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BAVELIER, Daphné, PRASADA, Sandeep, SEGUI, Juan

Abstract

Repetition Blindness (RB) is the failure to recall the 2nd instance of a rapidly presented word. Five experiments investigated the orthographic and phonological representations involved in RB. Exps 1 and 2 found that the RB effect between orthographic neighbors is modulated by the relative frequency of the words, but not their absolute frequency. Exp 3 showed that the reduced RB effect between neighbors as compared with identical words is due to the reduced orthographic overlap, not to a lack of morphological or semantic overlap. Exps 4 and 5 showed that the RB effect occurs between phonologically related items, and that phonological and frequency properties of the target's orthographic neighbors affect the size of the effect. It is concluded that orthographic RB and phonological RB are sensitive to the target's neighborhood organization and arise from similar mechanisms, but at different stages of processing.


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Repetition Blindness Between Words: Nature of the Orthographic and Phonological Representations Involved

Daphne Bavelier, Sandeep Prasada, and Juan Segui

Repetition blindness (RB) is the failure to recall the second instance of a rapidly presented word. Five experiments investigated the orthographic and phonological representations involved in RB. Experiments 1 and 2 found that the RB effect between orthographic neighbors is modulated by the relative frequency of the words, but not their absolute frequency. Experiment 3 showed that the reduced RB effect between neighbors as compared with identical words is due to the reduced orthographic overlap, not to a lack of morphological or semantic overlap. Experiments 4 and 5 showed that the RB effect occurs between phonologically related items and that phonological and frequency properties of the target's orthographic neighbors affect the size of the effect. We conclude that orthographic RB and phonological RB are sensitive to the target's neighborhood organization and arise from similar mechanisms, but at different stages of processing.

The term repetition effect has recently received much attention in cognitive psychology. In this phenomenon, the presentation of a word facilitates the processing of that word on a subsequent presentation. This effect is robust and has been demonstrated using a variety of experimental paradigms, including recognition thresholds (Carroll & Kirsner, 1982; Evett & Humphreys, 1981; Feustel, Shiffrin, & Salasoo, 1983; Humphreys, Besner, & Quinlan, 1988; Jacoby, 1983; Morton, 1979), lexical decision (Besner & Swan, 1982; Forbath, Stanners, & Hochhaus, 1974; Kirsner & Smith, 1974; Norris, 1984; Scarborough, Cortese, & Scarborough, 1977; Scarborough, Gerard, & Cortese, 1979, 1984), and naming (Feustel et al., 1983; Scarborough et al., 1977). The effect is also observed when the first presentation is masked and thus prevents conscious identification of the prime (Evett & Humphreys, 1981; Forster & Davis, 1984; Forster, Davis, Schoknecht, & Carter, 1987; Humphreys et al., 1988; Segui & Grainger, 1990).

Theoretical implications underlying the repetition effect concern not only psycholinguistics, inasmuch as this research bears directly on problems of lexical access and word recognition, but also cognitive psychology in general and particularly the modeling of memory mechanisms. Although the repetition effect is empirically robust and of obvious theoretical interest, just how it should be interpreted remains an open question. The standard interpretations in terms of the temporary modification of the activation state of word detectors (Morton, 1969; McClelland & Rumelhart, 1981) or in terms of episodic memory traces (Jacoby, 1983; Jacoby & Brooks, 1984) fail to account for the full range of phenomena. In fact, it appears that the repetition effect comprises multiple components (perceptual, lexical, and memory) whose respective roles vary with different experimental conditions (see Monsell, 1987).

Any attempt at explaining the repetition effect has been rendered even more challenging by the recent demonstration of paradoxical repetition effects characterized by a decrement in performance on the second occurrence of a repeated word (Humphreys et al., 1988; Kanwisher, 1987; Marohn & Hochhaus, 1988a, 1988b; Mozer, 1989). For example, Humphreys et al. (1988) observed an "inhibitory" repetition effect when a word is repeated immediately and when its second presentation is extremely brief (in a perceptual identification task). However, the standard facilitatory repetition effect reemerged when the presentations were separated by a highly segregable pattern mask or when the first occurrence was not consciously detected. Accordingly, the authors suggested that the inhibitory effect resulted from subjects being unable to process the two presentations of the word as two separate visual events. Similarly, Kanwisher (1987) reported that subjects often fail to report the second occurrence of a repeated item during rapid serial visual presentation (RSVP). This effect, termed repetition blindness (Kanwisher, 1987), occurs only if the first occurrence is consciously identified and recalled (Kanwisher, 1987, Experiment 3). Kanwisher interpreted this effect as...
arising from a constraint on the process responsible for the
parsing of the visual flow into separate visual events. Accord-
ing to Kanwisher, the formation of memory traces is guided by
the visual-orthographic representations that the presented
words activate. The presentation of two visually similar words
activate similar representations and thus are less likely to
establish two separate visual event representations than if two
visually distinct words were presented. Difficulties in process-
ing repeated words have generally been taken to reflect
specific constraints on the formation of separate episodic
memory representations of the presented words. The study of
repetition blindness can thus provide a potential tool for under-
standing the processes and representations involved in
word recognition. This article investigates how certain param-
eters known to be relevant in word recognition interact with
repetition blindness. Possible relationships between repetition
blindness and priming are also discussed.

Previous research has shown homographs (e.g., to wind vs.
the wind) can produce a repetition blindness effect (Kanwisher
& Potter, 1990). Furthermore, exact identity of orthographic
information is not required for repetition blindness to occur
because repetition blindness has also been found between
orthographically similar pairs of words (e.g., cap and cape)
(Kanwisher & Potter, 1990). In this respect, the role of
orthographic codes in repetition blindness seems to be similar
to the well-established role of orthographic information during
word recognition. One of the first studies to show that word
recognition is affected by orthographic similarity was con-
ducted by Meyer, Schvaneveldt, and Rudy (1974). In their
experiment, target words that had been primed by orthograph-
ically similar words (e.g., brie and tribe) led to faster lexical
decision responses than unprimed targets (although not reli-
ably so), suggesting that word access is sensitive to ortho-
graphic similarity. Since then, orthographic priming has been
established with tasks such as tachistoscopic identification
(Evett & Humphreys, 1981), lexical decision (Forster et al.,
1987), naming (Forster & Davis, 1991), and reading (Lima &
Inhoff, 1985). The results of these and other studies indicate
that the orthographic neighborhood of a word affects the
processes involved in word recognition as well as the processes
involved in repetition blindness.

The absence of a repetition blindness effect between pairs of
anagrams such as early and layer (Kanwisher & Potter, 1990)
suggests that, like priming, repetition blindness observed at the
word level cannot be explained at the level of single, nonor-
dered letters. Similarly, no repetition blindness is found for
words that share a single letter in the same serial position (e.g.,
fault and heart). For example, given a first word such as fault
and a second word such as heart, subjects never recalled the
word hear, as would be expected if repetition blindness could
occur between individual letters of different words (Kanwisher
& Potter, 1990). These findings suggest that repetition blind-
ness occurs at the level of letter clusters rather than single
letters or whole words. This level of orthographic representa-
tion has been shown to be relevant in the early stages of word
recognition. Converging evidence suggests that orthographic
representations are initially organized along letter clusters in
which activations combine to activate full orthographic strings
(Humphreys, Evett, & Quinlan, 1990; McClelland & Rumel-
hart, 1981; Mozer, 1989). In Experiments 1, 2, and 3, we
investigated the nature and organization of the orthographic
representations involved in repetition blindness and their
relation to the orthographic representations implicated in the
early stages of word recognition.

The recent finding of repetition blindness between digits
presented in different formats (e.g., 9 vs. nine) and between
heterographic homophones (e.g., ate vs. eight; Bavelier &
Potter, 1992) indicates, however, that repetition blindness
between words cannot be fully explained in terms of their
orthographic representations; phonological identity by itself
also produces repetition blindness. Phonological information
about a written word has been shown to be available almost
immediately after presentation and to affect word recognition
(Coltheart, Besner, Jonasson, & Davelaar, 1979; Hillinger,
1980; Lukatela & Turvey, 1991; Pollatsek, Lesch, Morris, &
Rayner, 1992; Van Orden, Johnston, & Halle, 1988; Van
Orden, Pennington, & Stone, 1990). Phonological effects in
priming paradigms suggest that the identification of a target
word is affected by its phonological neighborhood (Ferrand &
Grainger, 1992; Lesch & Pollatsek, 1993; Lukatela, Carello, &
Turvey, 1990; Perfetti & Bell, 1991). Moreover, the phonologi-
cal characteristics of a target (regular vs. irregular) have been
shown to affect its processing time in lexical decision and
naming tasks (Andrews, 1982; Baron & Strawson, 1976;
Seidenberg, Waters, Barnes, & Tanenhau, 1984; Stanovich &
Bauer, 1978). In Experiments 4 and 5, we tested whether the
processes involved in repetition blindness are sensitive to the
organization into phonological neighborhoods as revealed by
word recognition studies.

**Experiment 1**

Frequency is one of the most salient factors in word
recognition (see Monsell, 1991, for a review). High-frequency
words yield shorter reaction times than low-frequency words in
lexical decision, naming, and reading tasks (Forster & Cham-
bers, 1973; Inhoff & Rayner, 1986; Rayner & Duffy, 1986;
Whaley, 1978). Threshold techniques have shown that high-
frequency words are easier to detect than low-frequency words
(Howes & Solomon, 1951). Moreover, the frequency of a word
has been shown to affect the processing of its orthographic
neighbors (Grainger, O’Regan, Jacobs, & Segui, 1989; Grainger
& Segui, 1990; Jared, McRae, & Seidenberg, 1990). When a
target word is orthographically similar to a more frequent word
(e.g., blur similar to blue), it is harder to recognize (as
measured by eye fixation duration) than a word of equivalent
frequency that does not have any higher frequency neighbors.
The neighborhood frequency effect has also been shown to
affect the nature of both unmasked and masked priming
between orthographic neighbors (Segui & Grainger, 1990). Segui
and Grainger’s data suggest that a fast presentation of a
high-frequency prime inhibits its lower frequency neighbors
but not vice versa. By contrast, a long presentation of a
low-frequency prime inhibits its higher frequency neighbors
but not vice versa. These data suggest that inhibition due to
high-frequency words develops more rapidly than inhibition
due to low-frequency words.

