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Superficial priming in episodic recognition

Stephen Dopkins [a,*], Jesse Sargent [b], Catherine T. Ngo [c]

[a] Psychology Department, George Washington University, 2125 G Street, NW, Washington, DC 20052, United States
[b] Psychology Department, Washington University, Campus Box 1125, One Brookings Drive, St. Louis, MO 63130-4899, United States
[c] Department of Physical Medicine and Rehabilitation, Baylor College of Medicine, One Baylor Plaza, Mail Stop TIRR A-221, Houston, TX 77030, United States

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ABSTRACT

We explored the effect of superficial priming in episodic recognition and found it to be different from the effect of semantic priming in episodic recognition. Participants made recognition judgments to pairs of items, with each pair consisting of a prime item and a test item. Correct positive responses to the test item were impeded if the prime and test item were superficially related; this was the case when the items were words and the crucial relationship was phonological and orthographic as well as when the items were letter strings and the crucial relationship was orthographic. The results of further experiments suggested that the priming effect cannot be attributed to a process of discounting or to habituation in a familiarity assessment process.

Introduction

In recognizing an entity, one performs an act of classification. In *episodic recognition*, one classifies an entity as having been encountered previously in a particular context. In *semantic recognition* (often termed *lexical decision*), one classifies an entity simply as having been encountered previously, without regard to context.

Because recognition judgments are made quickly and effortlessly, they are subject to priming effects. Such effects occur when a recognition judgment to a *test item* is either facilitated or impeded consequent to prior processing of a *prime item*. Our research program seeks to learn about recognition by studying the effects of priming on recognition judgments. Pursuing this goal, Ngo, Sargent, and Dopkins (2007) explored the effect of semantic priming in episodic recognition. They found that such priming impeded correct negative episodic recognition responses but had no effect on positive recognition trials.

The present study explored the effect of superficial – that is, phonological and/or orthographic – priming in episodic recognition. The effect of this sort of priming has not previously been explored using traditional priming procedures. However, several studies of the role of processing fluency in recognition judgments have examined the situation in which participants make episodic recognition judgments to test words a short time after having read superficially related non-words (Rhodes & Kelley, 2003; Whittlesea & Williams, 2001). In the experiments that most closely approximated standard priming procedures (Experiments 1 and 2 of Rhodes and Kelley (2003)) the participant experienced the following events on each test trial: The prime item, a non-word string, was presented and the participant read it aloud; 500 ms after the participant did this, the test word was presented and the participant, first, read it aloud and, then, made a recognition response to it. The prime item either did (e.g. PINGLE) or did not (e.g. BARDEN) rhyme with the test word (e.g. SINGLE) (Rhodes & Kelley, 2003). Participants emitted more false alarms to the test word when the prime item and the test word rhymed than when they did not.

The implication of these results is that superficial priming impedes correct negative recognition responses and has no effect on positive recognition responses; in short,

* Corresponding author. Fax: +1 202 994 1602.
E-mail address: dopkins@gwu.edu (S. Dopkins).

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the implication is that superficial priming has the same effect as semantic priming in episodic recognition (recall Ngo et al., 2007). Notice, however, that the temporal interval between the presentation of the test word and the recognition response to the test word was longer in these fluency experiments than in traditional priming studies. As a consequence, it was possible for participants to make a covert recognition judgment to the test word, and to revise that judgment, prior to making the required overt recognition response. Thus, these fluency experiments may not provide a true picture of the effect of superficial priming in episodic recognition.

In the present study we sought to examine the effect of superficial priming in episodic recognition using more traditional procedures than have been used in previous fluency experiments. We found the effect of superficial priming to be different from the effect that has been observed in the fluency experiments and different from the effect of semantic priming in episodic recognition. Three initial experiments demonstrated the priming effect in question. The results of a fourth and fifth experiment argued against some uninteresting interpretations of the priming effect.

Experiment 1

Experiment 1 was an initial attempt at demonstrating an effect of superficial priming in episodic recognition. The stimuli for the experiment were common nouns (e.g. bun). In each of the eight blocks of the experiment, the participant read a list of 32 words, counted backwards for three seconds, and then responded to a series of 32 *test trials*, on each of which a *test pair* consisting of a *prime word* and a *test word* was presented, with the participant making a separate recognition response to each of these words. The recognition response to the test word was of primary interest; the data for this response were examined as a function of whether or not the test word rhymed with the prime word (e.g. bun/gun vs. pot/gun).

