicated in later experiments. Kanwisher and Potter (1990), Exp. 6, and Park and Kanwisher (1994), Exp. 7, obtained RB instead of priming in tasks similar to that of Kanwisher (1987), Exp. 3). Similarly, Luo and Caramazza (1995) found RB instead of repetition priming when subjects were asked to report only the second occurrence of the repeated item. Thus, the type-refractoriness hypothesis remains a viable framework in which to explain the RB phenomenon. One explanation proposed by Bavelier and Jordan (1993) is that R2 fails to be recognized because of the temporary increase in the recognition threshold that follows recognition of R1: the close temporal proximity of R2 to R1 prevents the recognition threshold from getting reset to a sufficiently small value to allow a second detection. Alternatively, it can be thought that after recognition of R1 there is a phase of negative activation, such that activation from R2 fails to reach recognition threshold (Luo and Caramazza, 1996). In either case, the consequence is a refractory period during which a type node is hyposensitive.

Another class of explanations attributes the RB phenomenon to post-perceptual, retrieval processes (Fagot and Pashler, 1994). On this view, both items of a repeated set are recognized but retrieval and report biases conspire against reporting R2. In this respect, RB may be considered to be a variant of the Ranschburg effect, in which less accurate performance is obtained for the second occurrence of a repeated item when a series of slowly presented (2 items/s) items must be reported (see Crowder, 1968). A possible mechanism for the selective difficulty in reporting R2 is output interference caused by the report of R1: if items are deleted from the memory buffer after their report, R2 may be deleted along with R1 because of their similarity (Crowder, 1968). Alternatively (or additionally), RB may be caused by an output bias against repeated items (Fagot and Pashler, 1994); for example, subjects may employ a strategy of only guessing items that have not already been reported, as has been suggested for the Ranschburg effect (Jahnke, 1969). The use of this guessing strategy would occasionally produce a correct response only for the unrepeated condition, thus overestimating the amount of RB. However, when error performance on the unrepeated trials is used as a measure to correct the size of RB (Park and Kanwisher, 1994) no significant reduction in the size of the effect has been found. Furthermore, although Fagot and Pashler (1994) failed to find RB in tasks that do not require full report of items, as expected by the hypothesis of retrieval interference, other studies, using a variety of experimental paradigms, have found RB independently of any requirement to overtly report both occurrences of a repeated item (e.g., Kanwisher et al., 1995, Exp.3; Mozer, 1989; Luo and Caramazza, 1995; see also Bjork and Murray, 1977, and Santee and Egeth, 1980, 1982, for related findings).

The literature on RB suggests that this phenomenon occurs for: (a) items that are

identical—that is, they are the same at every level of processing and share a lexical representation (e.g., ''couch–couch''); (b) items that are identical at some level of processing but do not share a lexical representation (e.g., homonyms such as ''rose''; (c) items that are similar, but not identical, at any level of lexical processing (e.g., orthographically similar items such as ''car–cart''). How do the selective memory loss, the token-binding and the type-refractoriness hypotheses account for this pattern of results? In particular, how do they account for those cases where the ''repeated'' items are only similar? The explanations we have briefly reviewed here only consider the case of repeated-identical items. The finding of RB for the repeated-similar cases is highly problematic for all three hypotheses. Indeed, if the similarity cases are instances of RB, then the theories need to be reformulated. Alternatively, the findings obtained in the repeated-similar case may constitute instances of a phenomenon different from RB.

The selective memory loss hypothesis could interpret the case of RB for orthographically similar items as instances of misperception of the second item, such that it would be just an accidental variant of the identity case. The token-binding hypothesis could also resort to the misperception interpretation or it could be reformulated by assuming that the level at which the constraint on the formation of tokens takes place is that of ordered letter clusters (Bavelier et al., 1994). On this view, RB would occur at a pre-lexical level of processing—a level at which sub-lexical feature similarities are the relevant dimensions causing RB. Finally, the type-refractoriness hypothesis would also have to assume that the cases of orthographic similarity are the result of a misperception occurring at a pre-lexical level.

The need for such reformulations of the proposed explanations of RB is predicated on the assumption that the effects observed for identical and similar items have a common cause. However, there are preliminary indications that the cause of the effect for similar items may not be the same as that for identical items. In a recent study concerned with the effects of word frequency and morphological structure on RB, Bavelier et al. (1994) may have inadvertently provided an important clue on how to distinguish between the identical and the similar cases of ''repetition'' deficits. Recall that one of the characteristic features of RB is the lag effect—more severe blindness at short lags, decreasing with increasing lag.[1] Across different experiments, Bavelier et al. found the standard lag effect for repeated identical items (Exp. 2; Table 2, p. 1441) but they failed to find the standard lag effect in conditions in which the ''repeated'' items were only orthographically similar (e.g., Exp. 1; Table 1, p. 1439). The authors do not comment on these contrasting effects as an indication that the RB observed for identical and similar cases may have different causes. However, if the contrasting temporal patterns of performance deficit for the two sets of items were to be

[1] The monotonically decreasing RB effect as a function of lag obtained in RSVP experiments is not obtained in brief-spatial-visual presentation (BSVP) conditions. In the latter case, RB first increases and then decreases with increases in lag (Luo and Caramazza, 1996). Since the present experiments used the RSVP paradigm, we will not pursue these differences in results.

reliable, we would have a possible basis for empirically distinguishing between RB—a phenomenon exclusively obtained with identical items—and similarity inhibition. In the following experiments we explore this issue.

EXPERIMENT 1: THE CASE OF ORTHOGRAPHIC NEIGHBORS

The objectives of Experiment 1 are to firmly establish whether identical and similar ''repeated'' items show different lag effects in reporting R2, and to characterize the specific form of the lag effect for orthographically similar items. These objectives are driven by the hypothesis that orthographically similar lexical items are affected by an inhibitory effect characterized by a time function that differs from that found for pairs of identical items. To these ends, sentences containing a repeated word (e.g., After checking your *barn* the *barn* was closed) are contrasted with sentences containing two orthographically similar words (e.g., After checking your *yarn* the *barn* was closed) at three different lags.

2. Method

2.1. Subjects

Thirty-six subjects were recruited for the experiment. They were native speakers of American English and had normal or corrected-to-normal vision. They were students at Dartmouth College, and participation in this experiment was in fulfillment of their requirements in the Psychology program.

2.2. Material

A first set of 36 sentences containing a repeated word was constructed (e.g., My favorite *fish* killed another *fish* in the tank). These sentences constitute the repeated-identical condition (R-I). There were two controls for this condition. The unrepeated control (C-I) in which for each sentence the first occurrence of the critical word (R1) was replaced by another word close in meaning (e.g., my favorite *bass* killed another *fish* in the tank). The blank control (B-I) in which for each sentence the second occurrence of the repeated word (R2) was omitted, thus resulting in an ungrammatical sentence (e.g., My favorite *fish* killed another in the tank).

A second set of 36 sentences also containing a ''repeated'' item was constructed. In this case the repeated condition consists of a pair of orthographically similar words, which only differed by one grapheme (and one phoneme). This set of sentences constitutes the repeated-neighbor (R-N) condition (e.g., My favorite *dish* is fresh *fish* with lemon sauce). There are two controls for this condition: the unrepeated control (C-N—e.g., My favorite *meal* is fresh *fish* with lemon sauce), and the blank control (B-N—e.g., My favorite *dish* is fresh with lemon sauce).

The number of intervening items between R1 and R2 was varied, and ranged from one to three words. Although it was intended to have 12 pairs of sentences at each lag, after the experiment was completed a sentence group was found to mistakenly have a lag of 1 instead of 3 and was scored accordingly. As a result, there were 13 sentence groups with lag 1 and only 11 with lag 3. For each lag condition, half of the R-I sentences had a noun as the repeated item and the other half had a verb. For the R-N sentences, 1/4 had two nouns, 1/4 two verbs, 1/4 a noun and a verb, and 1/4 a verb and a noun. In one third of the R-N the sentences R1 and R2 differed in the initial grapheme (e.g., barn–yarn), in one third in the middle grapheme (e.g., draft–drift), and in the remaining third in the final grapheme (e.g., grin–grip).

Target words were either four or five letters long and for the R-N condition R1 and R2 were matched for frequency (surface and cumulative), absolute number of higher-frequency neighbors, and frequency of their highest-frequency neighbor.

For each pair of sets of sentences (R-I and R-N), target and control words were matched for frequency (surface and cumulative) and length in number of words. Sentence length ranged from 7 to 10 words. Grammatical class, orthographic variation, target frequency, and neighborhood size were controlled in order to minimize the potential effects of these variables on RB. Apart from the target words no other word or functor in the sentences was repeated. Repeated words never appeared in the first or last position in the sentence. The full list of experimental sentences is shown in Appendix A. Another set of 16 sentences was used as fillers. Eight of these sentences were missing one word.

2.3. Design

The six variants of each sentence (R-I, C-I, B-I, and R-N, C-N, B-N) appeared in different versions of the experiment, counterbalanced so that each subject saw six sentences in each condition for a total of 36 experimental sentences per subject. The sentences appeared in pseudo-random order.

2.4. Procedure

Each trial began when the subject clicked on the mouse. A fixation point appeared in the middle of the screen. The sentence appeared one word at a time in the center of the screen. A row of pound signs (####) appeared at the end of each sentence to signal that the sentence was over. Each word was displayed at one of four pre-selected speeds for any given subject. The speed of presentation was chosen for each subject according to the following criterion: during the practice session, the subject had to show blindness on at least one of two sentences with a repeated item and be able to perform correctly on at least six of eight sentences with no repeated items. Each subject was tested at four different speeds (83, 100, 116, 134 ms). For each speed, the subject was presented with 10

sentences, two of which had a repeated word. These sentences also served as practice trials. The speed selected was the fastest consistent with the stated criterion. The experiment was then run at the selected speed for that subject: One subject viewed the words at 83 ms exposure, 27 subjects at 100 ms, five subjects at 117 ms, and three subjects at 134 ms. Subjects who did not meet the criterion at any of the four speeds were not used for the experiment (two subjects, who were replaced). There was a 17 ms interstimulus interval (ISI) (screen refresh time) between successive words in a sentence.