If the orthographic representations involved in repetition
REPETITION BLINDNESS BETWEEN WORDS

blindness are similar to the ones involved in early word recognition, then one would predict there to be effects of neighborhood frequency. We investigated the effect of neighbor frequency by holding the frequency of the second critical word (C2) constant while varying the frequency of the first critical word (C1), an orthographic neighbor of C2. On half the trials, C1 was an orthographic neighbor of C2 that had a similar frequency (e.g., fact vs. past); on the other half of the trials, C1 was an orthographic neighbor of C2 with a different frequency (e.g., tact vs. past). On half of the trials, C2 was a high-frequency word and on the other half it was a low-frequency word. It was predicted that if the orthographic representations involved in repetition blindness were the same as the representations involved in the priming effect, then high-frequency C1s should produce more repetition blindness than low-frequency C1s.

Method

Subjects. Thirty-two undergraduate students from the Massachusetts Institute of Technology participated in this experiment. All the subjects were native speakers of American English and were paid for their participation.

Material and design. We selected 32 high-frequency words and 32 low-frequency words. For each of them, we selected two orthographic neighbors, one of equivalent frequency and the other of opposite frequency (the frequency values were obtained from Kucera and Francis, 1967). For example, we used the word just (872 per million) as a high-frequency word, and paired it with the words must (1,013 per million) and gut (2 per million); similarly we used tact (6 per million) as a low-frequency word and paired it with past (5 per million) and fact (447 per million). For each of the words in the 64 triplets, we selected a control word of identical length, equivalent frequency, and different spelling (i.e., not a neighbor). The list of triplets is given in Appendix A. For the first group of triplets, the mean frequency of the low-frequency target words was 11.3 per million (11 per million for their corresponding control words); the mean frequency of the high-frequency target words was 1,426 per million (883 per million for their corresponding controls). For the other group of triplets, the mean frequency of the low-frequency target words was 6.7 per million (6.5 per million for their corresponding control words); the mean frequency of the high-frequency target words was 1,472 per million (855 per million for their corresponding controls).

The main variable of interest, repeatedness, was counterbalanced across items. Whether C2 was a high- or low-frequency word was a between-items variable. The two remaining variables, C1 frequency given C2 frequency, as well as which of the two words of equivalent frequency would appear as C2, were counterbalanced across items. This $2 \times 2 \times 2$ design resulted in eight versions of the experiment. A final between-items variable was the lag between C1 and C2. On half the trials, in each of the eight conditions one word intervened between C1 and C2 (Lag 1), and on the other half a word plus a row of symbols intervened between C1 and C2 (Lag 2). Each list began with 6 practice trials followed by 64 experimental and 20 filler trials.

Procedure. Each trial began when the subject pressed the space bar on the computer keyboard. The fixation point, a row of asterisks, disappeared and the items appeared one at a time in the same place (centered) for 100 ms each.

Subjects were instructed to read the words and ignore the rows of symbols. After each trial, subjects were asked to write down the words they saw in the order they had seen them. They were told that there could be one, two, or three words per trial, and that if they saw the same word twice, they were to report it twice.

Table 1

<table>
<thead>
<tr>
<th>Condition</th>
<th>C2 high frequency</th>
<th>C2 low frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HF-HF</td>
<td>HF-LF</td>
</tr>
<tr>
<td>Lag 1</td>
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<tr>
<td>Lag 2</td>
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<tr>
<td>Lag 2</td>
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<td>62</td>
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<tr>
<td>Lag 1</td>
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<td>32</td>
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<td>Lag 2</td>
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<td>18</td>
</tr>
<tr>
<td>Lag 1</td>
<td>30</td>
<td>16</td>
</tr>
<tr>
<td>Lag 2</td>
<td>16</td>
<td>18</td>
</tr>
</tbody>
</table>

Note. For HF-HF, words used were man and can; for LF-HF, words used were tan and can; for HF-LF, words used were found and mound. C1 = first critical word; C2 = second critical word; Lag 1 = one intervening item; Lag 2 = two intervening items; HF = high frequency; LF = low frequency; NR = nonrepeated; R = repeated; NR-R = nonrepeated–repeated.

Apparatus. The stimuli were presented on a NEC JC1401P3A monitor with B22 phosphor of medium-to-short persistence controlled by an IBM-AT. The experiment was carried out in normal room illumination.

Results

We scored how often C2 was recalled given C1 was recalled. The use of similar but not identical words allowed us to disambiguate between C1 and C2 on repeated trials (Table 1). On some of the trials, subjects reported a neighbor of the word they saw, which we did not consider as a repetition blindness effect; conservatively, these reports were scored as correct. These errors were, for the most part, conversions of low-frequency words to high-frequency words. This kind of scoring did not affect the main results of the experiment. In this and all experiments reported here, analyses of variance (ANOVAs) were performed with subjects as the random variable ($F_1$) as well as with items as the random variable ($F_2$). The strength of the effects as indexed by their corresponding eta squared value was also reported.

A $2 \times 2 \times 2 \times 2$ ANOVA was performed with repeatedness, C1 frequency, C2 frequency, and lag as the independent variables and the percentage of trials in which C2 was recalled given that C1 was recalled as the dependent variable. There was an overall repetition effect, $F_1(1, 31) = 58.5, p < .0001, MS_e = .11; F_2(1, 60) = 103.6, p < .0001, MS_e = .03$, as well as a main effect of C1 frequency, $F_1(1, 31) = 5.2, p < .03, MS_e = .04$, but $F_2(1, 60) = 2.1, p > .15, MS_e = .02$. More important, the interaction between repeatedness and C1 frequency was significant, $F_1(1, 31) = 4.8, p < .036, MS_e = .08, \eta^2 = .13; F_2(1, 60) = 6.5, p < .013, MS_e = .03, \eta^2 = .09$, showing that

1 Eta squared indexes the strength of a relationship between the dependent and independent variables. It represents the proportion of variability in the dependent variable that is associated with the independent variable; \( \eta^2 = 1 - (SSerror/SStotal) = (dfbetween*MSF/((dfbetween)^2 + dfwithin)) \). Eta squared can range from 0 to 1.0. Values close to 1.0 indicate a strong relationship between the independent and dependent variables; values close to 0.0 indicate a weak relationship between the variables. For a given alpha level, the power of a test can be computed using the eta squared value and the number of subjects.
repetition blindness was greater when C1 was a high-frequency word (28%) than a low-frequency word (17%). There was no effect of the frequency of C2 on repetition blindness ($p_1 > .3$ and $p_2 > .6$, $\eta^2 = .017$). A main effect of lag was found, $F_1(1, 31) = 5.2, p < .029, MS_e = .05$ ($p_2 > .3$ due to a slightly greater number of errors at Lag 1 than Lag 2; however, the interaction between repetition and lag was not significant ($ps > .35$).

None of the other effects were significant.

Although the triple interaction between C1 frequency, repetition, and lag was not significant, when C1 was low-frequency, the size of the repetition blindness effect was larger at Lag 2 (21%) than at Lag 1 (14%). Moreover, separate analysis of Lag 1 and Lag 2 trials revealed a greater amount of repetition blindness for high-frequency than low-frequency C1s only at Lag 1 (28% vs. 14%); $F_1(1, 31) = 6.5, p < .0016, MS_e = .05, \eta^2 = .17; F_2(1, 30) = 4.8, p < .036, MS_e = .03, \eta^2 = .14$. At Lag 2, repetition blindness was of comparable size whether C1 was a high- or low-frequency word (27% vs. 21%).

$ps > .18; \eta^2 = .05$.

When recall of neighbors was scored as incorrect, the only results that differed between the two kinds of scoring were main effects of C1 and C2 frequency, each showing better recall for high- than for low-frequency items ($ps < .02$). Importantly, analyses with repetition and C1 frequency as variables confirmed the interaction between repetition and C1 frequency, $F_1(1, 31) = 4.5, p_1 < .042, MS_e = .08; F_2(1, 63) = 5.9, p_2 < .018, MS_e = .02; \eta^2 = .11$.

**Discussion**

The results of Experiment 1 confirmed the finding that repetition blindness occurs between orthographic neighbors. Furthermore, the repetition blindness effect was found to be sensitive to the frequency of the words used. Although the size of this effect was relatively small, repetition blindness between orthographic neighbors was found to be larger for high-frequency C1s (28%) than low-frequency C1s (17%). The lack of a C2 frequency effect suggests that C1 frequency, rather than the relative C1–C2 frequency, affects the pattern of repetition blindness. Although the effects of neighbor frequency in priming studies have been proposed to be due to the relative frequency of the prime and target (Grainger, 1990), they could be due to the frequency of C1 alone. Indeed, although the absolute frequency of the target was shown not to be responsible for the effects of frequency between orthographic neighbors in priming when using French words (Segui & Grainger, 1990), the role of the prime’s frequency has not been independently tested. The present finding of a larger repetition blindness effect for high-frequency C1 than low-frequency C1 is consistent with the finding in priming studies that high-frequency words inhibit their orthographic neighbors more rapidly than low-frequency ones. Moreover, the tendency for a modification of the effect of C1 frequency on repetition blindness as lag varies is consistent with the results found in priming studies. If high-frequency C1s, like high-frequency primes, inhibit their neighbors more rapidly than low-frequency C1s, high-frequency C1s would be expected to lead to more repetition blindness than low-frequency C1s at short lags. One would expect this difference to go away at longer lags because the longer lag would allow inhibition from low-frequency C1s to develop. Although the present results are only suggestive, they point to the investigation of the time course and properties of the interaction between orthographic neighbors as a potentially fruitful direction of research.