In more detail, the experiment was organized as follows. Nine of the test pairs for each block were *experimental pairs* and 23 of the test pairs were *filler pairs*. Over the eight blocks of the experiment, the prime and test word rhymed in half (36) of the 72 experimental pairs and had no obvious phonological or orthographic relationship to one another in half of the experimental pairs. The prime and test word were never related in the 184 filler pairs. Thus, the prime word and the test word rhymed in 14% of the test pairs. The prime word was old (that is, present in the list) in half of the (experimental and filler) test pairs and new (that is, absent from the list) in half of the test pairs. The test word was old in half of the test pairs and new in half of the test pairs.

Method

Participants

The participants were 112 students at the George Washington University. They received extra credit in a psychology course in exchange for their efforts.

Design

Relationship (Related/Unrelated), Prime Word (Old/New), and Test Word (Old/New) were manipulated within participants. Crossing these three independent variables produced eight experimental conditions. Over the course of the experiment, nine experimental pairs were presented for each of these conditions.

Materials

The experimental pairs were generated from a set of 72 common noun triples. The first and second words of each triple rhymed and were linked by no obvious semantic relationship (gun, bun). The third word had no obvious phonological, orthographic, or semantic relationship to the first word (pot). The rest of the words used in the experiment were sampled from a set of 792 common nouns.

The materials for each participant were created as follows: First, the experimental pairs were created. The 72 triples were assigned to the eight blocks, nine triples to a block, according a random scheme that was unique to the participant in question. The triples were then assigned to the experimental conditions, nine triples to a condition, according to a random scheme under which each condition was tested roughly once per block. The experimental pairs were extracted from the triples, as follows: The first word of each triple was the test word. For conditions in which the prime word and test word rhymed, the second word of the triple was the prime word. For conditions in which the prime word and test word did not rhyme, the third word of the triple was the prime word.

Next, the lists and the filler pairs were created. Given the experimental pairs that had been created for a given block, the list for the block was created as follows: (1) For the experimental pairs that were assigned to conditions in which the prime word was old, the prime word was placed in the list. (2) For the experimental pairs that were assigned to conditions in which the test word was old, the test word was placed in the list. (3) The rest of the 32 words in the list were sampled without replacement from the set of 792 common nouns. The words in the list were then placed in a random order that was unique to the participant in question. The filler pairs for the block were then created as follows: (1) Each of the words in the list that was not part of an experimental pair was placed randomly as either a prime word or a test word in one of the filler pairs. (2) The rest of the words in the filler pairs were then sampled without replacement from the set of 792 common nouns. Finally, the 32 test pairs were placed in a random order that was unique to the participant in question.

Procedure

The experiment was conducted on a microcomputer. The participant initiated each block by pressing the space bar of the computer keyboard. The list for the block in question was then presented, word by word, with each successive word appearing alone in the middle of the screen for 1600 ms and being followed by an inter-word interval of 400 ms. After the last word of the list was presented, a message appeared at the top of screen instructing

the participant to count backwards silently from a randomly-selected number. After 3000 ms, this message disappeared and a message appeared, instructing the participant to prepare for the test phase. After 1000 ms, this message disappeared and the test trials occurred, with each trial unfolding as follows: A message appeared announcing the test pair. After 1000 ms, this message disappeared and the prime word appeared. This word remained on the screen until the participant made his/her recognition response, at which point it disappeared and the test word appeared in the same location. This word remained on the screen until the participant made his/her response, at which point it disappeared. If the participant had made an error on the prime word and/or the test word, a message then appeared to that effect (no feedback was given for correct responses). This feedback message remained on the screen for 2000 ms. After the disappearance of the feedback message, or after the disappearance of the test word (in the event that the participant had made no errors), a message appeared announcing the presentation of the next test pair.

The participant was instructed that she/he would be presented with a series of pairs of words and that she/he should indicate, for each word in each pair, whether it had appeared in the current list. She/he was instructed to press the "B" and "N" keys to indicate positive and negative responses, respectively, and to respond as quickly as possible, without sacrificing accuracy. Fig. 1 shows the sequence of events on each trial.

Results

For simplicity, only the data for the test word will be presented. These data are summarized in Figs. 2 and 3.