Subjects were instructed to read the sentence as carefully as possible and to repeat it aloud as soon as it ended. They were told that some sentences were missing one word and that they had to report the sentences as they saw them, without ''filling in the gaps''. Feedback on performance was given during practice so that subjects would be aware that some sentences had repeated items and others were ungrammatical. No feedback was provided during the experimental phase.

2.5. Apparatus

A Macintosh IIvx with a MultiSync 5FG screen was used to present the stimuli. The subjects' responses were recorded using a Panasonic RQ-L335 Mini Cassette Recorder. The sentences were displayed using the software Psycholab v1.0-074.

3. Results

3.1. Scoring procedures

Accuracy of report was very high overall. For the repeated condition, R1 and R2 were scored as correct when they where both reported correctly, otherwise either R1 or R2 (or neither) was scored as correct as determined by the position of the word in the sentence context. The same criteria were used for scoring responses for the unrepeated condition. Accuracy of report of the identity and position of R1 and R2 in those cases in which only one of the two was reported provides a partial measure of migration errors for the repeated conditions. There were very few such errors. For the blank conditions, R2 was scored as correct unless R1 was inserted in the location of the missing word.

3.2. Analyses

The data set was screened for outliers. Weighted performance was used for this purpose. All errors were assigned a value of 1 except in the case of substitution of R2 in any of the repeated conditions where they were assigned a value of 1/2 point. The reason for this weighting procedure was because there were many more

Table 1
Percent correct recall of R1 and R2 for repeated and unrepeated conditions collapsing across lags and type of repeated word: replication of the overall RB effect

Condition	Repeated	Unrepeated	Blank
R1	95	93	97
R2	51	83	0.5*

*Insertion rate of R1.

errors for R2 than R1. The weighting procedure represents an effort to balance the relative contribution of R1 and R2 while assessing overall error performance. Subjects or sentence groups that were more than 2.5 standard deviations from their respective group mean were excluded from analysis. On the basis of this criterion, one subject's data were excluded from further analysis.

A first analysis of the data was carried out in order to determine whether our results replicate the RB effect reported for sentences by Kanwisher (1987, Exp. 2). Performance was compared for sentences in the repeated and unrepeated conditions, collapsing across lags and type of repeated word. Overall, the same pattern of performance reported in Kanwisher was obtained (Table 1): considerably poorer performance in the repeated condition than the unrepeated control ($F(1, 30) = 79.7$, $p < .0001$). Furthermore, when we compare overall performance in the R-I and R-N conditions by collapsing across lags, no significant difference was found between them (Table 2). These results are similar to the findings reported in Kanwisher and Potter (1990), Exp. 4b): there are strong ''RB'' effects for both the R-I and R-N conditions.

Several ANOVAs were carried out in order to analyze the differences in performance for R2 as a function of lag and word type (see Table 3). One ANOVA was carried out to compare the percentage of correct recall in the repeated-identical condition and its control (R-I and R-C). The analysis showed a main effect of condition ($F(1, 30, .05) = 59.5$; $p < .0001$), but not of lag ($F(2, 30, .05) = 1.3$; $p < .3$), and a significant interaction of lag by condition ($F(2, 30, .05) = 3.3$; $p < .05$). These results indicate that there is an effect of repetition and a lag effect for the repeated condition, replicating the basic RB phenomenon for identical items. Another analysis was carried out to compare the percentage of correct recall in the repeated-neighbor condition and its control (R-N and C-N). The analysis revealed a main effect of condition ($F(1, 30, .05) = 45.3$; $p < .0001$)

Table 2
Percent correct recall of R1 and R2 for the two conditions of repeated-identical and repeated-neighbors collapsing across lags

Pair type / Critical word	R1		R2	
	Rep.	Unrep.	Rep.	Unrep.
Identical (fish – fish)	96	96	52	85
Neighbors (dish – fish)	94	90	51	81

Table 3
Percent correct recall of R2 (R and C conditions) and insertion rate of R1 (B conditions) at different lags for the different conditions

Condition	Lag		
	1	2	3
R-I	44	49	65
R-N	62	54	34
C-I	84	90	81
C-N	81	82	78
B-I	1.3	0	0
B-N	1.3	0	0

and lag ($F(2, 30, .05) = 4.2$; $p < .03$), but no significant interaction ($F(2, 30, .05) = 2.5$; $p < .1$). These results show that there is an effect of repetition in the R-N condition. However, as may be seen in Fig. 1, the function that describes this effect varies over time in a fashion different from that of the basic RB phenomenon for the R-I condition (see Fig. 1). The average ISIs shown in this

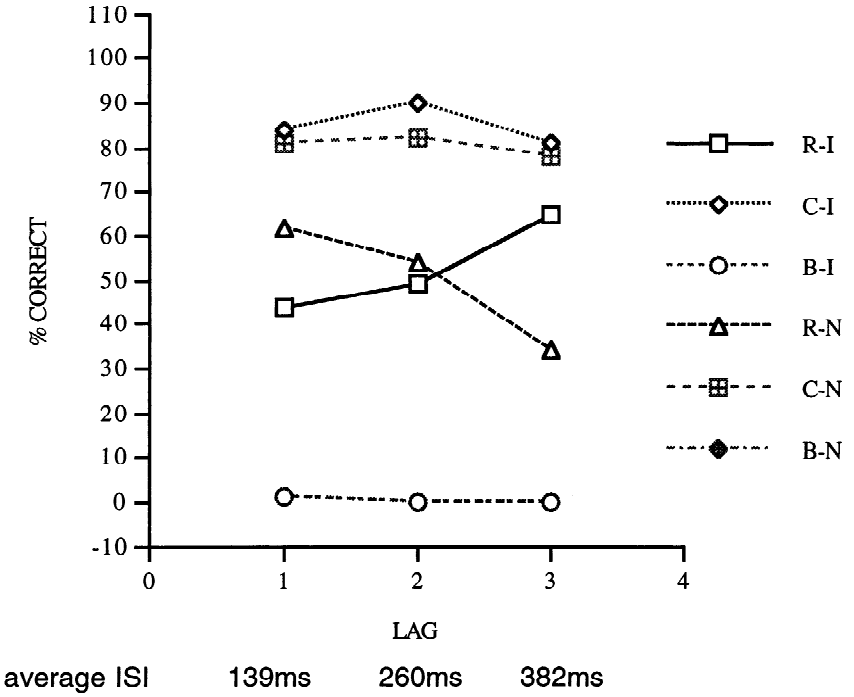

Fig. 1. Percent correct recall of R2 at different lags for repeated-identical (R-I), repeated-neighbor (R-N), and their controls.

figure were calculated by computing the overall time interval occurring from the end of R1 to the beginning of R2. The mean exposure duration for each intervening word across all subjects was calculated first. For the lag 1 condition, a screen refresh time of 17 ms was added twice to this average. For the lag 2 condition, the word average plus one screen refresh time was added to the previous interval, and this step was repeated once more to compute the ISI at the lag 3 condition. The obtained ISIs are only a rough approximation of the true ISIs for each subject.

A third analysis compared the R-I condition with the R-N condition, by evaluating the difference between each repeated sentence and its own unrepeated control (C-I minus R-I and C-N minus R-N). The analysis showed no main effects of condition ($F(1, 30, .05) = .2$; $p < .7$) and lag ($F(2, 30, .05) = .3$; $p < .7$), but a significant interaction of the two ($F(2, 30, .05) = 7.4$; $p < .003$). These results show that there is no difference between identical items and neighbors when comparing the two conditions overall, but there is a significant difference between the two conditions when lag is considered. That is, the shape of the function that describes performance over time for the identity condition is significantly different from that for the neighbor condition (see Fig. 1).

4. Discussion

There are two sets of findings in the analyses reported above. First, the results replicate the overall RB effect for the R-I (Kanwisher, 1987, Exp. 2) and R-N (Kanwisher and Potter, 1990, Exp. 4b) conditions. And, second, there are clear differences in the form of the lag effect obtained for the R-I and R-N conditions. Thus, while the shape of the function that describes correct recall of R2 in the R-I condition increases with increases in lag (as reported in Kanwisher, 1987, Exp. 1; see also Kanwisher and Potter, 1990; Park and Kanwisher, 1994), the shape of the function that describes correct recall of R2 for the R-N condition (initially) decreases with increases in lag. These results invite the inference that the RB effects obtained in the R-I and R-N conditions may have different causes. Specifically, it could be argued that repetition blindness is only obtained when an item is repeated (the R-I condition), and that the effect obtained when a similar item is presented (R-N condition) merely looks like RB but is, in fact, a form of inhibition with a different underlying cause from that at work in the R-I condition.