It is worth noting that the results of Experiment 1 also help to characterize the nature of the lag that is important in repetition blindness. It shows that repetition blindness is not sensitive to the lag between the end of the processing of C1 and the initial arrival of C2. Because access time is shorter for high-frequency than low-frequency words (Forster & Chambers, 1973; Inhoff & Rayner, 1986; Whaley, 1978), such a lag would be minimal for low-frequency C1s and maximal for high-frequency C1s. Hence, it would predict more repetition blindness for low-frequency C1s than high-frequency C1s, which is the opposite of the observed pattern.

As we discussed previously, the results of Experiment 1 are consistent with the hypothesis that the orthographic representation involved in repetition blindness are similar to the ones retrieved during the early phase of word recognition. However, there is an alternative explanation. Specifically, these data may not be due to the frequency organization of orthographic neighborhoods but rather to the frequency of C1 per se (i.e., absolute frequency of C1). If so, high-frequency C1s should lead to a greater amount of repetition blindness whether C2 is an orthographic neighbor of C1 or identical to C1. In Experiment 2, we tested this possibility by comparing the amount of repetition blindness found between two occurrences of a high-frequency word (e.g., like and like) and the amount of repetition blindness found between two occurrences of a low-frequency word (e.g., lice and lice).

**Experiment 2**

**Method**

Subjects. Thirty-two undergraduates from the Massachusetts Institute of Technology participated in this experiment. All the subjects were native speakers of American English and were paid for their participation.

Material and design. Six practice trials were followed by 40 experimental trials, 40 trials used to test another hypothesis, and 13 filler trials. Each trial consisted of a sequence of six strings preceded and followed by a row of percentage signs. On the experimental trials, three of the six strings were words, written in lowercase. The other three strings each consisted of rows of three, four, or five identical keyboard symbols. The position of the two critical words C1 and C2 was varied, but C1 was always preceded by at least a row of symbols and the two critical words were always separated by at least a third word. On half the trials, only one word intervened between C1 and C2 (Lag 1); on the other half, a row of symbols also intervened between the two critical words (Lag 2). The 13 filler trials consisted of two words (sometimes repeated) and four strings of symbols.

We used 80 high-frequency words and 80 low-frequency words (Kucera & Francis, 1967). Mean frequency was 1,517 per million for the high-frequency target words and 9 per million for the low-frequency target words. The list of words used is given in Appendix B. In the repeated condition, C1 and C2 were identical. In the nonrepeated condition, C1 words were replaced by words of the same length and comparable frequency but of entirely different spelling. The mean frequency was 2,533 per million for the high-frequency controls and 8.5 per million for the low-frequency controls.
The two main variables of interest, repeatedness and frequency (high vs. low) were counterbalanced across the eight versions of the experiment. The lag variable (one or two intervening items between C1 and C2) was counterbalanced across subjects but not across items.

The procedure and apparatus were otherwise identical to that of Experiment 1. Specifically, items were displayed one at a time, centered, for 100 ms each.

Results

The percentage of recall of both C1 and C2 as a function of frequency and lag is given in Table 2. As in Experiment 1, trials in which subjects reported a neighbor of one of the word they saw were scored as correct. This kind of scoring did not affect the main results of the experiment (a separate analysis in which these errors were scored as incorrect confirmed that the interaction effect between repetition and frequency was unchanged by the kind of scoring).

The result of interest concerned the size of repetition blindness between identical words as a function of frequency. An ANOVA was carried out on the percentage of trials in which both C1 and C2 were recalled with lag and frequency as variables. We observed an overall repetition effect, $F_1(1, 31) = 98.4, p < .0001, MS_e = .06; F_2(1, 79) = 102.8, p < .0001, MS_e = .08$, no frequency effect ($ps > .9$), and more important, no interaction of frequency and repetition ($ps > .19; \eta^2_p = .03$). A main effect of lag, $F_1(1, 31) = 67.2, p < .0001, MS_e = .03; F_2(1, 79) = 22.8, p < .0001, MS_e = .11$, as well as an interaction between lag and repeatedness, $F_1(1, 31) = 67.2, p < .0001, MS_e = .03; F_2(1, 79) = 51, p < .0001, MS_e = .05$, confirmed that repetition blindness was larger at Lag 1 than Lag 2.

Although no effect of frequency was observed when we scored neighbor recall as correct, a significant effect of frequency appeared when recall of neighbors were scored as incorrect. This result was the only one that differed between the two kinds of scoring (crucially, the interaction between repeatedness and frequency was again not significant, $ps > .21; \eta^2_p = .03$). When scoring recall of neighbors as errors, recall of both C1 and C2 averaged 62% for the high-frequency trials and 55% for the low-frequency trials, $F_1(1, 31) = 5.8, p < .022, MS_e = .04; F_2(1, 79) = 5.8, p < .018, MS_e = .05$. Hence, recall of high-frequency words was more accurate than the recall of low-frequency words.

Table 2

<table>
<thead>
<tr>
<th>Condition</th>
<th>HF–HF</th>
<th>LF–LF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lag 1</td>
<td>Lag 2</td>
</tr>
<tr>
<td>NR</td>
<td>84</td>
<td>83</td>
</tr>
<tr>
<td>R</td>
<td>33</td>
<td>64</td>
</tr>
<tr>
<td>NR–R</td>
<td>51</td>
<td>19</td>
</tr>
</tbody>
</table>

Note. For HF–HF, words used were like and like; for LF–LF, words used were ice and iced. C1 = first critical word; C2 = second critical word; HF = high frequency; LF = low frequency; Lag 1 = one intervening item; Lag 2 = two intervening items; NR = nonrepeated; R = repeated; NR–R = nonrepeated–repeated.

Discussion

A sizable repetition blindness effect was found for high-frequency (35%) as well as low-frequency (29%) words. For each of these conditions, the amount of repetition blindness was greater at Lag 1 than at Lag 2. This result is consistent with the finding that repetition blindness decreases as lag increases (Kanwisher, 1987). These results show that the size of repetition blindness is not significantly altered by the frequency of the repeated word. It seems unlikely that the lack of interaction may be due to insensitivity of our technique to the frequency attenuation effect, given that the eta squared values were of the order of .03. Furthermore, a main effect of frequency was present in the experiment, and the frequency of C1 interacted with repetition blindness in Experiment 1.

The finding of a repetition blindness effect between low-frequency words seems to conflict with the results of Hochhaus and Mihura (1992). Hochhaus and Mihura reported that only high-frequency words show repetition blindness effects; low-frequency words were found to show either no effect or positive priming. However, Hochhaus and Mihura used a novel paradigm, rather than RSVP that was used in the present study and in most previous studies of repetition blindness. The use of this novel paradigm, which involves the use of a prime-target technique in which a long prime (500 ms) precedes a briefly presented target that is subsequently masked, makes the comparison of results difficult. It remains a question for future research whether the new technique taps into the same phenomenon as previous research on repetition blindness (Bavelier, 1992; Bavelier & Potter, 1992; Kanwisher, 1987; Kanwisher & Potter, 1989, 1990).

The data from Experiment 1 clearly established that repetition blindness can be obtained for low-frequency words. Moreover, the absence of an effect of C1 frequency on repetition blindness between identical items in Experiment 2 suggests that the C1 frequency effect between orthographic neighbors in Experiment 1 is due to the frequency organization of orthographic neighborhoods rather than the frequency of C1 itself. Hence, the results of Experiments 1 and 2 suggest that the orthographic representations involved in repetition blindness are characterized by a neighborhood organization that is similar to the organization known to affect the early stages of word recognition.

Experiment 3

The finding of a repetition blindness effect between orthographic neighbors is interesting in that it shows that identity of orthographic representations is not required and that a high amount of orthographic overlap is sufficient for repetition blindness to occur. A further implication is that overlap in morphological or semantic information cannot be a necessary condition for repetition blindness.
condition for the occurrence of repetition blindness. However, it is not known whether morphological overlap between words contributes to the occurrence of repetition blindness, independently of orthographic–phonological overlap. The amount of repetition blindness found between neighbors is usually less than the amount of repetition blindness found between identical items (Kanwisher, 1991; Kanwisher & Potter, 1990). It is not clear whether this decrement in the amount of repetition blindness is due to the lack of morphological–semantic overlap, or whether it is due to the differing amounts of orthographic–phonological overlap between identical items and neighbors. The present experiment addressed this question.

Research in word recognition that uses priming, reading, recognition, production, and detection studies has found that morphological information influences the processing of words (see Henderson, 1985; Taft, 1991 for reviews). The locus of morphological effects in the various tasks is a topic of debate but it is clear that morphological information plays a role that is distinct from orthographic and phonological information in word recognition (Lima, 1987; Murrel & Morton, 1974; Rapp, 1992; Rubin, Becker, & Freeman, 1979). In Experiment 3, we investigated whether morphological information is relevant to the processes involved in repetition blindness by comparing the effect of orthographic and morphological similarity on repetition blindness. In addition to investigating the role of morphology in repetition blindness, the experiment provided further data on the characteristics of orthographic neighborhoods by including pairs of items that differed by more than one letter at the end or in the middle of the word.

Previous research (Bavelier, 1988; Kanwisher & Potter, 1990) suggested that morphological overlap between two words may not be relevant to the processes underlying repetition blindness, but this result may be the product of certain methodological limitations. Kanwisher and Potter (1990, Experiment 5) found the same amount of repetition blindness between words differing by a final letter whether they were morphologically related or not (e,g. silk and silky vs. cape and cap). This experiment suggests that the processes underlying repetition blindness are indifferent to the morphological representations of words. This conclusion is supported by experiments reported by Bavelier (1988) in which French words that differed by more than one letter at the end of the word were used. Bavelier found repetition blindness between prefixed words and their roots (e.g., tache vs. detaché), suffixed words and their roots (e.g., malade vs. maladie), as well as between two prefixed (e.g., defect vs. refer), or two suffixed (e.g., sonnette vs. sennerie) forms; however, repetition blindness was also found between morphologically unrelated words differing by up to two or three letters at the beginning or the end of the words (e.g., ciseaux vs. seaux and sac vs. sacre). Although these experiments (Bavelier, 1988; Kanwisher & Potter, 1990) suggest that morphological information does not play a role in repetition blindness, they have two major weaknesses. First, both experiments tested repetition using an RSVP sentence-reading task, which requires subjects to process sentences and to work under high memory loads. This demanding task may have wiped out a small but real morphological effect. Second, in these experiments the morphologically related items and their controls were neither matched for length nor for frequency, nor for the sentence context in which they appeared. This strongly weakens the power of the comparison of the size of repetition blindness for morphologically related and unrelated pairs. Experiment 3 was designed to overcome these problems.