Test word old

Time for correct responses did not vary as a function of whether or not the prime and test word were related [$F(1, 111) < 1$] or as a function of whether the prime word was old or new [$F(1, 111) = 3.68$, $MSe = 26{,}037$]. The effects

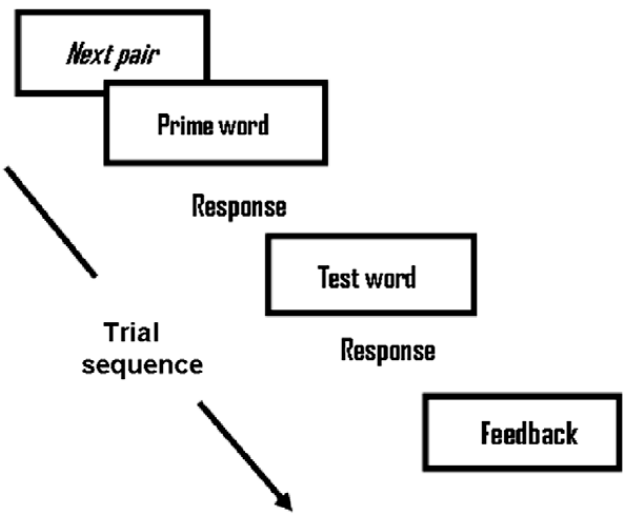

Fig. 1. Sequence of events on a test trial for Experiment 1.

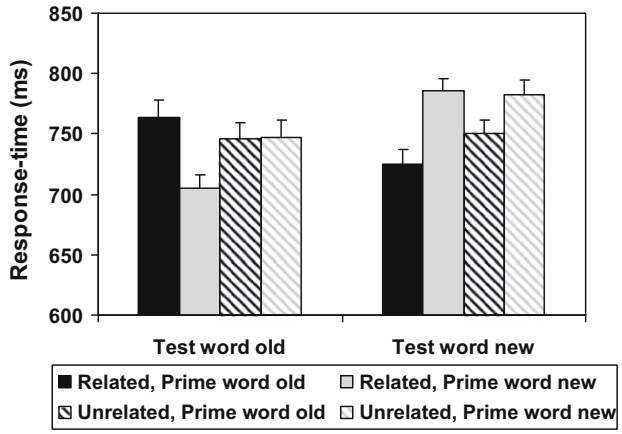

Fig. 2. Experiment 1: time for correct responses to the test word as a function of whether the prime word was old or new, whether the test word was old or new, and whether or not the prime word and test word rhymed.

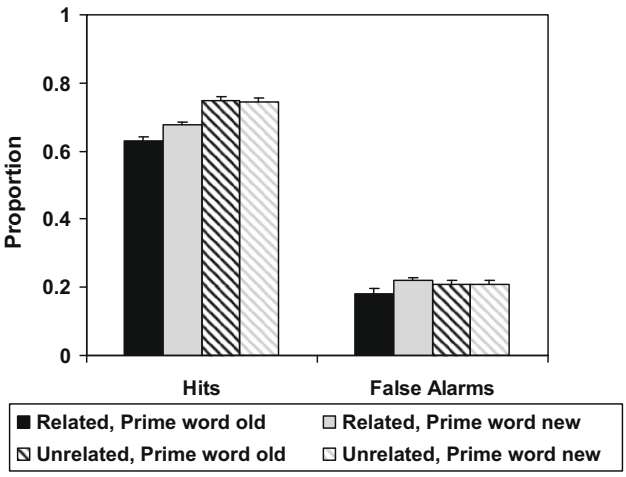

Fig. 3. Experiment 1: proportion of positive responses to the test word a function of whether the prime word was old or new, whether the test word was old or new, and whether or not the prime word and test word rhymed.

of Relationship and Prime Word did not interact in the response-time data [$F(1, 111) = 2.59$, $MSe = 38{,}003$] (All statistical tests were conducted against a significance criterion of .05).

Hit rate was lower when the prime and test word were related than when they were unrelated [$F(1, 111) = 26.62$, $MSe = .036$]. Hit rate did not vary as a function of whether the prime word was old or new [$F(1, 111) = 1.22$, $MSe = .034$]. The effects of Relationship and Prime Word did not interact in the hit-rate data [$F(1, 111) = 2.11$, $MSe = .035$].

Test word new

Time for correct responses did not vary as a function of whether or not the prime and test word were related [$F(1, 111) < 1$]. Time for correct responses was greater when the prime word was new than when it was old [$F(1, 111) = 8.51$, $MSe = 29{,}369$]. The effects of Relationship

and Prime Word did not interact in the response-time data [$F(1, 111) < 1$].

False-alarm rate did not vary as a function of whether or not the prime and test word were related [$F(1, 111) < 1$] or as a function of whether the prime word was old or new [$F(1, 111) < 1$]. The effects of Relationship and Prime Word did not interact in the false-alarm-rate data [$F(1, 111) = 1.89$, $MSe = .023$].