In the Introduction we noted that there are two ways in which extant accounts of RB might be able to explain the occurrence of the effect for both identical and orthographically similar items. One explanation is based on the assumption that R2 is misperceived as R1 and, thus, should be subject to repetition blindness. The other explanation is based on the assumption that the effect occurs not at the lexical level but at the level of sub-lexical, graphemic representation; that is, ‘‘blindness’’ occurs at the level of individual letters (or ordered letter clusters) that are shared between orthographically similar items (Bavelier et al., 1994). On either

view, the RB effect for the R-N condition should be *qualitatively* the same as that for the R-I condition. This expectation is motivated by the fact that both accounts assume that the ''blindness'' effects for identical and similar items have the same cause. The two hypotheses also make similar predictions concerning the magnitude of RB as a function of lag. Both hypotheses predict that the magnitude of the RB effect should be smaller in the R-N than the R-I condition—in one case because R2 is unlikely to be systematically misperceived as R1 and, thus, there will be fewer opportunities for ''blindness'' to occur, and, in the other, because R2 and R1 share fewer letters in the R-N than the R-I condition and, thus, there will also be fewer opportunities for ''blindness'' to occur. In other words, on either account, the size of the RB effect at any lag should not be larger for the R-N than the R-I condition. These expectations were not confirmed by the results of Experiment 1. We are thus led to conclude that the impaired performance in the R-N condition is unlikely to be due to repetition blindness. We will discuss this issue in greater detail in the General Discussion. Before doing so, however, we present additional evidence against the common cause hypothesis of RB for the R-I and R-N conditions.

EXPERIMENT 2: THE CASE OF HOMONYMS

Independently of the nature of the mechanism that gives rise to RB, the results we have reported indicate that this effect is sensitive to the factor of identity. However, both orthographic and lexical identity may be the source of this effect in word recognition tasks. In order to investigate whether orthographic identity is a sufficient factor in eliciting RB or whether lexical identity is required for the effect to occur, a second experiment was designed.

Experiment 2 has a two-fold purpose: it is a partial replication of Experiment 1, and an investigation of the roles of lexical and orthographic identity as sources of RB in word recognition. The following question is addressed: is the amount of RB elicited by sentences containing repeated-homonym (R-H) forms that belong to different grammatical classes (nouns and verbs) significantly different at any given lag from that elicited by sentences containing an R-I form? The reason for using homonyms is because these words are identical at the orthographic level but differ at the lexical level. If RB in word recognition tasks were to result merely from orthographic overlap between R1 and R2, then, performance for homonyms should be indistinguishable from performance with identical items—after all, homonyms are orthographically (and phonologically) identical. However, if RB in word recognition tasks were to result from activation of a common lexical representation, then, performance for the R-H condition should be different from that for the R-I condition, and similar to the R-N condition.

Two variables were investigated in this experiment: type of ''repeated'' item (identical word vs. homonym) and temporal distance (lag) between the first and the second occurrence of the repeated item. Lag ranged between one and three intervening words. Repeated items could either be identical and therefore belong

to the same grammatical class (either noun or verb) or they could be homonyms and belong to different grammatical classes (noun or verb).

Two versions of this experiment were run: a pilot test (Experiment 2a) and a replication (Experiment 2b).

EXPERIMENT 2A: PILOT

5. Method

5.1. Subjects

Twenty-four subjects were recruited for the experiment. They were native speakers of American English and had normal or corrected-to-normal vision. They were students from Johns Hopkins University. Subjects were paid for their participation.

5.2. Materials

A set of 15 sentences containing a repeated word—the R-I condition—was constructed (e.g., To pick the rose she put her rose down). As in Experiment 1, there are two controls for this condition: the unrepeated control (C-I: e.g., To pick the flower she put her rose down) and the blank control (B-I: e.g., To pick the rose she put her down).

Another set of 15 sentences containing a ''repeated'' item—the R-H condition—was constructed. In this case the repeated items were pairs of homonym words (e.g., To pick a rose she quickly rose from the chair). As for the previous set of experimental sentences, two sets of controls were constructed: the unrepeated control (C-H: e.g., To pick a flower she quickly rose from the chair) and the blank control (B-H: e.g., To pick a rose she quickly from the chair).

All sentences were 6–10 words long. The two sets of sentences (R-I and R-H and their controls) were matched overall for length in number of words (mean length = 8.5 for both conditions). There were three sets of sentences for the lag 1 condition, eight sets for the lag 2 condition, and four sets for the lag 3 condition. In eight of the R-I sentences for each lag condition the repeated word was a noun (e.g., To pick the rose she put her rose down), and in seven a verb (e.g., Some workers pound slowly but pound well). For the R-H sentences, six sentences presented the alternation N-V (e.g., She dropped her ring hearing the bell ring loudly), and nine the alternation V-N (e.g., He trains conductors of trains well). No other word or functor in the sentences was repeated. The repeated words never appeared first or last in the sentence. The full list of experimental sentences is shown in Appendix B.

Two other sets of sentences were used as fillers: The sentences (nine repeated, nine unrepeated control, and nine blank control sentences) used by Kanwisher

(1987, Exp. 2), which we included to evaluate our replication of the RB effect, and 16 new sentences, eight of which had a missing word.

5.3. Design

The six versions of each sentence (R-I, C-I, B-I, and R-H, C-H, B-H) appeared in different versions of the experiment, counterbalanced so that each subject saw five sentences in each condition (repeated, unrepeated, and blank) for a total of 15 experimental sentences per subject. The sentences appeared in pseudo-random order.

5.4. Procedure and apparatus

The same procedure and apparatus as that used in Experiment 1 weres used in this experiment. Speed of presentation was selected according to each subject's ability to perform the task, as described in Experiment 1. Speeds ranged from 33 to 100 ms: One subject viewed the words at 33 ms exposure, three subjects at 50 ms, 11 subjects at 67 ms, and four subjects at 83 ms.

6. Results

6.1. Scoring procedures

These were as in Experiment 1.

6.2. Analyses

As in Experiment 1, the data set was screened for outliers. No sentence group or subject was excluded.

A first analysis of the data evaluated whether an RB effect comparable to that reported for sentences by Kanwisher (1987, Exp. 2) was obtained in our experiment. For this purpose, we compared performance on the repeated and unrepeated sentences used by Kanwisher (Table 4a). An ANOVA by subjects showed an overall repeatedness effect on recall of R2 ($F(1, 18, .05) = 25.3$; $p < .0001$). This effect replicates the results obtained by Kanwisher (1987) in her Experiment 2. The same comparison was carried out for the sentences used in our experiment by collapsing across lag and type of repeated word (Table 4b). Overall, the same pattern of performance is obtained: there is a significant difference between the repeated condition and the unrepeated control. An analysis by subjects revealed an overall repeatedness effect on recall of R2 ($F(1, 18, .05) = 38.6$; $p < .0001$), and a main effect of lag ($F(2, 18, .05) = 23.3$; $p < .0001$), but no significant interaction.

Table 4
(a) Percent correct recall of R1 and R2 for repeated and unrepeated conditions collapsing across lags (Replication with Kanwisher's sentences). (b) Percent correct recall of R1 and R2 for repeated and unrepeated conditions collapsing across lags (Replication of the overall RB effect)

Condition	Repeated	Unrepeated	Blank
(a)			
R1	97.2	97.2	100.0
R2	51.4	97.2	1.5*
(b)			
R1	98.1	98.1	98.0
R2	53.9	92.3	2.0*

*Insertion rate of R1.

When overall performance in the R-I and R-H conditions (collapsing across lags) are compared, no significant difference is found between them (Table 5a). These results replicate the findings reported in Kanwisher and Potter (1990), Exp. 4b), which are reproduced in Table 5b for ease of comparison.

ANOVAs were then carried out to analyze the differences in performance for R2 among the different experimental conditions (Table 6). One analysis was carried out to compare the percentage of correct recall in the R-I condition and its control. This showed a main effect of condition ($F(1, 18, .05) = 53.9$; $p < .0001$) and lag ($F(2, 18, .05) = 15.7$; $p < .0001$), and a significant interaction of lag and condition ($F(2, 18, .05) = 6.2$; $p < .009$). These results indicate that there is an effect of repetition, and replicate the basic RB phenomenon for identical items.

Another analysis was carried out to compare the percentage of correct recall in the R-H condition and its control. This showed a main effect of condition ($F(1, 18, .05) = 42.2$; $p < .0001$) and lag ($F(2, 18, .05) = 6.0$; $p < .01$), but not a significant interaction of the two ($F(2, 18, .05) = 2.8$; $p < .09$). These results show that there is an effect of repetition in this condition as well, but that the magnitude of the

Table 5
(a) Percent correct recall of R1 and R2 for the repeated-identical and repeated-homonym conditions collapsing across lags. (b) Percent correct recall of R1 and R2 for the repeated-identical and repeated-homonym conditions collapsing across lags (Reproduced with modifications from Kanwisher and Potter, 1990, Exp. 4b)

Pair type/Critical word	R1		R2	
	Rep.	Unrep.	Rep.	Unrep.
(a)				
Identical (the watch – the watch)	97	98	45	92
Homonym (the watch – you watch)	99	98	62	96
(b)				
Identical (the cat – the cat)	93	89	54	93
Homonym (the rose – she rose)	91	85	48	85

Table 6
Percent correct recall of R2 (R and C conditions) and insertion rate of R1 (B conditions) at different lags for the different conditions

Condition	Lag		
	1	2	3
R-I	8.3	43.8	81.3
R-H	83.3	51.6	50.0
C-I	83.3	93.8	100.0
C-H	100.0	93.8	93.8
B-I	0.0	3.2	0.0
B-H	8.3	0.0	12.5

effect varies over time in a fashion different from the basic RB phenomenon (in the R-I condition).