As in Experiments 1 and 2, we used the presentation of short lists of words intermixed with rows of symbols (Bavelier & Potter, 1992); this technique enabled us to control for the context in which the words appear and requires the subject to work under a relatively low memory load. We presented morphologically related words and morphologically unrelated words that had identical amounts of orthographic overlap and were matched for their frequency. We used pairs of verbs in their present and past forms (e.g., edit and edited). For each pair of verbs, we constructed a pair of orthographic controls, sharing the same orthographic relationships as the verbs (e.g., for edit and edited, we used wand and wander).

**Method**

**Subjects.** Sixteen undergraduates from the Massachusetts Institute of Technology participated in this experiment. All the subjects were native speakers of American English and were paid for their participation.

**Material and design.** Eight practice trials were followed by 88 experimental and 20 filler trials. Twenty-eight pairs of regular verbs and 16 pairs of irregular verbs were selected. For each pair of verbs, a control pair was constructed such that the control words shared the same orthographic overlap as the pair of verbs but were not morphologically related. For example, the pair edit and edited had wand and wander as its control, and the pair take and took had bake and book as its control. We tried to match the frequency of the verbs and their controls as much as possible. For each of the different categories, mean frequencies were 10 for regular present and 10 for their controls, 16 for regular past and 15 for their controls, 84 for irregular present and 29 for their controls, and 65 for irregular past and 49 for their controls. The list of the 44 pairs used is given in Appendix C.

There were three main variables counterbalanced within items and subjects: repeated or nonrepeated, verbs or controls, and which word of the pair appeared first. Identical (wand and wand) or related (wander and wander) repetition was a between-items factor, as was lag (one item between C1 and C2 vs. two items). We used the same procedure and apparatus as in Experiment 1.

**Results**

The percentage of recall of both C1 and C2 for the verbs and their orthographic controls is given in Table 3. On some of the trials subjects reported a neighbor of the word they saw; conservatively, we scored these responses as correct. For example, when subjects reported the right verb but the wrong tense, their answer was scored as correct. This kind of scoring did not affect the main results of the experiment.

In this experiment, there was a general tendency for there to be more repetition blindness at Lag 1 than at Lag 2. This trend

---

3 Because in Experiment 3 we were interested in comparing the size of repetition blindness between identical versus similar items, the recall of both C1 and C2 seemed to be the only indicator of the repetition blindness effect that would not introduce a scoring bias between the two kinds of items. This was also true for Experiment 4.
Table 3

<table>
<thead>
<tr>
<th>Condition</th>
<th>Verbs</th>
<th>Orthographic controls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NR</td>
<td>85</td>
<td>75</td>
</tr>
<tr>
<td>R</td>
<td>51</td>
<td>51</td>
</tr>
<tr>
<td>NR–R</td>
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<td>24</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>Pairwise</td>
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<td></td>
</tr>
<tr>
<td>NR</td>
<td>80</td>
<td>84</td>
</tr>
<tr>
<td>R</td>
<td>69</td>
<td>66</td>
</tr>
<tr>
<td>NR–R</td>
<td>11</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identical</td>
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<td>86</td>
</tr>
<tr>
<td>R</td>
<td>55</td>
<td>47</td>
</tr>
<tr>
<td>NR–R</td>
<td>25</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pairwise</td>
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<td>86</td>
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<td>R</td>
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<td>77</td>
</tr>
<tr>
<td>NR–R</td>
<td>3</td>
<td>9</td>
</tr>
</tbody>
</table>

Note. In the regular condition, identical verbs were *edit* and *edit* and orthographic controls were *wand* and *wand*; pairwise verbs were *edited* and *edited* and orthographic controls were *wander* and *wander*. In the irregular condition, identical verbs were *took* and *took* and orthographic controls were *book* and *book*; pairwise verbs were *take* and *took* and orthographic controls were *bake* and *book*. C1 = first critical word; C2 = second critical word; NR = nonrepeated; R = repeated; NR–R = nonrepeated–repeated.

is in accordance with the finding that repetition blindness decreases when lag increases (Kanwisher, 1986). This effect was stronger when C1 and C2 were identical than when they were similar. However, because the lag effect never interacted with the variable of interest (morphological vs. orthographic relationships), results for Lag 1 and Lag 2 were collapsed in the following analyses.

We carried out ANOVAs on the number of trials in which both C1 and C2 were recalled in the different conditions. We decided to analyze the trials with regular verbs separately from those with irregular verbs because under certain theories, regularly and irregularly inflected forms are represented differently (Kempley & Morton, 1982; Pinker & Prince, 1988; Stanners, Neisser, Hernon, & Hall, 1979). Moreover, the amount of orthographic overlap between regular targets was higher than between irregular ones.

For the regular pairs (e.g., the verbs *edit* or *edited* or the controls *wand* or *wander*) there was a main effect of repetition, $F_1(1, 15) = 27, p < .0001, MS_e = .2; F_2(1, 54) = 38, p < .0001, MS_e = .07$; and type of repetition (identical or repeated repetition) in the subject analysis, $F_1(1, 15) = 7.2, p < .02, MS_e = .11$, and marginally significant in the item analysis, $F_2(1, 54) = 3, p < .09, MS_e = .07$, suggesting a larger repetition blindness effect between identical (e.g., edited and edited or wand and wand) than related targets (edit vs. edited or wand vs. wand). No other significant effect was found; in particular, morphological relatedness did not interact with repetition ($ps > .5, \eta^2 = .03$), suggesting that morphological information did not influence repetition blindness.

Because we expected the same amount of repetition blindness for verbs and their controls in the identical repetition condition but not necessarily in the related condition, we ran separate ANOVAs for the identical and related pairs. We found an overall effect of repetition for the identical pairs (e.g., the verbs *edit* and *edit* and their controls *wand* and *wand*), $F_1(1, 15) = 37, p < .0001, MS_e = .04; F_2(1, 27) = 24, p < .0001, MS_e = .09$. None of the other effects reached significance ($ps > .3$), showing that the amount of repetition blindness for identical verb pairs was comparable to that for their orthographic controls. To test whether morphological relationships led to a greater amount of repetition blindness than orthographic relationships alone, it was important to compare morphologically related pairs (e.g., the verbs *edited* and *edit*) with orthographically related pairs (e.g., *wander* and *wand*) while excluding the identical pairs. ANOVAs revealed an overall repetition effect, $F_1(1, 15) = 7.6, p < .015, MS_e = .17; F_2(1, 27) = 13.8, p < .001, MS_e = .1$, but none of the other effects reached significance ($ps > .3$). In particular, there was no interaction between morphology and repetition ($p > .3; \eta^2 = .03$). These results show that the amount of repetition blindness is similar when the targets are morphologically related (11%) and when they are morphologically unrelated (18%).

For the irregular pairs (e.g., the verbs *took* and *take*) and controls (*book* and *book*), there was a main effect of repetition, $F_1(1, 15) = 23.7, p < .0001, MS_e = .2; F_2(1, 30) = 36, p < .0001, MS_e = .03$, and of identical or related repetition, $F_1(1, 15) = 26.4, p < .0001, MS_e = .11; F_2(1, 30) = 6.7, p < .014, MS_e = .11$. There was also an interaction between these variables, $F_1(1, 15) = 14.8, p < .002, MS_e = .14; F_2(1, 30) = 16.5, p < .0001, MS_e = .03$, due to a larger repetition blindness effect between identical words than between related words. None of the other effects were significant ($p > .08$).

As with the regular verbs, we ran a separate ANOVA for the related condition (e.g., the verbs *took* and *take*) versus the control condition (e.g., *book* and *book*), excluding the identical pairs. No effect of repetition was found in the subject analysis ($p > .15$) and a marginal effect of repetition was found in the item analysis, $F_2(1, 15) = 4, p = .063, MS_e = .03$, but the interaction between morphology and repetition was not significant ($p > .4; \eta^2 = .03$). Hence, the size of the repetition effect was similar whether the targets were morphologically related (3%) or not (9%); furthermore, the main effect of repetition found with irregular pairs was mostly due to identical pairs (e.g., *take* and *take* or *book* and *book*). The lack of repetition blindness between different-spelling irregular pairs (e.g., *sing* and *sang* or *break* and *broke*) was surprising given that half of the items were orthographic neighbors (e.g., *sing* and *sang*) differing only by one letter. Given previous findings of repetition blindness between orthographical neighbors, we would expect a repetition blindness effect for the eight orthographic neighbor pairs used. To better understand the results for the irregular items, we analyzed the eight items that were orthographic neighbors and the other eight items separately. For the orthographic neighbors, we found a small repetition blindness effect (10%), which was marginally signifi-
cant by a subjects analysis \( F(1, 15) = 3.5, p_1 = .08, MS_e = .06, \eta^2 = .19 \), and significant by items analysis, \( F(7, 15) = 15, p_2 < .006, MS_e = .006, \eta^2 = .68 \); none of the other effects were significant. This confirms the presence of repetition blindness between orthographic neighbors and shows that repetition blindness was of the same size between irregular verbs and their controls. For the other set of items (the items that were not orthographic neighbors), no effect of repetition was observed (size of the effect was 2%; \( p_3 > .7, \eta^2 = .009 \)). These results indicate that morphological relationships do not influence repetition blindness and that the manifestation of repetition blindness is chiefly dependent on the degree of orthographic-phonological similarity between the items.