Overall

An estimate of the rate of corrected recognition was computed from each participant's data for each of the four conditions that occurred when Prime Word and Relationship were crossed. The corrected recognition estimate for a given condition was the difference between the proportions of hits and false alarms for that condition. The rate of corrected recognition was lower when the prime word and test word were related than when they were unrelated [$F(1, 111) = 12.39$, $MSe = .061$]. The rate of corrected recognition did not vary as a function of whether the prime word was old or new [$F(1, 111) < 1$]. The effects of Relationship and Prime Word did not interact in the corrected-recognition data [$F(1, 111) < 1$].

Discussion

Rhyme priming impeded correct positive recognition responses to old test words and had no effect on recognition responses to new test words. When the results were examined independently of the list status of the test word, rhyme priming reduced the accuracy of the recognition judgments. An additional result occurred as a function of the list status of the prime word. Correct negative judgments to the test word were faster when the prime word was old than when it was new. This may reflect a list priming effect. When the prime word was old, the judgment to the test word may have been facilitated because the list was activated following the judgment to the prime word.

Experiment 2

The effect of superficial priming in Experiment 1 was different from the effect of semantic priming in episodic recognition and different than had been suggested by previous fluency studies. The effect was demonstrated with a strong manipulation of the relationship between the prime item and the test item. Experiment 2 sought to demonstrate the same superficial priming effect with a weaker manipulation of the prime–test relationship. Whereas Experiment 1 manipulated whether or not the prime item and the test item were linked by a phonological/orthographic (rhyme) relationship, Experiment 2 manipulated whether or not the prime item and the test item were linked by an orthographic relationship. The stimuli for the experiment were randomly generated consonant strings. We assumed that strings with multiple shared consonants were orthographically related. Because the strings consisted entirely of consonants, and were not readily pronounceable, the role of phonological relationship was minimized.

In more detail, the experiment was organized as follows. Because consonant strings are more difficult to remember than words, the procedure of the experiment differed in several respects from the procedure of Experiment 1. Whereas Experiment 1 consisted of a relatively small number of blocks, with a relatively long list and a relatively large number of test pairs being presented in each block, Experiment 2 consisted of a relatively large number of blocks, with a relatively short list and a relatively small number of test pairs being presented in each block. Specifically, whereas Experiment 1 consisted of eight blocks, Experiment 2 consisted of 72 blocks; whereas a 32-element list was presented in each block of Experiment 1, an 8-element list was presented in each block of Experiment 2; whereas 32 test pairs were presented in each block of Experiment 1, a single test pair was presented in each block of Experiment 2.

Method

Participants

The participants were 68 students from the same population as was used in Experiment 1.

Design

The design was the same as for Experiment 1. Over the course of the experiment, nine blocks apiece were assigned to each of the eight conditions.

Materials

Each of the stimuli used in the experiment was a string of four consonants created by a process in which each successive consonant was sampled with replacement from the set of 21 possible consonants (e.g. CGTP). The test pairs were generated from a set of 72 string triples. The first and second string of each triple shared three of the possible four consonants. The third string of the triple shared no consonants with the first string. The rest of the stimuli for the experiment came from a set of 792 strings.

The materials for each participant were created as follows: First, the test pairs were created, as follows: (1) The 72 string triples were assigned to the 72 blocks according to a random scheme that was unique to the participant in question. (2) The 72 blocks were assigned to the eight different conditions, nine blocks to a condition, according to a random scheme that was unique to the participant in question. (3) Once these assignments were made, the test pair for a given block was created as follows: The first string of the triple for the block was the test string. If the triple was assigned to a condition in which an orthographic relationship was present between the prime string and the test string, the second string of the triple was the prime string. If the triple was assigned to a condition in which an orthographic relationship was absent between the prime and test string, the third string of the triple was the prime string.

Next, the lists were created, as follows: (1) For blocks assigned to conditions in which the prime string was old, the prime string was placed in the list. (2) For blocks assigned to conditions in which the test string was old, the test string was placed in the list. (3) The rest of the strings

in the list were then sampled without replacement from the set of 792 strings. (4) Finally, the eight strings in the list were placed in a random order that was unique to the participant in question.

Procedure

The procedure was the same as for Experiment 1 except that the message announcing the beginning of the test phase remained on the screen for 3000 rather than 1000 ms.