A third analysis compared the R-I condition with the R-H condition (by comparing the difference between repeated sentences and their controls). This analysis showed no main effects of condition ($F(1, 18, .05) = 2.3$; $p < .2$) and lag ($F(2, 18, .05) = 1.1$; $p < .4$), but a significant interaction of the two ($F(2, 18, .05) = 7.0$; $p < .006$). These results show that there is no difference between identical items and homonyms when comparing the two conditions overall, but there is a significant difference between the two conditions when comparing them lag by lag. That is, the shape of the function that describes performance over time for the identity condition differs significantly from that for the homonym condition (see Fig. 2). These results replicate the main results of Experiment 1: they confirm

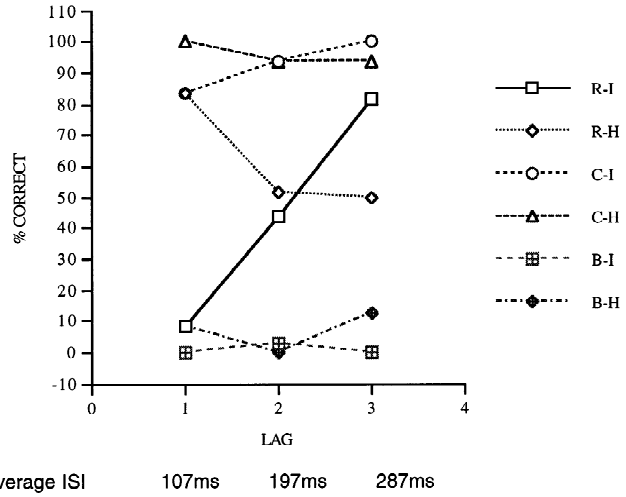

Fig. 2. Percent correct recall of R2 at different lags for repeated-identical (R-I), repeated-homonym (R-H), and their controls.

that the decreasing effect of RB as a function of lag is only obtained when the repeated items are identical at the lexical level.

EXPERIMENT 2B: A REPLICATION

The results from the pilot experiment with homonyms indicate that lexical identity rather than orthographic (and phonological) identity is the crucial factor in inducing the occurrence of RB. However, because the number of sentences at each lag in Experiment 2A varied, such that there were only three sets of sentences at one lag condition, we decided to replicate these findings with an expanded version of the pilot experiment. In the new version of the experiment an equal number of sets of sentences is used at each lag.

7. Method

7.1. Subjects

Thirty-six subjects were recruited for the experiment. They were native speakers of American English and had normal or corrected-to-normal vision. They were students either at Johns Hopkins University or Dartmouth College. Subjects from Johns Hopkins University were paid for their participation, whereas participation in this experiment for the Dartmouth College subjects constituted part of their requirements in the Psychology program.

7.2. Material

A set of 24 sentences containing a repeated word—the R-I condition—was constructed (e.g., Paper boats will *sink* and *sink* quickly). As in the previous experiment, there are two controls for this condition: the unrepeated control (C-I: e.g., Paper boats will *flip* and *sink* quickly) and the blank control (B-I: e.g., Paper boats will *sink* and quickly).

Another set of 24 sentences containing a ''repeated'' item—the R-H condition—was constructed. In this case, the repeated items were a pair of homonym words in which one was a noun and the other a verb (e.g., Paper boats in the *sink* will *sink* quickly). There were two controls for this condition as well: the unrepeated control (C-H: e.g., Paper boats in the *lake* will *sink* quickly), and the blank control (B-H: e.g., Paper boats in the *sink* will quickly).

The number of intervening items between R1 and R2 was varied, and ranged from one to three words. Each pair of R-I and R-H sentences was matched for lag. There were eight sentences for each lag for each condition. In one half of the R-I sentences for each lag condition the repeated word was a noun (e.g., After they got my *check* the *check* was stolen); in the other half the repeated word was a verb (e.g., Paper boats will *sink* and *sink* quickly). In one half of the R-H sentences the grammatical class of R2 was the same as that of R2 in the R-I sentences (e.g., R-I:

Paper boats will *sink* and *sink* quickly; R-H: Paper boats in the *sink* will *sink* quickly), and in the other half the grammatical class of R2 was different from that of R2 in the R-I sentences (e.g., R-I: Set the *watch* by that *watch* on my table; R-H: Set the *watch* when you *watch* him play). No other word or functor in the sentences was repeated. The repeated words never appeared in the first or last position in the sentence. Sentences were matched in length. The full list of experimental sentences is shown in Appendix C.

Two other sets of sentences were used as fillers. The set of 27 sentences (nine repeated, nine unrepeated control, and nine blank control sentences) used by Kanwisher (1987, Exp. 2), which we included in order to directly evaluate our replication of the RB effect. Another set of 22 sentences was used as fillers; of these, 11 had a missing word.

7.3. Design

The six versions of each sentence (R-I, C-I, B-I, and R-H, C-H, B-H) appeared in different versions of the experiment, counterbalanced so that each subject saw four sentences in each condition for a total of 24 experimental sentences per subject. The sentences appeared in pseudo-random order.

7.4. Procedure and apparatus

The same procedure and apparatus as that used in Experiment 1 were used in this experiment. Speed of presentation was selected according to each subject's ability to perform the task, as described in Experiment 1. Speeds of presentation ranged from 33 ms to 84 ms: five subjects viewed the words at 33 ms exposure, eight subjects at 50 ms, 12 subjects at 67 ms, and 11 subjects at 83 ms.

8. Results

8.1. Scoring procedures

The same scoring procedure as that used in Experiment 1 was used in this experiment.

8.2. Analyses

As in Experiment 1, the data set was screened for outliers. No subjects but four sentence groups were excluded from analysis.

A first analysis of the remaining data was carried out in order to determine whether we could replicate Kanwisher's (Kanwisher, 1987, Exp. 2) original RB result. Since a subset of the filler sentences used in our experiment were Kanwisher's original sentences, we first compared performance for those sentences in the repeated and unrepeated condition (Table 7a). The effect obtained with these

Table 7
(a) Percent correct recall of R1 and R2 for repeated and unrepeated conditions collapsing across lags (replication with Kanwisher's sentences). (b) Percent correct recall of R1 and R2 for repeated and unrepeated conditions collapsing across lags (replication of the overall RB effect)

Condition	Repeated	Unrepeated	Blank
(a)			
R1	96.2	98.1	100.0
R2	42.2	87.5	0.0*
(b)			
R1	92.5	98.7	96.2
R2	54.3	95.7	4.2*

*Insertion rate of R1.

sentences replicates the effect obtained by Kanwisher. The same comparison was made for the sentences used in our experiment by collapsing across lag and type of repeated word (Table 7b). Overall, the same pattern of performance was obtained: we observed a significant difference in report of R2 between the repeated condition and the unrepeated control ($F(1, 30) = 169.6,\ p < .0001$).

When overall performance in the R-I and R-H conditions (collapsing across lags) are compared, no significant difference is found between them (Table 8). These results replicate the findings reported in Kanwisher and Potter (1990, Exp. 4b) (see Table 5b).

A series of ANOVAs were then carried out in order to analyze the differences in performance for R2 among the different experimental conditions (see Table 9).

One analysis was carried out to compare the percentage of correct recall in the R-I condition and its control. This analysis showed significant main effects of condition ($F(1, 30, .05) = 102.1;\ p < .0001$) and lag ($F(2, 30, .05) = 9.7;\ p < .001$), and a significant interaction of lag by condition ($F(2, 30, .05) = 10.5;\ p < .0003$). These results indicate that there is an effect of repetition, and replicate the basic RB phenomenon for identical items.

Another analysis was carried out to compare the percentage of correct recall in the R-H condition and its control. This showed significant main effects of condition ($F(1, 30, .05) = 91.7;\ p < .0001$) and lag ($F(2, 30, .05) = 5.4;\ p < .01$), but the interaction of the two was not significant ($F(2, 30, .05) = 2.3;\ p < .1$). These results show that there is an effect of repetition in this condition as well, but

Table 8
Percent correct recall of R1 and R2 for the repeated-identical and repeated-homonym conditions collapsing across lags

Pair type/Critical word	R1		R2	
	Rep.	Unrep.	Rep.	Unrep.
Identical (the watch – the watch)	94	98	57	95
Homonym (the watch – you watch)	90	98	51	97

Table 9
Percent correct recall of R2 (R and C conditions) and insertion rate of R1 (B conditions) at different lags for the different conditions

Condition	Lag		
	1	2	3
R-I	31.4	67.7	71.7
R-H	64.5	39.4	47.7
C-I	91.7	97.2	95.7
C-H	100.0	94.3	95.6
B-I	0.0	0.0	4.3
B-H	11.1	2.9	6.3

that the magnitude of the effect varies over time in a fashion different from the basic RB phenomenon (in the R-I condition).

A third analysis compared the R-I condition with the R-H condition (by comparing the difference between repeated sentences and their respective control sentences). This analysis showed no significant main effects (condition ($F(1, 30, .05) = .7$; $p < .4$) and lag ($F(2, 30, .05) = .8$; $p < .5$)), but a significant interaction of the two ($F(2, 30, .05) = 8.4$; $p < .001$). These results show that there is no difference between identical items and homonyms when comparing the two conditions overall, but there is a significant difference between the two conditions when comparing them lag by lag. That is, the shape of the function that describes performance over time for the identity condition is significantly different from that for the homonym condition (see Fig. 3). These results replicate the results from

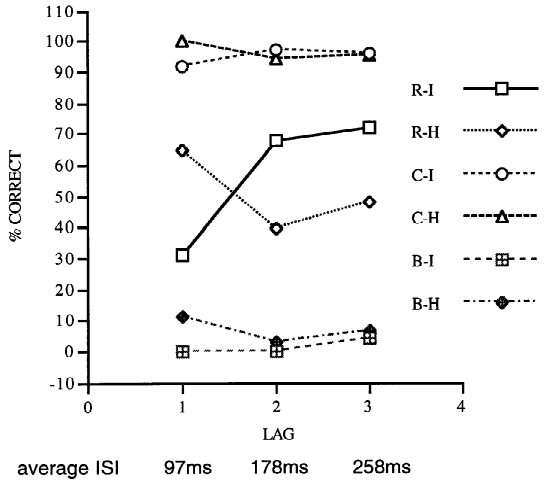

Fig. 3. Percent correct recall of R2 at different lags for repeated-identical (R-I), repeated-homonym (R-H), and their controls.