**Discussion**

The amount of repetition blindness found between morphologically related words did not differ significantly from the amount of repetition blindness found for morphologically unrelated words with the same amount of orthographic overlap. The lack of effect is unlikely to be due to a lack of power because the corresponding eta squares were only about .03 (moreover, there was a tendency for there to be more repetition blindness between the orthographic controls than the morphological pairs). Furthermore, these results are consistent with Kanwisher and Potter’s (1990) and Bavelier’s (1988) finding that morphological relationships do not increase the size of the repetition blindness effect. Performance on the irregular items in the current experiment also support the conclusion that repetition blindness is sensitive to the amount of orthographic-phonological overlap but not to morphological relatedness. For the irregular items, a repetition blindness effect was found between items with a large amount of orthographic overlap but not between items with a small amount of orthographic overlap.

Finally, the experiment provided further data regarding the kind of orthographic overlap that is needed for repetition blindness to occur. As in Experiment 1, repetition blindness was found between orthographic neighbors (items differing by a single letter), confirming previous findings that orthographic identity is not required. However, no repetition blindness was found between present and past tense forms of irregular verbs when the forms differed by the replacement of two or three letters usually at the end of the word (e.g., break and broke). This finding seems surprising given that previous studies have found repetition blindness between words that differ by more than two letters. For example, repetition blindness has been found between words differing by the addition of up to three letters at the end of the word (sirloin and sir; Kanwisher, 1991). Similarly, a repetition blindness effect was found for the regular verbs and the regular controls in the present experiment even though the items differed by two letters. In both the Kanwisher (1991) study and the regular verb and regular control conditions of our Experiment 3, C1 and C2 were always in an inclusion relationship, suggesting that repetition blindness between words differing by more than one letter is conditional on an inclusion relationship between C1 and C2. However, Bavelier (1988), using French stimuli, found repetition blindness between words that did not include each other and differed by up to three letters at the end of the word (sonnette and sonnerie). The main difference between the irregulars in the present experiment (shake and shook) and the Bavelier (1988) material (sonnette and sonnerie) is the number of common letters between C1 and C2 (1.7 and 5.2 letters) relative to the length of the C1s and C2s used (4.2 and 8.3 letters in each of the experiments, respectively). Repetition blindness failed to occur when only one or two letters were shared at the same position by C1 and C2, but did occur when C1 and C2 shared about four letters at the same position. Taken together, these results suggest that in order for repetition blindness to occur, two items need to share three to five letters in the same position.

Experiments 1, 2, and 3 in combination with previous research suggest that the processes underlying repetition blindness are sensitive only to the amount of orthographic-phonological similarity there is between two words and not to the amount of morphological similarity. Neither an identity or inclusion relation between C1 and C2 is needed for repetition blindness to occur; it seems that having C1 and C2 share more than 60% of the letters in the same position is sufficient for repetition blindness to occur. Finally, the experiments show that the orthographic representations that are involved in repetition blindness are sensitive to the frequency organization of orthographic neighborhoods. Although we conclude that repetition blindness is sensitive to the sharing of letters between C1 and C2, rather it may have been due to the sharing of phonemes (Bavelier & Potter, 1992; Kanwisher, 1991). In Experiments 4 and 5, we investigate the relations of orthographic and phonological representations in repetition blindness.

**Experiment 4**

The occurrence of repetition blindness between phonologically identical but orthographically dissimilar items (e.g., eight vs. ate) shows that orthographic similarity is not a necessary condition for the occurrence of a repetition blindness effect, and that phonological identity is sufficient for repetition blindness to occur (Bavelier & Potter, 1992). Kanwisher’s (1991) finding of repetition blindness between stimuli such as certify and sir shows that phonological identity is also not necessary and that only some degree of phonological similarity is required. However, in this experiment, for each pair C2 was always part of C1. Hence, it is not clear whether an inclusion relationship is necessary for phonological repetition blindness to occur or whether other types of phonological similarity also lead to repetition blindness. In Experiment 4, we investigated whether repetition blindness due to phonological overlap requires there to be an inclusion relation or whether only phonological similarity is required.

Experiments 1, 2, and 3 (and previous research) established that a high degree of orthographic overlap can lead to a repetition blindness effect. However, it is unclear to what extent this effect can be attributed to orthographic overlap and to what extent the effect is due to phonological overlap given the confounding of orthographic and phonological similarity. The current experiment tried to address this problem by investigating the relative strengths of orthographic and phono-
logical overlap in repetition blindness. We constructed pairs of words that differed either by one letter but were phonologically dissimilar (e.g., reach and react), as well as pairs of words that differed by one phoneme but were orthographically dissimilar (e.g., great and freight). This material allowed us to test repetition blindness between phonologically similar but not identical words and to compare the effect of orthographic and phonological similarity on repetition blindness. We compared each of these conditions with a third condition in which orthography and phonology were identical (e.g., doctor and doctor).

Method

Subjects. Eighteen undergraduates from the Massachusetts Institute of Technology participated in this experiment. All the subjects were native speakers of American English and were paid for their participation.

Material and design. Twelve practice trials were followed by 72 experimental and 20 filler trials. Twenty-four pairs of orthographically similar but phonologically dissimilar words were used; this set is called the orthographic set. In each of the pairs, the two words differed only by one letter but were phonologically dissimilar (e.g., reach and react). Another 24 pairs of orthographically dissimilar but phonologically similar pairs were used; this set is called the phonological set. In each of the pairs, the two words differed by only one phoneme but were orthographically dissimilar (e.g., great and freight). Finally, 24 words were selected within the same range of frequency as the previous 48 pairs. These words were used to control for identical repetition; this set is called the identical set. The mean frequency was 59 per million for the orthographic set, 70 per million for the phonological set, and 59 per million for the identical set. The list of the three different sets used is given in Appendix D.

On half the trials, C1 and C2 were related and on the other half they were unrelated. The nonrelated version was created by replacing C1 by a member of one of the other experimental pairs for the orthographic and phonological condition. For the identical condition, 24 new words were selected to be used as nonrelated C1s. Hence, a given word appeared only once in each experimental list. Each of the words in the orthographic and phonological pairs appeared as C2 (order) was counterbalanced within items and subjects. There were two variables counterbalanced within items and subjects: relatedness and order. The two other variables were between items: type of relationships between C1 and C2 (identical vs. orthographic vs. phonological) and lag between C1 and C2 (Lag 1 vs. Lag 2). The design, procedure, and apparatus were otherwise identical to those of Experiment 1.

Results

We used the same method of scoring as in Experiment 2. On some of the trials subjects reported a neighbor of the word they saw, which we did not consider as a repetition blindness effect; conservatively, these reports were scored as correct. This kind of scoring did not affect the main results of the experiment. The percentage of recall of both C1 and C2 as a function of the nature of their relatedness and lag is given in Table 4.

We carried out ANOVAs on the number of trials in which both C1 and C2 were recalled. The main 3 × 2 × 2 ANOVA with type of trials, repeatedness, and lag as independent variables (carried out on the number of trials in which both C1 and C2 were recalled) showed a three-way interaction between type, repeatedness, and lag. Table 4 shows Percentage of Trials in Which C1 and C2 Were Both Recalled.

Table 4

<table>
<thead>
<tr>
<th>Condition</th>
<th>Orthographic</th>
<th>Phonological</th>
<th>Identical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lag 1</td>
<td>Lag 2</td>
<td>Lag 1</td>
</tr>
<tr>
<td>NR</td>
<td>76</td>
<td>81</td>
<td>81</td>
</tr>
<tr>
<td>R</td>
<td>44</td>
<td>66</td>
<td>74</td>
</tr>
<tr>
<td>NR-R</td>
<td>32</td>
<td>15</td>
<td>7</td>
</tr>
</tbody>
</table>

Note. For the orthographic condition, words were reach and react; for the phonological condition, words were great and freight; for the identical condition, words were doctor and doctor. C1 = first critical word; C2 = second critical word; Lag 1 = one intervening item; Lag 2 = two intervening items; NR = nonrepeated; R = repeated; NR-R = nonrepeated–repeated.

03; F(2, 66) = 5.8, p < .005, MS_e = .02, but no interaction between type and repeatedness (ps > .19). This pattern of results shows that the amount of repetition blindness for each type is not different when averaged across lags, but when lags are taken into consideration a significantly different pattern of repetition blindness emerges between the three types.

We ran three separate 2 × 2 ANOVAs with repeatedness and lag as independent variables for identical, orthographic, and phonological trial types. These ANOVAs were carried out on the number of times C1 and C2 were both recalled. For identical trials, a main effect of repeatedness was found, F(1, 17) = 26.5, p < .0001, MS_e = .04; F(2, 22) = 33.5, p < .0001, MS_e = .02, as well as an interaction between repeatedness and lag, F(1, 17) = 12.7, p < .002, MS_e = .03; F(2, 22) = 14, p < .001, MS_e = .02, indicating a larger repetition blindness effect at Lag 1 than Lag 2. A similar pattern of results was found for the orthographic trials. A main effect of repeatedness was found, F(1, 17) = 19.7, p < .0001, MS_e = .05; F(2, 22) = 27.2, p < .0001, MS_e = .025, as well as an interaction between repeatedness and lag by subjects, F(1, 17) = 6.9, p < .017, MS_e = .02. This interaction was also marginally significant by items, F(2, 22) = 3.7, p = .065, MS_e = .025. This pattern of results also shows that orthographic repetition blindness has a tendency to be larger at Lag 1 than at Lag 2. For the phonological trials, a main effect of repeatedness was found, F(1, 17) = 8.2, p < .011, MS_e = .04; F(2, 22) = 7.5, p < .012, MS_e = .03, but this effect did not interact with lag (ps > .2). In fact, unlike the identical or orthographic trials, the size of repetition blindness in phonological trials was numerically larger at Lag 2 than Lag 1 (19% vs. 7%). This first set of analyses confirms the presence of a repetition blindness effect between identical items and extends the finding of repetition blindness to orthographically related, but phonologically different, items (e.g., reach and react). Moreover, it also clearly establishes the presence of repetition blindness between phonologically related but orthographically dissimilar items (e.g., great and freight).