Experiment 1 in one important respect: namely, that the decreasing effect of RB as a function of lag is only obtained when the repeated items are identical at the lexical level.

9. Discussion

The analyses reported above show two sets of findings. First, the results replicate the overall RB effect in which we observe an effect of repetition when comparing sentences with a repeated word versus their controls (Kanwisher, 1987, Exp. 2); the results also replicate Exp. 4b of Kanwisher and Potter (1990), in which no overall effect of type of repeated words is found when comparing sentences with repeated words and sentences with homonyms. Second, the results replicate the effect of lag in the R-I condition (Kanwisher, 1987, Exp. 1) as well as, and more importantly, the interaction of word type by lag reported in Experiment 1. That is, the shapes of the functions that describe correct performance for R2 are different for the R-I and R-H conditions (Fig. 2).

The first set of results indicates that our findings are congruent with the results reported in the RB literature. The second set of results shows that there are different effects for repeated identical and homonym forms. Specifically, we find that performance for ''repeated'' homonyms is impaired relative to control words but that the form of the impairment is not the same as that for repeated words. This pattern of results is similar to that obtained in Experiment 1 between the R-I and R-N conditions. However, unlike Experiment 1 where R1 and R2 in the R-N condition were not orthographically identical, in Experiment 2, R1 and R2 in the R-H condition are orthographically identical. Thus, the different patterns of performance between the identical and the orthographically similar conditions (R-H and R-N) cannot be attributed to differences in degree of orthographic overlap: orthographic identity (and, therefore, also similarity) is not a sufficient condition for eliciting the full-blown pattern of repetition blindness in word recognition tasks. We discuss the implications of this conclusion in the General Discussion.

GENERAL DISCUSSION

The results of Experiment 1 and 2 provide crucial information for the interpretation of the RB effect. The novel result in these experiments is that the temporal function that characterizes the impairment in reporting the second occurrence of a repeated item (Kanwisher, 1987, Exp. 2) is only obtained when R2 and R1 are identical at the lexical level. When R2 and R1 are not identical at the lexical level, regardless of whether they were orthographically similar (orthographic neighbors) or identical (homonyms), the characteristic temporal function showing a reduction in RB with increases in lag was not obtained. This pattern of results has implications for our understanding of the phenomenon of repetition

blindness and for theories of lexical representation and processing. We discuss these in turn.

An obvious implication of the results we have reported is that it helps define more precisely the empirical boundaries of the RB phenomenon. A spate of results showing impaired processing of the second of two visually (. . . *car* . . . *cart* . . .) or phonologically (. . . *ate* . . . *eight* . . .) similar items have been subsumed under the rubric of repetition blindness (Kanwisher and Potter, 1990; Bavelier and Potter, 1992; Bavelier et al., 1994). However, in none of these studies was the effect of lag on correct recall of R2 considered to be a relevant factor for distinguishing between RB and other forms of performance impairment. Our studies show that the pattern of repetition impairment as a function of lag has a different shape for identical and similar items. If we include the effect of lag on performance in defining RB, then, our results show that the impaired performance observed for the R-N and R-H conditions and that obtained for the R-I condition are different phenomena that have been inappropriately subsumed under a common rubric.

The contrast in performance between similar and identical items does not depend on the fact that we used a sentence repetition task in our experiments, nor is it restricted to visual similarity. In a series of experiments in which subjects were required to report a string of three words, we also observed an interaction between lag and type of ''repeated'' item in the correct recall of R2 (Caramazza and Pérez, in preparation). In these experiments, patterned after Bavelier et al. (1994), subjects were shown six-item strings consisting of sets of symbols and words arranged in such a way as to obtain different lag conditions (e.g., Lag 1: &≠$&% DICE (DINE) LONG DICE %$&@% $&≠%@; Lag 2: %$&@% DICE (DINE) $&≠%@ LONG DICE &≠$&%). Performance for identical items (. . . *dice* . . . *dice* . . .) showed the characteristic pattern of increasing correct performance in the recall of R2 as a function of increases in lag between R1 and R2. However, this signature effect was not systematically obtained for orthographically similar words (. . . *dine* . . . *dice* . . .) nor was it obtained for homophones (. . . *eight* . . . *ate* . . .). Thus, it would appear that the interaction of word type by lag in the correct recall of R2 is a robust effect that is not restricted to sentence recall, nor is it restricted to visual similarity but extends to homophones as well.

We have interpreted our results as indicating that, in tasks that involve word recognition, RB is only obtained for items that are ''identical'' at the lexical level. That is, we have argued that neither orthographic similarity (i.e., graphemic overlap) nor even orthographic identity (homonyms) are sufficient conditions for obtaining RB. However, there is considerable evidence which suggests that RB can be obtained for letters (e.g., Park and Kanwisher, 1994), numbers (e.g., Bavelier and Potter, 1992), color patches (Kanwisher et al., 1995) and pictures (Bavelier, 1994). How, then, do we reconcile these seemingly contradictory claims? The apparent contradiction dissolves once we clarify what might be meant by an ''identical'' item. In the present context, identity is not defined in terms of

physical properties of the stimulus but in terms of a common representation at a given level of processing. More specifically, identity is defined at the level at which stimulus information is encoded for recognition. And, since we may be required to recognize single letters as well as words, identity may correspondingly be defined in terms of individual letters or words. That is, in tasks that require subjects to recognize and report a string of letters, identity is defined in terms of individual letters; in tasks that require subjects to recognize and report strings of words, identity is defined in terms of words. This contrast is well illustrated by results reported by Kanwisher and Potter (1990), who found that RB is obtained for letters presented one at the time but still comprising a word (M-A-N-A-G-E-R recognized as *manger*) but not for letters presented within a word context (*heart* preceded by *fault* is not recognized as *hear*). That is, in tasks that require recognition of individual letters, identity is defined in terms of individual letters and RB is obtained for repeated letters; in tasks that require recognition of strings of words, identity is defined in terms of words and *no* RB is obtained for repeated letters. On this view, RB is an effect that occurs at the level of representation where a stimulus is encoded for recognition and recall; earlier levels of representation do not contribute to the RB effect.[2]

The reported interaction of word type by lag has led us to distinguish between two types of ''repetition'' impairment. One type of impairment—repetition blindness—occurs when the same item (at the relevant level of processing) is presented twice for recognition within a short time period. The other type of ''repetition'' impairment is an inhibitory effect between lexical neighbors. That is, recognition of R2 is impaired because of the inhibitory effect produced in the course of recognizing R1 on all orthographically (or phonologically) similar lexical entries.[3] This interpretation finds independent support in findings relative to lexical processing of orthographic neighbors (e.g., Colombo, 1986; Grainger et al., 1989) and stem homographs[4] (Laudanna et al., 1989, 1992). These studies show that negative activation (inhibition) occurs under conditions in which lexical forms compete for selection.

The hypothesis that the selection of a target lexical representation is the result of the joint effects of positive (priming) and negative activation (inhibition) has

[2] This may be too strong a claim. It is entirely possible that early levels of processing may modulate aspects of the RB effect. Nonetheless, if there are any such modulating effects they are relatively small compared to the effects of lexical identity.

[3] Bavelier et al. (1994) discuss in some detail the relationship between the type of lag effect obtained in the R-N condition and the results of priming studies with orthographic neighbors. However, they did not pursue the possibility suggested here that the impaired performance observed for the R-I and the R-N and R-H conditions have different underlying causes.

[4] A stem homograph is that part of a lexical item that remains after it has been stripped of its inflectional affixes. It is an ambiguous stem that can belong to different grammatical classes. For example, in Italian, ''port-'' as in ''porta'' can be interpreted as ''egli porta'' (he carries) from the verb ''port-are'' (to carry), or as ''la porta'' (the door) from the noun ''port-a'' (door, sing., fem.).

previously been invoked in order to explain various effects in word recognition experiments. Positive activation is the result of activation from the input stimulus, such that the strength of activation of any lexical representation is directly proportional to its similarity to the input stimulus (Morton, 1979; McClelland and Rumelhart, 1981; Rumelhart and McClelland, 1981), as well as the result of excitatory connections among lexical forms at a lexicon-internal level, as in the case of morphologically related items (e.g., Murrell and Morton, 1974; Stanners et al., 1979; Fowler et al., 1985; Caramazza et al., 1988; Marslen-Wilson et al., 1994). Negative activation has been shown to occur under conditions in which lexical items compete for selection. Such inhibition may occur among orthographically similar lexical forms (Colombo, 1986; Grainger et al., 1989; Grainger, 1990; Grainger and Segui, 1990; Segui and Grainger, 1990; Snodgrass and Mintzer, 1993; but see Grainger et al., 1992) as well as between stem homographs (Laudanna et al., 1989, 1992) and competing suffixes (Caramazza et al., 1988; Marslen-Wilson et al., 1994).