We were also interested in comparing the size of repetition blindness between each of the types of trials. The three contrasts of interest were identical versus orthographic, identical versus phonological, and orthographic versus phonological. Hence, three 2 × 2 × 2 ANOVAs with repeatedness, type of relatedness, and lag as dependent variables were carried out.
Table 5
Comparison of the Repeatedness Effect for the Different Types of Similarity: Numerical Difference and Interaction

<table>
<thead>
<tr>
<th>Type of similarity</th>
<th>RB(1) − RB(2)</th>
<th>Lag 1</th>
<th>Lag 2</th>
<th>Rep × Type</th>
<th>Lag × Rep. × Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ortho. (1) vs. Id. (2)</td>
<td>−7</td>
<td>7</td>
<td></td>
<td>Etas = .0, ps &gt; .2</td>
<td>Etas = .06, ps &gt; .2</td>
</tr>
<tr>
<td>Phono. (1) vs. Id. (2)</td>
<td>−32</td>
<td>11</td>
<td></td>
<td>Etas = .08, ps &gt; .12</td>
<td>Etas = .29, ps &lt; .005</td>
</tr>
<tr>
<td>Phono. (1) vs. Ortho. (2)</td>
<td>−25</td>
<td>4</td>
<td></td>
<td>Etas = .07, ps &gt; .14</td>
<td>Etas = .18, ps &lt; .03</td>
</tr>
</tbody>
</table>

Note. RB(1) − RB(2) = amount of repetition blindness for Type 1 minus amount of repetition blindness for Type 2; Rep. × Type = interaction of the type of similarity with repeatedness; Lag × Reg. × Type = interaction of the type of similarity with repeatedness and lag; Ortho. = orthographically related material; Id. = identical material; Phono. = phonologically related material.

on the number of times C1 and C2 were recalled. Results are reported in Table 5.

For orthographic versus identical similarity, the type of relatedness never interacted with the repeatedness factor, showing that the size of repetition blindness was comparable for the identical (23%) and orthographic (23%) sets. For phonological versus orthographic or identical similarity, the triple interaction between type of similarity, repeatedness, and lag indicated that the amount of repetition blindness varied differently with lag for the phonological items as compared with the identical and orthographic items. Although identical and orthographic similarity led to a greater repetition blindness at Lag 1 than at Lag 2, the reverse pattern was observed for phonological trials.

Discussion

The results of Experiment 4 confirmed Kanwisher’s (1991) findings of repetition blindness between orthographically similar but phonologically dissimilar words as well as repetition blindness between phonologically similar words that have almost no orthographic overlap. The experiment also showed that repetition blindness occurs between phonologically similar but not identical items, even if the items are not in an inclusion relation. Sharing most of the letters but almost no phonemes or sharing most of the phonemes but almost no letters is sufficient to produce repetition blindness. Although morphological relationships failed to elicit repetition blindness, either orthographic or phonological similarity seem sufficient for repetition blindness.

The comparison of the size of repetition blindness for orthographic and identical trials showed an equivalent amount of repetition blindness between these two types of trials. This suggests that high orthographic similarity produces the same amount of repetition blindness as identity. However, more repetition blindness was found between identical words than between orthographic neighbors in Experiment 3 as well as in other experiments (Bavelier, 1988; Kanwisher & Potter, 1990). It seems that, in general, repetition blindness between orthographic neighbors is less than, or at most, equal to repetition blindness between identical words. Our results suggest that the manipulation of phonological similarity, given that the orthographic similarity is high, does not decrease the amount of repetition blindness.

Although the amount of repetition blindness between phonologically similar and identical items was not significantly different, the absolute size of repetition blindness was smaller between phonologically similar items (13%) than between identical items (23%). This result is consistent with the results of Bavelier and Potter (1992), who found that the amount of repetition blindness between differently spelled homophones is less than the amount of repetition blindness between similarly spelled homophones. The finding in Experiment 4 that phonological repetition blindness tends to be stronger at Lag 2 than Lag 1 while the reverse pattern is observed for identical or orthographic repetition blindness suggests that phonological repetition blindness takes a longer time to develop. However, this finding needs to be confirmed because this pattern was not found for homophones (Bavelier & Potter, 1992). In so far as the constraints of written English allowed us to dissociate orthographic versus phonological similarity, the material used in Experiment 4 suggests that orthographic and phonological information play distinct and nonadditive roles in repetition blindness.

Experiment 5

Experiment 5 was run to further investigate the role of phonological similarity in repetition blindness. To do this, we held the orthographic similarity of items constant while varying the amount of phonological similarity between the items (e.g., rough and tough vs. rough and cough). If phonological repetition blindness is sensitive to the amount of phonological overlap, one would expect there to be more repetition blindness between items such as rough and tough than between rough and cough. The experiment also bears on the question of how orthographic and phonological information interact. A number of studies in the word recognition literature have shown that the nature of the relationship between orthographic and phonological codes influences the amount of time needed to recognize a word. For example, irregular words, or words that do not follow the grapheme to phoneme correspondences take longer to name (Coltheart, 1985) and have also been shown to influence the naming time of their regular neighbors (Glushko, 1979). Along the same lines, priming studies have shown that lexical decision latencies to a target word such as rough were facilitated when preceded by the rhyme prime word tough but inhibited when preceded by the
similarly spelled nonrhyme word *cough* (see also Hillinger, 1980; Meyer et al., 1974). If the representations that underlie repetition blindness are the same as those that are used in word recognition, one would expect there to be similar effects of spelling-sound regularity.

We investigated these questions by comparing the amount of repetition blindness found between orthographic neighbors that are either consistent or inconsistent with the spelling-sound correspondences of English (e.g., home and dome vs. some and come). We compared the size of repetition blindness between two regular (e.g., home and dome) or irregular (e.g., some and come) words and between a regular and an irregular word (e.g., some and dome or home and come).

**Method**

**Subjects.** Sixteen undergraduates from the Massachusetts Institute of Technology participated in this experiment. All the subjects were native speakers of American English and were paid for their participation.

**Material and design.** Six practice trials were followed by 72 experimental and 20 filler trials. Nine quadruplets of two irregular words that are orthographic neighbors of each other (e.g., four and pour) and two of their regular neighbors (e.g., sour and hour) were selected. The list of the nine quadruplets used is given in Appendix E.

There were two main variables counterbalanced within items and subjects: repeatedness and same or different pronunciation. The other two variables, whether C2 followed the pronunciation rule of English (regular) or not (irregular) and whether there was Lag 1 or Lag between C1 and C2, were counterbalanced within subjects but across items. We used the same design, procedure, and apparatus as in Experiment 4.

**Results**

We scored how often C2 was recalled given C1 was recalled because the use of similar but not identical words allowed us to disambiguate between C1 and C2 on repeated trials (Table 6). Because lag did not interact with the size of the repetition blindness effect in the different conditions, results for Lag 1 and Lag 2 were collapsed in the following analyses. On some of the trials, subjects reported a neighbor of the word they saw, which we did not consider as a repetition blindness effect; conservatively, these reports were scored as correct. This kind of scoring did not affect the main results of the experiment.

We carried out ANOVAs on the number of trials in which C2 was recalled given that C1 was recalled. First, we tested the role of the identical–different pronunciation factor on the size of the repetition blindness effect. A 2 × 2 ANOVA with identical–different pronunciation and repeatedness as dependent variables was carried out. The only significant effect was the repetition effect, $F_1(1, 15) = 48, p < .0001; MS_e = .006$; $F_2(1, 17) = 39.9, p < .0001, MS_e = .02$; whether the pronunciation was identical (15%) or different (12%) did not influence the size of the repetition blindness effect ($p > .5$; $\eta^2 = .025$). We then looked at the role of the C1 and C2 types (regular or irregular) on the repetition blindness effect. A 2 × 2 ANOVA with type of C1, type of C2, and repeatedness was carried out. It revealed an overall repetition effect, $F_1(1, 15) = 40.7, p < .0001, MS_e = .01$; $F_2(1, 16) = 39.9, p < .0001, MS_e = .02$. The only other significant effect was the interaction between the type of C1 and repeatedness, $F_1(1, 15) = 8.44, p < .011, MS_e = .02$; $F_2(1, 16) = 9.7, p < .007, MS_e = .02$, due to a larger repetition blindness effect when C1 is irregular than regular.

Contrary to our initial hypothesis, the nature of C1 rather than the phonological similarity determined the amount of repetition blindness. Because the frequency of the words used in Experiment 5 averaged 239 per million for the irregular pairs versus 90 per million for the regular pairs, it was important to check that the role of the type of C1 on the size of repetition blindness was not due to the fact that irregular C1 were higher frequency words than regular C1. Analyses by subjects grouping C1 by high- or low-frequency revealed that the role of the type of C1 on repetition blindness could not merely be attributed to frequency of C1 because this latter factor did not interact with repeatedness ($p > .7; \eta^2 = .008$). Moreover, a triple interaction between same–different pronunciation, repeatedness, and C1 frequency, $F_1(1, 15) = 14.5, p < .002, MS_e = .03; \eta^2 = .49$, revealed that, whereas in the different pronunciation condition repetition blindness tended to be greater for high-frequency C1, in the same pronunciation condition repetition blindness tended to be greater for low-frequency C1. Hence, the effect of C1 regularity cannot merely be accounted for by regularity.

**Discussion**

The results of Experiment 5 showed that repetition blindness is greater when C1 is an irregular word, and that whether the type of spelling-to-sound mapping for C1 and C2 was the same (e.g., home and dome or come and some) or not (e.g., some and home) did not affect the size of the repetition blindness effect. Furthermore, when C1 was an enemy of C2 (i.e., C1 and C2 have different pronunciations), a greater amount of repetition blindness was observed if C1 was a high-frequency enemy than if it were a low-frequency enemy; however, when C1 was a friend of C2 (i.e., same pronunciation), a greater repetition blindness was observed if C1 was a low-frequency friend. This set of findings is consistent with other findings on the role of frequency and phonological similarity in the organization of words' neighborhood. For example, Jared, McRae, and Seidenberg (1990) showed that...
targets with high-frequency enemies (e.g., gave) took longer to name than the ones with low-frequency enemies (e.g., haste), and that targets with low-frequency friends (e.g., moth) took longer to name than the ones with high-frequency friends (e.g., brew). As in Experiment 1, it seems that the neighborhood organization revealed by naming experiments correctly predicts the pattern of repetition blindness observed in the current experiment.

The lack of interaction between repetition blindness and same–different pronunciation was not expected given the previously described characteristics of repetition blindness. Although a greater amount of similarity leads to a greater amount of repetition blindness when considering orthographic similarity, the same does not seem to be true for phonological similarity. There is, however, an alternative explanation for this result. It may be that if two words share highly similar orthographic forms, whether their phonological codes are similar or different cannot affect the amount of repetition blindness. If this is correct, then phonological similarity would not affect the amount of repetition blindness when the items are very similar orthographically; however, as the amount of orthographic similarity decreases, one would expect phonological similarity to affect the size of the repetition blindness effect. This could account for the lack of a phonological similarity effect in Experiment 5, as well as the finding in Experiment 4 of an equal amount of repetition blindness between identical and orthographically similar but phonologically dissimilar words. We next discuss the manner in which orthographic and phonological information interact in repetition blindness in greater detail.

General Discussion

The experiments reported in this article suggest that repetition blindness is sensitive to the overlap in the orthographic and phonological representations of the target words. The results of Experiments 1 and 2 confirmed that repetition blindness occurs between orthographically similar words and established that the processes underlying repetition blindness are sensitive to the neighborhood frequency organization shown to affect early word recognition. Experiment 3 showed that the finding of a smaller amount of repetition blindness between neighbors than between repetitions is due to the difference in the amount of orthographic–phonological overlap rather than due to a lack of morphological overlap between neighbors. Experiments 4 and 5 investigated the interaction of orthographic and phonological overlap. Experiment 4 established that either orthographic similarity or phonological similarity is sufficient for repetition blindness to occur, and that the amount of repetition blindness due to phonological overlap may be smaller than that due to orthographic overlap. The results of Experiment 5 showed that repetition blindness is sensitive to the regularities in the spelling-sound correspondence of neighbors. Moreover, the results of Experiments 4 and 5 suggested that phonological overlap plays a role in repetition blindness only when orthographic overlap is low. We now discuss the findings of the current study in the context of previous research on repetition blindness and relate the results to certain findings from the literature on word recognition.

Orthographic Repetition Blindness

Kanwisher (1986, 1987) proposed that orthographic repetition blindness is due to a limitation on the number of episodic representations (termed tokens) the activation of a given orthographic pattern (termed orthographic type) can lead to in a short amount of time. Given this account, an important part of understanding the repetition blindness phenomenon involves the characterization of the orthographic types. In principle, the constraint on the formation of tokens could apply at any level of orthographic representation. Thus, the repetition of letters, clusters of letters, or whole words could all lead to a repetition blindness effect. We would like to suggest, however, that the level of representation on which the constraint on token formation operates is the level of ordered letter clusters. Given this proposal, it is possible to explain a wide range of phenomena.

First, the finding of a repetition blindness effect between neighbors falls out as a natural consequence of the fact that words that are neighbors also share letter clusters. Second, the lack of a repetition blindness effect between words that are anagrams is predicted because whereas anagrams share the same letters, they do not, in general, share letter clusters. Similarly, the lack of a repetition blindness effect between letters of different words is expected. Finally, it is possible to account for the finding that nonwords can lead to repetition blindness of words (N. G. Kanwisher, personal communication, December, 1991) because nonwords can activate letter clusters that are shared by words. The proposal that representations of ordered letter clusters are activated in the course of the processing of visually presented words receives independent evidence from experiments of word recognition ( Humphreys et al., 1990; Inhoff & Tousman, 1990). These studies provide independent motivation for a role for ordered letter clusters during word recognition.

In addition to providing evidence regarding the orthographic type that is relevant to the processes underlying repetition blindness, our study also characterized the nature of the interactions between these representations during processing. The processing of these representations is affected by the frequency of neighbors as well as the nature of the spelling-sound correspondence of neighbors. Experiments 1 and 2 showed that the frequency of C1 affects the processing of C2 neighbors such that there is a greater amount of repetition blindness when C1 is of high frequency than when C1 is of low frequency. This result would follow naturally if processing a high-frequency word temporarily inhibits or disrupts the processing of its neighbors. This has been proposed by researchers studying word recognition using the masked and unmasked priming paradigms (Grainger et al., 1989; Grainger & Segui, 1990; Jared et al., 1990). For example, these studies showed that it takes longer to identify a target if it has orthographic neighbors of high frequency than if it does not have any high-frequency neighbors. Experiment 5 presented evidence that the nature of a word’s spelling-sound correspondence influences the processing of neighbors. Specifically, there is a greater amount of repetition blindness when C1 is an irregular word than when it is a regular word. Furthermore, when C1 was an enemy of C2 (i.e., C1 and C2 have different pronunciations), a greater amount of repetition blindness was observed if
C1 was a high-frequency enemy than if it was a low-frequency
enemy; however, when C1 was a friend of C2 (i.e., same
pronunciation), a greater repetition blindness was observed if
C1 was a low-frequency friend. Once again, a similar effect has
been reported in the word recognition literature. Jared et al.
(1990) showed that targets with high-frequency enemies (e.g.,
gave) take longer to name than targets with low-frequency
enemies (e.g., haste), and that targets with low-frequency
friends (e.g., moth) take longer to name than targets with
high-frequency friends (e.g., brew). Thus, it seems that the
neighborhood frequency and spelling-sound correspondence
effects found in Experiments 1, 2, and 5 provide further
evidence that suggests that the orthographic representations
involved in repetition blindness are the same as orthographic
representations in word recognition.

Taken together, the experiments reported in our study show
that the nature and organization of the orthographic represen-
tations that characterize the orthographic type from which
episodic tokens are formed are similar to the nature and
organization of the orthographic representations that have
been implicated in the early stages of word recognition.
Further research is needed to determine the time course and
interaction of the processes that are involved in the processing
of visually presented words such that the repetition of a word
can give rise to either facilitation or a decrement in the
processing of a subsequent presentation of that word. It seems,
however, that one account of these seemingly paradoxical
effects is as follows. If orthographic repetition blindness is due
to the activation following the presentation of C2 being
interpreted as residual activation from C1 and thus not
processed as a new token, then priming could result when the
activation following the presentation of C1 fails to establish a
token. This facilitates the instantiation of a token when a
similar C2 is presented because of initial activation level being
higher than rest levels (Humphreys et al., 1988; Masson &
Isaak, 1992). This type of an account is supported by the
findings that repetition blindness reverts to priming when C1 is
not consciously identified (Kanwisher, 1987; M. C. Potter,
personal communication, February, 1992).

**Phonological Repetition Blindness**

In Experiments 4 and 5, we showed that repetition blindness
occurs between words that are phonologically similar but not
different, even if the words are not in an inclusion relation.
This finding, along with the finding of repetition blindness
between phonologically identical but orthographically dissimi-
lar words, shows that repetition blindness due to phonological
overlap is distinct from orthographic repetition blindness. We
propose that the mechanism responsible for phonological
repetition blindness is of the same type as the mechanism
responsible for orthographic repetition blindness, that is, a
limitation on the number of episodic representations a given
phonological representation can be linked to in a short amount
of time. It is still unclear exactly what the nature of these
phonological representations is. It seems that the code is
different than the articulatory code used for rehearsal in
short-term memory (STM; Conrad, 1964) because articulation
does not interfere with repetition blindness between hetero-
graphic homophones (Bavelier & Potter, 1992). This finding
points to a phonological code automatically activated from the
orthographic representation in the early stage of word recogni-
tion as the phonological representation involved in phonologi-
cal repetition blindness. Such a code has been proposed to
exist by Baddeley (1986). Baddeley proposed that "as a result of
learning to read and to name objects, a route is built up
whereby the phonological representation of a name or a word
can be accessed from LTM [long-term memory], leaving a
comparatively weak trace within the phonological store" (p.
86). Evidence for an early phonological code has been gath-
ered using various techniques such as lexical decision, naming,
or reading times (Besner & Davelaar, 1982; Lukatelja &
Turvey, 1991; Perfetti & Bell, 1991; Pollatsek et al., 1992). For
element, Pollatsek et al. (1992) proposed that there is an early
phonological code that plays at least some role during the
integration of information across saccades. They proposed that
"phonological coding is used to preserve the 'memory' of a
word from one fixation to aid in its identification on the next
fixation" (p. 159). Although further research is needed to
determine the properties of these phonological representa-
tions as well as the properties of the phonological representa-
tions relevant to repetition blindness, these phonological
representations appear as a good candidate for the ones that
are relevant for repetition blindness.

Although the disruption of tokenization observed in ortho-
graphic and phonological repetition blindness was due in each
case to the similarity of the representation of the critical items,
the level of processing at which the disruption occurs seemed to
be different for orthographic and phonological repetition
blindness (Bavelier, 1994). Bavelier showed that whereas
orthographic repetition blindness is better understood as a
failure to initially set up a second new token from a repeated
orthographic code, phonological repetition blindness is better
accounted for by a failure to stabilize in short-term memory
the newly established tokens sharing a same phonological
code. For example, Bavelier showed that the amount of
phonological repetition blindness one observes can be manipu-
lated by task factors that either encourage or discourage the
use of phonological codes during the stabilization of tokens in
short-term memory. By contrast, the amount of orthographic
repetition blindness was not sensitive to such task manipula-
tions. Experiments 4 and 5 of our study support the view that
tokenization is a two-level process. The different pattern of
repetition blindness found for orthographic and phonological
trials in Experiment 4 shows that orthographic and phonologi-
cal information play distinct and nonadditive roles in repeti-
ition blindness. The finding in Experiments 4 and 5 that
phonological similarity has little or no effect on repetition
blindness when orthographic similarity is high suggests that
two orthographically similar items may escape orthographic
repetition blindness only if stable orthographic representa-
tions for each of these items are initially established, thereby
rendering those items less subject to phonological repetition
blindness. Again, this is consistent with a two-level process for
tokenization.