The roles of positive and negative activation are well illustrated in the study on stem homographs by Laudanna et al. (1989). In this study, lexical decisions were facilitated when prime and target word shared both form and meaning, whereas inhibition was obtained when only form was shared. Thus, for example, reaction time was consistently faster than the appropriate control for the target *conto* (*cont-*: to count; *-o*: first person singular, present tense) when preceded by *conta* (*cont-*: to count; *-a*: third person singular, present tense), but was consistently slower than the appropriate control when preceded by *conte* (*cont-*: the count (nobility); *-e*: masculine, singular). Note that what distinguishes the pair *conta*/*conto* from the pair *conte*/*conto* is that the former share a lexical stem (*cont-*) whereas the latter do not have a common lexical entry even though they have orthographically identical stems. In other words, what determines whether facilitation or inhibition is obtained is whether or not the two orthographic forms share a common lexical entry. Thus, while the findings relative to orthographic neighbors suggest the presence of an inhibitory effect at some (unspecified) level of processing of the input forms, the findings relative to the stem homographs point to the presence of such an effect at the lexical level, that is, at a level at which a given orthographic form is identified as a lexical form (a stem in this case). Similarly, our findings relative to the orthographically similar forms (Experiment 1) suggest the presence of an inhibitory effect that may arise as early as the pre-lexical orthographic level, that is, at a level at which items that are orthographically similar compete for selection. The findings relative to the homonyms (Experiment 2) indicate, instead, the presence of an inhibitory effect at a lexical level of processing, that is, at a level at which items that are lexically similar compete for selection. The available results do not allow us to decide whether effects at different levels are at play in the case of orthographically similar and orthographically identical (homonyms) forms or whether both effects result from inhibition between lexical forms. However, the results with homonyms (like those with stem homographs) do require that we assume inhibitory processes at the lexical level.

If we adopt the position that the cause of the impaired performance for orthographically similar items is the inhibitory process between lexical neighbors, we must assume that the strength of the inhibitory effect has its maximum value not immediately upon presentation of R1 but after a brief delay during which the strength of inhibition increases. This assumption is necessary in order to account for the lag effect observed in the R-N and R-H conditions, where impaired performance in reporting R2 (initially) increased with increases in lag.[5] Obviously, this assumption must receive independent confirmation before it can be asserted with any confidence. Unfortunately we are not aware of strong evidence in support of the assumption, although there are results that are consistent with it (e.g., Grainger and Segui, 1990).

Independent evidence consistent with the hypothesis that the point of maximum inhibition between competing lexical representations occurs some 200–300 ms after the prime word is provided by results on lexical disambiguation. Results obtained with a cross-modal, semantic priming paradigm for homonyms in sentence contexts have shown access of the multiple meanings of the ambiguous words at short SOAs with selection of the contextually relevant meaning only at longer SOAs (Conrad, 1974; Neely, 1977; Swinney, 1979; Tanenhaus et al., 1979; Seidenberg et al., 1982; Frost and Bentin, 1992; but see Tabossi, 1988; Simpson, 1994). For example, Tanenhaus et al. (1979) investigated the processing of noun–verb homonym forms in syntactic contexts which either biased the noun reading or the verb reading (e.g., I bought the watch; I will watch). Their results showed that at 0 ms stimulus onset asynchrony (SOA) naming latencies related to either reading were facilitated regardless of the biasing context, whereas at longer SOAs (200 ms) facilitation obtained only for targets related to the category specific reading of the ambiguous word biased by the context. These results can be interpreted as indicating that two distinct lexical representations (one for the noun and one for the verb) are initially accessed and only later is the contextually adequate reading selected as a result of either activation decay or inhibition of the other meanings. The crucial point here is that if the suppression of alternative readings of ambiguous words is achieved through inhibitory processes, then these processes seem to have their maximal effect not immediately upon presentation of the prime but after a brief delay.

Finally, it should be noted that the results of Experiment 2, which show

[5] An alternative account (or complicating factor) is that the increase in inhibition as a function of lag might reflect the specific mixture of word frequencies of the ''repeated'' items. The work of Grainger and Segui (1990) and Segui and Grainger (1990) has shown that inhibition among orthographic neighbors is modulated by the relative frequencies of primes and targets. These authors found that higher-frequency primes inhibit competitors sooner (60 ms.) than lower-frequency primes (360 ms). The shape of the lag function for the R-N and R-H conditions in our experiments may simply reflect the distribution of high–low and low–high frequency pairs. Future work will have to systematically explore the frequency factor.

different effects for repeated words and homonyms, have interesting implications for theories of lexical processing. If we are correct in concluding that RB is only obtained when two items share a common representation at the relevant level of processing, then it follows that homonyms do not share a common representation at the lexical level. This is obviously true at the level of semantics: (the) *rose* and (he) *rose* have independent semantic representations; in fact, they are not even semantically related. It also seems to be true at the level of lexical form. Thus, although the lexical forms of ambiguous words can be represented either by a single entry (e.g., $<$BUG$>$) which is linked to two distinct meanings (e.g., {tiny microphone} and {insect}) or as two independent forms (e.g., $<BUG_1>$ and $<BUG_2>$) each linked to its own set of semantic representation, the results of Experiment 2 seem to favor the latter hypothesis. This conclusion is consistent both with cross-modal priming experiments (e.g., Tanenhaus et al., 1979; Seidenberg et al., 1982) and neuropsychological evidence on reading and spelling of homonyms (Caramazza and Hillis, 1991; Hillis and Caramazza, 1995). The latter studies have shown that brain-damaged subjects can be selectively impaired in producing or recognizing words of only one grammatical class (either nouns or verbs) in only one modality of use (either phonology or orthography). Thus, there are neurologically impaired subjects who show modality-specific impairments in processing only the noun or only the verb member of homonym pairs: for example, a patient may be able to write and orally name (he) *rose* but only be able to orally name (the) *rose*; another patient may be able to auditorially and visually recognize (the) *rose* but only be able to auditorially recognize (he) *rose*. These results strongly indicate that homonyms have independent lexical representations.

In conclusion, the results we have reported have direct implications for the interpretation of the RB effect. We have shown that orthographic similarity (and even identity) although necessary is not a sufficient factor in eliciting the inhibitory effect defined as RB in word recognition tasks. Identity at the relevant level of processing is required in order to obtain the full pattern of performance characteristic of RB. Our results also indicate that the RB effect can be used as a method for investigating lexical processing. Through the use of this method we have provided converging evidence that orthographically similar items are inhibitorily linked and that homonyms have independent representations at both the semantic and the lexical form level.

Acknowledgments

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Appendix A

Materials for Experiment 1

Lag 1

Set #	Cond.	Stimuli
1	RI	After checking his old barn the barn was closed
1	CI	After checking his old cow the barn was closed
1	BI	After checking his old barn the was closed
1	RN	After searching for your yarn the barn was closed
1	CN	After searching for your thread the barn was closed
1	BN	After searching for your yarn the was closed
2	RI	While stepping over a grate the grate popped up
2	CI	While stepping over a sewer the grate popped up
2	BI	While stepping over a grate the popped up
2	RN	When kneeling beside his grave the grate popped up
2	CN	When kneeling beside his memorial the grate popped up
2	BN	When kneeling beside his grave the popped up
3	RI	As I looked at his grin my grin got bigger
3	CI	As I looked at his smirk my grin got bigger
3	BI	As I looked at his grin my got bigger
3	RN	As I felt the gentle grip my grin got bigger
3	CN	As I felt the gentle grasp my grin got bigger
3	BN	As I felt the gentle grip my got bigger
4	RI	When in need to rest they rest for two hours
4	CI	When in need to relax they rest for two hours
4	BI	When in need to rest they for two hours
4	RN	When preparing to test they rest for two hours
4	CN	When preparing to dance they rest for two hours
4	BN	When preparing to test they for two hours
5	RI	When parents slap they slap their children gently
5	CI	When parents punish they slap their children gently
5	BI	When parents slap they their children gently
5	RN	Sometimes when children snap parents slap them gently
5	CN	Sometimes when children disobey parents slap them gently
5	BN	Sometimes when children snap parents them gently
6	RI	As I clean they clean their dirty clothes
6	CI	As I wash they clean their dirty clothes
6	BI	As I clean they their dirty clothes
6	RN	As I clear they clean off the table

Lag 1 (contd.)

Set #	Cond.	Stimuli
6	CN	As I dry they clean off the table
6	BN	As I clear they off the table
7	RI	I had so much greed and greed is bad
7	CI	I had so much avidity and greed is bad
7	BI	I had so much greed and is bad
7	RN	Often when young dogs breed their greed is strong
7	CN	Often when young dogs mate their greed is strong
7	BN	Often when young dogs breed their is strong
8	RI	After sharpening my blade the blade still looked dull
8	CI	After sharpening my skates the blade still looked dull
8	BI	After sharpening my blade the still looked dull
8	RN	The sharpener is to blame the blade is dull
8	CN	The sharpener is to fault the blade is dull
8	BN	The sharpener is to blame the is dull
9	RI	I modeled her scalp his scalp and the hand
9	CI	I modeled her nose his scalp and the hand
9	BI	I modeled her scalp his and the hand
9	RN	I often scald my scalp when taking a shower
9	CN	I often scorch my scalp when taking a shower
9	BN	I often scald my when taking a shower
10	RI	When I start to dust they dust with me
10	CI	When I start to sweep they dust with me
10	BI	When I start to dust they with me
10	RN	The museum owns a bust they dust every day
10	CN	The museum owns a statue they dust every day
10	BN	The museum owns a bust they every day
11	RI	Even when trying not to slide they slide on ice
11	CI	Even when trying not to stumble they slide on ice
11	BI	Even when trying not to slide they on ice
11	RN	I will cut a slice to slide under the microscope
11	CN	I will cut a sliver to slide under the microscope
11	BN	I will cut a slice to under the microscope
12	RI	When training to hurl they hurl stones
12	CI	When training to heave they hurl stones
12	BI	When training to hurl they stones
12	RN	When experiencing a hurt they hurl stones
12	CN	When experiencing a distress they hurl stones
12	BN	When experiencing a hurt they stones
13	RI	I want to rent and rent immediately

Lag 1 (contd.)