In summary, we propose that orthographic repetition blind-
ness and phonological repetition blindness arise from similar
mechanisms, but at two different stages in word processing.
Orthographic repetition blindness seems best understood as a
failure to open a new token, which is due to a confusion of the
activation of C1 and C2 at a sublexical orthographic level of representation. Phonological repetition blindness seems best accounted for in terms of a failure to stabilize an opened token in STM, which is due to a confusion of the activation from C1 and C2 at a phonological level of representation. Whether this phonological level of representation is organized along phonemes, cluster of phonemes, syllables, or entire words is still unknown. It is clear that the further understanding of phonological repetition blindness will require working out the characteristics of the phonological representations involved in repetition blindness itself as well as refining the structure and roles of the phonological level of representations during word recognition and STM storage. The similarity in the representations and the organization of orthographic information relevant in repetition blindness and word recognition also suggests that future research in each of these areas may benefit from findings from the other.

References


## Appendix A

Material Used in Experiment 1

Note: C1 = first critical word; C2 = second critical word; HF = high frequency; LF = low frequency.

### Triplets With Low-Frequency C2 and Their Corresponding Controls

<table>
<thead>
<tr>
<th>C1 HF</th>
<th>C2s LF</th>
<th>C1 control</th>
<th>C2s control</th>
<th>C1 HF</th>
<th>C2s LF</th>
<th>C1 control</th>
<th>C2s control</th>
</tr>
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<tr>
<td>fact</td>
<td>pact, tact</td>
<td>once</td>
<td>suck, thaw</td>
<td>gust</td>
<td>just, must</td>
<td>slap</td>
<td>down, even</td>
</tr>
<tr>
<td>war</td>
<td>wax, wan</td>
<td>yes</td>
<td>hut, fry</td>
<td>ant</td>
<td>any, and</td>
<td>tee</td>
<td>our, was</td>
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<tr>
<td>did</td>
<td>dip, dig</td>
<td>end</td>
<td>sly, cab</td>
<td>ape</td>
<td>age, are</td>
<td>bye</td>
<td>nor, two</td>
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<td>for</td>
<td>fir, fur</td>
<td>its</td>
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<td>soy</td>
<td>has, few</td>
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<td>tan</td>
<td>can, man</td>
<td>pet</td>
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<td>not, now</td>
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<td>lake</td>
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<td>also</td>
<td>lily, hive</td>
<td>mast</td>
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<td>slid, user</td>
<td>hood</td>
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<td>some</td>
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<td>until</td>
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<td>whine</td>
<td>white, while</td>
<td>tribe</td>
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</table>
# Repetition Blindness Between Words

## Appendix B

### Critical Words Used With Their Nonrepeated Control in Parentheses

<table>
<thead>
<tr>
<th>High Frequency</th>
<th>Low Frequency</th>
<th>High Frequency</th>
<th>Low Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>down (same)</td>
<td>gown (taxi)</td>
<td>good (make)</td>
<td>hoo (enjoy)</td>
</tr>
<tr>
<td>know (year)</td>
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<td>more (than)</td>
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<td>since (every)</td>
<td>mince (adorn)</td>
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<td>few (ago)</td>
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<td>only (used)</td>
<td>oily (fake)</td>
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<td>are (you)</td>
<td>axe (thy)</td>
<td>here (some)</td>
<td>hare (cozy)</td>
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<td>were (this)</td>
<td>ware (gist)</td>
<td>can (she)</td>
<td>fan (lid)</td>
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<td>tao (bug)</td>
<td>far (man)</td>
<td>fir (bye)</td>
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<td>plate (stiff)</td>
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<td>over (much)</td>
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<td>other (could)</td>
<td>otter (fairy)</td>
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<td>any (now)</td>
<td>ant (hog)</td>
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<td>sway (limb)</td>
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<td>worm (beep)</td>
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<td>went (look)</td>
<td>wept (corch)</td>
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<td>tact (bury)</td>
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<td>home (find)</td>
<td>hose (yell)</td>
<td>most (even)</td>
<td>moss (duck)</td>
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<td>until (while)</td>
<td>untie (droop)</td>
<td>has (yet)</td>
<td>ham (pen)</td>
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<td>back (city)</td>
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<td>hound (lease)</td>
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<td>threw (admit)</td>
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<td>net (fly)</td>
<td>for (and)</td>
<td>fox (nap)</td>
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<tr>
<td>that (been)</td>
<td>chat (skip)</td>
<td>have (took)</td>
<td>has (jump)</td>
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<tr>
<td>high (come)</td>
<td>sigh (pump)</td>
<td>head (told)</td>
<td>heap (ruin)</td>
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<td>set (old)</td>
<td>sew (hid)</td>
<td>less (once)</td>
<td>lets (wrap)</td>
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<tr>
<td>may (her)</td>
<td>mat (rub)</td>
<td>said (eyes)</td>
<td>slid (jump)</td>
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<td>hand (form)</td>
<td>hang (fist)</td>
<td>after (these)</td>
<td>alter (prone)</td>
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<tr>
<td>like (case)</td>
<td>lice (mend)</td>
<td>must (each)</td>
<td>mist (bull)</td>
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<tr>
<td>both (take)</td>
<td>moth (clap)</td>
<td>own (use)</td>
<td>owl (fud)</td>
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<tr>
<td>where (under)</td>
<td>where (unify)</td>
<td>put (war)</td>
<td>pet (inn)</td>
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<td>just (came)</td>
<td>oost (mall)</td>
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<td>did (was)</td>
<td>dig (icy)</td>
<td>left (time)</td>
<td>lent (nail)</td>
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<td>suck (stew)</td>
<td>also (what)</td>
<td>alto (dump)</td>
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<td>get (way)</td>
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<td>small (right)</td>
<td>stall (wiped)</td>
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<td>shy (fur)</td>
<td>part (need)</td>
<td>cart (menu)</td>
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<td>him (out)</td>
<td>aim (bus)</td>
<td>but (his)</td>
<td>bun (ale)</td>
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<td>your (them)</td>
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<td>our (the)</td>
<td>cur (ewe)</td>
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<td>bow (nut)</td>
<td>great (asked)</td>
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<td>very (upon)</td>
<td>verb (dove)</td>
<td>last (knew)</td>
<td>lash (climb)</td>
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<tr>
<td>life (room)</td>
<td>lift (bowl)</td>
<td>will (they)</td>
<td>gill (edit)</td>
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<td>house (again)</td>
<td>mouse (filly)</td>
<td>from (when)</td>
<td>frog (dunk)</td>
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<td>then (made)</td>
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<td>yearn (bicep)</td>
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<tr>
<td>day (new)</td>
<td>pay (job)</td>
<td>too (why)</td>
<td>boo (ebb)</td>
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<td>one (all)</td>
<td>owe (rag)</td>
<td>state (being)</td>
<td>stare (width)</td>
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(Appendices continue on next page)
Appendix C

Material Used in Experiment 3

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<th>Regular Verbs and Their Controls</th>
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<td>toll</td>
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<td>hush</td>
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<td>alter</td>
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<td>knock</td>
</tr>
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<td>creek</td>
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<td>deem</td>
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<td>post</td>
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<td>tilt</td>
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<td>boil</td>
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<td>dump</td>
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<td>limp</td>
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<td>heed</td>
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<td>crack</td>
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<td>edit</td>
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<th>Irregular Verbs and Their Controls</th>
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<td>shake</td>
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<td>break</td>
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<td>grow</td>
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Appendix D

Material Used in Experiment 4

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<th>Orthographic Type</th>
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<td>safe–cafe</td>
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<td>mayor–manor</td>
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<tr>
<td>defect–defeat</td>
</tr>
<tr>
<td>noon–noon</td>
</tr>
<tr>
<td>bride–bridge</td>
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<td>senior–sensor</td>
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<th>Phonologic Type</th>
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<td>towel–foul</td>
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<td>eagle–evil</td>
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<td>bite–night</td>
</tr>
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<td>lawyer–liar</td>
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<td>cousin–dozen</td>
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<tr>
<td>dean–scene</td>
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<th>Identical Type</th>
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<td>abandon–abandon</td>
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<td>doctor–doctor</td>
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<td>heavy–heavy</td>
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<tr>
<td>league–league</td>
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<tr>
<td>nectar–nectar</td>
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<td>pair–pair</td>
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Appendix E

Material Used in Experiment 5

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<th>Exception Pairs</th>
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<td>pull–full</td>
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<tr>
<td>wear–tear</td>
<td>lost–cost</td>
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<tr>
<td>toll–roll</td>
<td>hush–rush</td>
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<tr>
<td>bush–push</td>
<td>crow–grow</td>
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<tr>
<td>home–dome</td>
<td>food–mood</td>
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<tr>
<td>brow–prow</td>
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<tr>
<td>hood–wood</td>
<td></td>
</tr>
<tr>
<td>dull–hull</td>
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<tr>
<td>fear–dear</td>
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Accepted December 10, 1993

New Editors Appointed, 1996–2001

The Publications and Communications Board of the American Psychological Association announces the appointment of two new editors for 6-year terms beginning in 1996. As of January 1, 1995, manuscripts should be directed as follows:

• For *Behavioral Neuroscience*, submit manuscripts to Michela Gallagher, PhD, Department of Psychology, Davie Hall, CB# 3270, University of North Carolina, Chapel Hill, NC 27599.

• For the *Journal of Experimental Psychology: General*, submit manuscripts to Nora S. Newcombe, PhD, Department of Psychology, Temple University, 565 Weiss Hall, Philadelphia, PA 19122.

Manuscript submission patterns make the precise date of completion of 1995 volumes uncertain. The current editors, Larry R. Squire, PhD, and Earl Hunt, PhD, respectively, will receive and consider manuscripts until December 31, 1994. Should either volume be completed before that date, manuscripts will be redirected to the new editors for consideration in 1996 volumes.