Set #	Cond.	Stimuli
13	CI	I want to compare and rent immediately
13	BI	I want to rent and immediately
13	RN	I want a tent to rent immediately
13	CN	I want a jeep to rent immediately
13	BN	I want a tent to immediately

Lag 2

Set #	Cond.	Stimuli
14	RI	My favorite fish killed another fish in the tank
14	CI	My favorite bass killed another fish in the tank
14	BI	My favorite fish killed another in the tank
14	RN	My favorite dish is fresh fish with lemon sauce
14	CN	My favorite meal is fresh fish with lemon sauce
14	BN	My favorite dish is fresh fish with lemon sauce
15	RI	I enjoy watching my duck while the duck eats
15	CI	I enjoy watching my frog while the duck eats
15	BI	I enjoy watching my duck while the eats
15	RN	Under my old wood dock the baby duck eats
15	CN	Under my old wood rocker the baby duck eats
15	BN	Under my old wood dock the baby eats
16	RI	I heard this idiom and another idiom I cannot remember
16	CI	I heard this rhyme and another idiom I cannot remember
16	BI	I heard this idiom and another I cannot remember
16	RN	The word was idiot in the idiom I cannot remember
16	CN	The word was imbecile in the idiom I cannot remember
16	BN	The word was idiot in the I cannot remember
17	RI	My socks cling but they cling only to their mate
17	CI	My socks stick but they cling only to their mate
17	BI	My socks cling but they only to their mate
17	RN	Atomic particles may fling when they cling to each other
17	CN	Atomic particles may merge when they cling to each other
17	BN	Atomic particles may fling when they to each other
18	RI	When I lift the books lift the shelf
18	CI	When I arrange the books lift the shelf
18	BI	When I lift the books the shelf
18	RN	When I list the names lift the books
18	CN	When I shout the names lift the books

Lag 2 (contd.)

Set #	Cond.	Stimuli
18	BN	When I list the names the books
19	RI	Some women like to curl hair and curl eyelashes
19	CI	Some women like to comb hair and curl eyelashes
19	BI	Some women like to curl hair and eyelashes
19	RN	When getting ready to curb fights we curl weights
19	CN	When getting ready to tackle fights we curl weights
19	BN	When getting ready to curb fights we weights
20	RI	I had a hunch and the hunch was correct
20	CI	I had a sensation and the hunch was correct
20	BI	I had a hunch and the was correct
20	RN	Do not try to punch my good hunch out
20	CN	Do not try to kick my good hunch out
20	BN	Do not try to punch my good out
21	RI	Skirts are a new craze after the craze for shorts
21	CI	Skirts are a new fad after the craze for shorts
21	BI	Skirts are a new craze after the for shorts
21	RN	Chocolate cake I sometimes crave but the craze is vanilla
21	CN	Chocolate cake I sometimes desire but the craze is vanilla
21	BN	Chocolate cake I sometimes crave but the is vanilla
22	RI	I found a red leaf and orange leaf beside me
22	CI	I found a red candy and orange leaf beside me
22	BI	I found a red leaf and orange beside me
22	RN	I saw two people leap over a leaf beside me
22	CN	I saw two people jump over a leaf beside me
22	BN	I saw two people leap over a beside me
23	RI	I will first flip burgers then flip hot dogs
23	CI	I will first broil burgers then flip hot dogs
23	BI	I will first flip burgers then hot dogs
23	RN	In the film clip many people flip over walls
23	CN	In the film take many people flip over walls
23	BN	In the film clip many people over walls
24	RI	I will gladly pose before you pose for the picture
24	CI	I will gladly perform before you pose for the picture
24	BI	I will gladly pose before you for the picture
24	RN	Stand by the pole and then pose for his picture
24	CN	Stand by the bush and then pose for his picture
24	BN	Stand by the pole and then for his picture
25	RI	When we grab books they grab the paper
25	CI	When we grasp books they grab the paper

Lag 2 (contd.)

Set #	Cond.	Stimuli
25	BI	When we grab books they the paper
25	RN	After a gram they always grab more chips
25	CN	After a bite they always grab more chips
25	BN	After a gram they always more chips

Lag 3

Set #	Cond.	Stimuli
26	RI	My rank soared over his rank last term
26	CI	My standing soared over his rank last term
26	BI	My rank soared over his last term
26	RN	The tank moved past a rank practicing maneuvers
26	CN	The jeep moved past a rank practicing maneuvers
26	BN	The tank moved past a practicing maneuvers
27	RI	I copied a draft from the rough draft yesterday
27	CI	I copied an essay from the rough draft yesterday
27	BI	I copied a draft from the rough yesterday
27	RN	The strong ocean drift carried my essay draft away
27	CN	The strong ocean breeze carried my essay draft away
27	BN	The strong ocean drift carried my essay away
28	RI	I cut the shrub and one small shrub today
28	CI	I cut the hedge and one small shrub today
28	BI	I cut the shrub and one small today
28	RN	He gave a shrug sitting by the shrub today
28	CN	He gave a shout sitting by the shrub today
28	BN	He gave a shrug sitting by the today
29	RI	Water will first flow fast but then flow slowly
29	CI	Water will first squirt fast but then flow slowly
29	BI	Water will first flow fast but then slowly
29	RN	It will first blow slowly and then flow away
29	CN	It will first whistle slowly and then flow away
29	BN	It will first blow slowly and then away
30	RI	Artists very often shade water colors to shade their paintings
30	CI	Artists very often darken water colors to shade their paintings
30	BI	Artists very often shade water colors to their paintings
30	RN	People who shave their skin should shade it from light

Lag 3 (contd.)

Set #	Cond.	Stimuli
30	CN	People who pierce their skin should shade it from light
30	BN	People who shave their skin should it from light
31	RI	Adults never spin chairs but children spin them often
31	CI	Adults never whirl chairs but children spin them often
31	BI	Adults never spin chairs but children them often
31	RN	Babies always spit milk but never spin their chairs
31	CN	Babies always swallow milk but never spin their chairs
31	BN	Babies always spit milk but never their chairs
32	RI	My left heel ached but his heel was feeling better
32	CI	My left elbow ached but his heel was feeling better
32	BI	My left heel ached but his was feeling better
32	RN	Doctors will peel skin off his heel during the operation
32	CN	Doctors will cut skin off his heel during the operation
32	BN	Doctors will peel skin off his during the operation
33	RI	The chocolate glaze and white coconut glaze were both good
33	CI	The chocolate frosting and white coconut glaze were both good
33	BI	The chocolate glaze and white coconut were both good
33	RN	Do not glare at the chocolate glaze on my cake
33	CN	Do not stare at the chocolate glaze on my cake
33	BN	Do not glare at the chocolate on my cake
34	RI	My thumb and his left thumb were not hurt
34	CI	My elbow and his left thumb were not hurt
34	BI	My thumb and his left were not hurt
34	RN	Do not thump your broken left thumb while hammering
34	CN	Do not smash your broken left thumb while hammering
34	BN	Do not thump your broken left while hammering
35	RI	To shape behaviors one must shape early childhood actions
35	CI	To mold behaviors one must shape early childhood actions
35	BI	To shape behaviors one must early childhood actions
35	RN	The shame one feels may shape her future actions
35	CN	The guilt one feels may shape her future actions
35	BN	The shame one feels may her future actions
36	RI	If you suddenly slip then I will slip too
36	CI	If you suddenly trip then I will slip too
36	BI	If you suddenly slip then I will too
36	RN	If the skirt slit is small you slip easily
36	CN	If the skirt vent is small you slip easily
36	BN	If the skirt slit is small you easily

Appendix B

Materials for Experiment 2a

Lag 1

Set #	Cond.	Stimuli
1	RI	Whoever tried to mug me mug students frequently
1	RD	Whoever tried to mug me broke a mug of yours
1	CI	Whoever tried to rob me mug students frequently
1	CD	Whoever tried to rob me broke a mug of yours
1	BI	Whoever tried to mug me students frequently
1	BD	Whoever tried to mug me broke a of yours
2	RI	When we box you box in red trousers
2	RD	When you box take a box of gloves
2	CI	When we fight you box in red trousers
2	CD	When you fight take a box of gloves
2	BI	When we box you in red trousers
2	BD	When you box take a of gloves
3	RI	The box of matches has matches painted on it
3	RD	The color of matches often matches her dress
3	CI	The box of cigarettes has matches painted on it
3	CD	The color of cigarettes often matches her dress
3	BI	The box of matches has painted on it
3	BD	The color of matches often her dress

Lag 2

Set #	Cond.	Stimuli
4	RI	To count well they count mentally
4	RD	To count well the count shuts his door
4	CI	To add well they count mentally
4	CD	To add well the count shuts his door
4	BI	To count well they mentally
4	BD	To count well the shuts his door
5	RI	Set the watch by that watch on my table
5	RD	Set the watch when you watch him play

Lag 2 (contd.)

Set #	Cond.	Stimuli
5	CI	Set the time by that watch on my table
5	CD	Set the time when you watch him play
5	BI	Set the watch by that on my table
5	BD	Set the watch when you him play
6	RI	A horse that hated its bit spat the bit out
6	RD	A horse that hated its bit angrily bit you
6	CI	A horse that hated its food spat the bit out
6	CD	A horse that hated its food angrily bit you
6	BI	A horse that hated its bit spat the out
6	BD	A horse that hated its bit angrily you
7	RI	John noticed my saw as the saw looked new
7	RD	John noticed my saw as he saw the tools
7	CI	John noticed my tool as the saw looked new
7	CD	John noticed my hammer as he saw the tools
7	BI	John noticed my saw as the looked new
7	BD	John noticed my saw as he the tools
8	RI	Some workers pound slowly but pound well
8	RD	Some workers can pound one pound of nails
8	CI	Some workers hammer slowly but pound well
8	CD	Some workers can hammer one pound of nails
8	BI	Some workers pound slowly but well
8	BD	Some workers can pound one of nails
9	RI	He trains conductors and trains them well
9	RD	He trains conductors of trains well
9	CI	He tests conductors and trains them well
9	CD	He tests conductors of trains well
9	BI	He trains conductors and them well
9	BD	He trains conductors of well
10	RI	We saw a bear though the bear was far away
10	RD	We could bear seeing a bear far away
10	CI	We saw an animal though the bear was far away
10	CD	We could stand seeing a bear far away
10	BI	We saw a bear though the was far away
10	BD	We could bear seeing a far away
11	RI	When Paul ground coffee he ground it finely
11	RD	When Paul ground coffee the ground got dirty
11	CI	When Paul prepared coffee he ground it finely
11	CD	When Paul prepared coffee the ground got dirty
11	BI	When Paul ground coffee he it finely
11	BD	When Paul ground coffee the got dirty

Lag 3

Set #	Cond.	Stimuli
12	RI	To pick the rose she put her rose down
12	RD	To pick a rose she quickly rose from the chair
12	CI	To pick the flower she put her rose down
12	CD	To pick a flower she quickly rose from the chair
12	BI	To pick the rose she put her down
12	BD	To pick a rose she quickly from the chair
13	RI	She dropped her ring when taking the ring off
13	RD	She dropped her ring hearing the bell ring loudly
13	CI	She dropped her keys when taking the ring off
13	CD	She dropped her keys hearing the bell ring loudly
13	BI	She dropped her ring when taking the off
13	BD	She dropped her ring hearing the bell loudly
14	RI	There was a fire but soon the fire went out
14	RD	Because of the fire he had to fire him
14	CI	There was an alert but soon the fire went out
14	CD	Because of the alert he had to fire him
14	BI	There was a fire but soon the went out
14	BD	Because of the fire he had to him
15	RI	I press once and then press again
15	RD	I press once for the press to come in
15	CI	I push once and then press again
15	CD	I push once for the press to come in
15	BI	I press once and then again
15	BD	I press once for the to come in

Appendix C

Materials for Experiment 2b

Lag 1

Set #	Cat.	Cond.	Stimuli
1	V-V	RI	Paper boats will sink and sink quickly
1		CI	Paper boats will flip and sink quickly
1		BI	Paper boats will sink and quickly
1	N-V	RH	Paper boats in the sink will sink quickly

Lag 1 (contd.)

Set #	Cat.	Cond.	Stimuli
1		CH	Paper boats in the lake will sink quickly
1		BH	Paper boats in the sink will quickly
2	N-N	RI	He piles tires upon tires on his truck
2		CI	He piles boxes upon tires on his truck
2		BI	He piles tires upon on his truck
2	V-N	RH	He easily tires changing tires on his truck
2		CH	He easily mastered changing tires on his truck
2		BH	He easily tires changing on his truck
3	V-V	RI	They wish to fly and fly alone
3		CI	They wish to go and fly alone
3		BI	They wish to fly and alone
3	N-V	RH	They hope the fly will fly away
3		CH	They hope the bee will fly away
3		BH	They hope the fly will away
4	N-N	RI	After they got my check the check was stolen
4		CI	After they got my gift the check was stolen
4		BI	After they got my check the was stolen
4	V-N	RH	We should check your check before cashing it
4		CH	We should sign your check before cashing it
4		BH	We should check your before cashing it
5	N-N	RI	The box of matches has matches painted on it
5		CI	The box of cigarettes has matches painted on it
5		BI	The box of matches has painted on it
5	N-V	RH	The color of matches often matches their box
5		CH	The color of cigarettes often matches their box
5		BH	The color of matches often their box
6	V-V	RI	Have them board then board everyone else
6		CI	Have them pass then board everyone else
6		BI	Have them board then everyone else
6	V-N	RH	We can board your board before everything else
6		CH	We can carry your board before everything else
6		BH	We can board your before everything else
7	V-V	RI	Some workers can pound and pound well
7		CI	Some workers can hammer and pound well
7		BI	Some workers can pound and well
7	V-N	RH	Some workers can pound one pound of nails
7		CH	Some workers can hammer one pound of nails
7		BH	Some workers can pound one of nails
8	N-N	RI	After they stepped on my rose the rose was dead
8		CI	After they stepped on my flower the rose was dead
8		BI	After they stepped on my rose the was dead

Lag 1 (contd.)

Set #	Cat.	Cond.	Stimuli
8	N-V	RH	To pick a rose she rose from the chair
8		CH	To pick a flower she rose from the chair
8		BH	To pick a rose she from the chair

Lag 2

Set #	Cat.	Cond.	Stimuli
9	N-N	RI	We saw a bear although the bear was far away
9		CI	We saw an animal although the bear was far away
9		BI	We saw a bear although the was far away
9	V-N	RH	We could not bear seeing the bear far away
9		CH	We could not stand seeing the bear far away
9		BH	We could not bear seeing the far away
10	V-V	RI	What does it matter if you matter to me
10		CI	What does it mean if you matter to me
10		BI	What does it matter if you to me
10	N-V	RH	Einstein says matter does not matter in this case
10		CH	Einstein says energy does not matter in this case
10		BH	Einstein says energy does not in this case
11	V-V	RI	Often when Paul ground coffee he ground it finely
11		CI	Often when Paul prepared coffee he ground it finely
11		BI	Often when Paul ground coffee he it finely
11	N-V	RH	He was sitting on the ground while you ground coffee
11		CH	He was sitting on the floor while you ground coffee
11		BH	He was sitting on the ground while you coffee
12	N-N	RI	We had a horse that chewed his bit until the bit broke
12		CI	We had a horse that chewed his halter until the bit broke
12		BI	We had a horse that chewed his bit until the broke
12	V-N	RH	We had a horse that bit on his bit too hard
12		CH	We had a horse that chewed on his bit too hard
12		BH	We had a horse that bit on his too hard
13	V-V	RI	When we box you should box in red trousers
13		CI	When we fight you should box in red trousers
13		BI	When we box you should in red trousers

Lag 2 (contd.)

Set #	Cat.	Cond.	Stimuli
13	V-N	RH	When we box take the box of red gloves
13		CH	When we fight take the box of red gloves
13		BH	When we box take the box of gloves
14	N-N	RI	Set the watch by that watch on my table
14		CI	Set the time by that watch on my table
14		BI	Set the watch by that on my table
14	N-V	RH	Set the watch when you watch him play
14		CH	Set the time when you watch him play
14		BH	Set the watch when you him play
15	V-V	RI	He trains conductors and trains them well
15		CI	He selects conductors and trains them well
15		BI	He trains conductors and them well
15	V-N	RH	He trains conductors of trains well
15		CH	He selects conductors of trains well
15		BH	He trains conductors of well
16	N-N	RI	John noticed my saw since the saw looked new
16		CI	John noticed my tool since the saw looked new
16		BI	John noticed my saw since the looked new
16	N-V	RH	John noticed my saw as he saw the tools
16		CH	John noticed my hammer as he saw the tools
16		BH	John noticed my saw as he the tools

Lag 3

Set #	Cat.	Cond.	Stimuli
17	N-N	RI	Laws come to this court before the other court approves them
17		CI	Laws come to this congress before the other court approves them
17		BI	Laws come to this court before the other approves them
17	V-N	RH	He tried to court her during the court trial
17		CH	He tried to please her during the court trial
17		BH	He tried to court her during the trial
18	N-N	RI	Her right arm and his left arm were broken
18		CI	Her right foot and his left arm were broken
18		BI	Her right arm and his left were broken
18	V-N	RH	She came to arm them but her arm was sore
18		CH	She came to test them but her arm was sore
18		BH	She came to arm them but her was sore

Lag 3 (contd.)

Set #	Cat.	Cond.	Stimuli
19	V-V	RI	We had to groom the dog and groom him well
19		CI	We had to brush the dog and groom him well
19		BI	We had to groom the dog and him well
19	N-V	RH	For their wedding the groom asked us to groom his dog
19		CH	For their wedding the bride asked us to groom her dog
19		BH	For their wedding the groom asked us to his dog
20	V-V	RI	I press once and then press again
20		CI	I push once and then press again
20		BI	I press once and then again
20	N-V	RH	Let the press in when I press once
20		CH	Let the guest in when I press once
20		BH	Let the press in when I once
21	N-N	RI	There was a fire but soon the fire went out
21		CI	There was an alert but soon the fire went out
21		BI	There was a fire but soon the went out
21	N-V	RH	Because of the fire he had to fire him
21		CH	Because of the alert he had to fire him
21		BH	Because of the fire he had to him
22	N-N	RI	She dropped her ring when taking the ring off
22		CI	She dropped her keys when taking the ring off
22		BI	She dropped her ring when taking the off
22	N-V	RH	She dropped her ring hearing the bell ring loudly
22		CH	She dropped her keys hearing the bell ring loudly
22		BH	She dropped her ring hearing the bell loudly
23	V-V	RI	Those who tried to mug me last year mug students frequently
23		CI	Those who tried to rob me last year mug students frequently
23		BI	Those who tried to mug me last year students frequently
23	V-N	RH	Those who tried to mug me broke a mug of yours
23		CH	Those who tried to rob me broke a mug of yours
23		BH	Those who tried to mug me broke a of yours
24	V-V	RI	To count well they often count mentally
24		CI	To add well they often count mentally
24		BI	To count well they often mentally
24	V-N	RH	To count well the old count shuts his door
24		CH	To add well the old count shuts his door
24		BH	To count well the old shuts his door

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