Results

Test string old

Time for correct responses did not vary as a function of whether or not the prime and test string were related [$F(1, 67) = 3.82$, $MSe = 125{,}558$] or whether the prime string was old or new [$F(1, 67) = 1.74$, $MSe = 94{,}014$]. The effects of Relationship and Prime String did not interact in the response-time data [$F(1, 67) = 1.10$, $MSe = 110{,}532$] (see Figs. 4 and 5).

Hit rate was lower when the prime and test string were related than when they were unrelated [$F(1, 67) = 19.81$, $MSe = .043$]. Hit rate did not vary as a function of whether the prime string was old or new [$F(1, 67) = 3.03$, $MSe = .050$]. The effects of Relationship and Prime String did not interact in the hit-rate data [$F(1, 67) = 3.20$, $MSe = .040$].

Test string new

Time for correct responses did not vary as a function of whether or not the prime and test string were related [$F(1, 67) = 1.88$, $MSe = 91{,}729$] or as a function of whether the prime string was old or new [$F(1, 67) = 2.76$, $MSe = 78{,}526$]. The effects of Relationship and Prime String did not interact in the response-time data [$F(1, 67) < 1$].

False-alarm rate did not vary as a function of whether or not the prime and test string were related [$F(1, 67) < 1$] or as a function of whether the prime string was old or new [$F(1, 67) < 1$]. The effects of Relationship and Prime String did not interact in the false-alarm-rate data [$F(1, 67) < 1$].

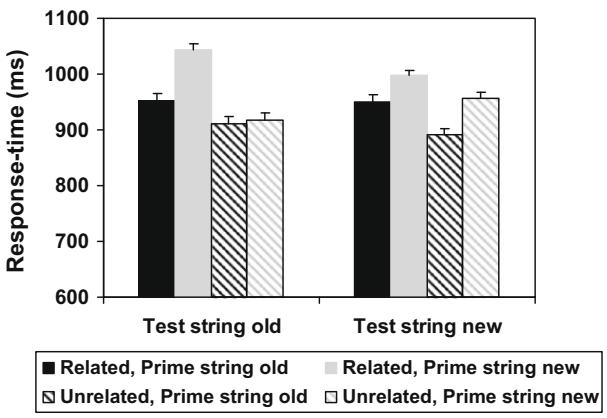

Fig. 4. Experiment 2: time for correct responses to the test string as a function of whether the prime string was old or new, whether the test string was old or new, and whether or not the prime string and test string were orthographically related.

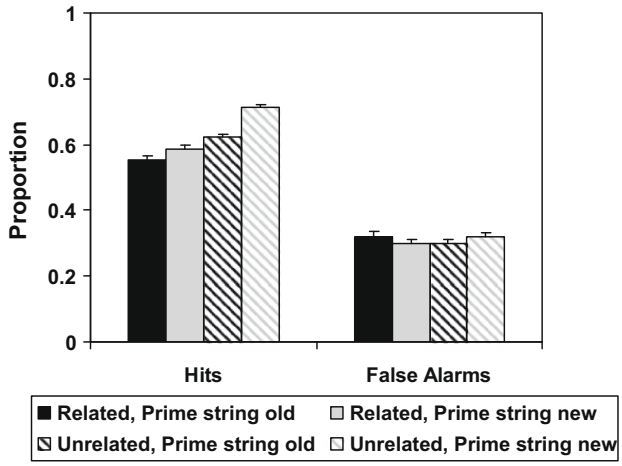

Fig. 5. Experiment 2: proportion of positive responses to the test string as a function of whether the prime string was old or new, whether the test string was old or new, and whether or not the prime string and test string were orthographically related.

Overall

The rate of corrected recognition was lower when the prime and test string were related than when they were unrelated [$F(1, 67) = 16.14$, $MSe = .013$]. The rate of corrected recognition did not vary as a function of whether the prime string was old or new [$F(1, 67) = 2.16$, $MSe = .021$]. The effects of Relationship and Prime String did not interact in the corrected-recognition data [$F(1, 67) < 1$].

Discussion

Orthographic priming impeded correct positive recognition responses to old test strings and had no effect on recognition responses to new test strings. When the results were examined independently of the list status of the test string, orthographic priming reduced the accuracy of the recognition judgments. These results resemble the results of Experiment 1.

Experiment 3

The effect of superficial priming in Experiments 1 and 2 was somewhat unexpected in light of past work in this area. Before going further, we wanted to be sure that the effect did not reflect uninteresting aspects of the particular experimental procedures we had used. A feature of the design for Experiments 1 and 2 was cause for concern in this respect. Consider the crucial trials on which the test item was old. When the prime item was also old and the prime and test item were related, a pair of related items was present in the list and those items were tested in succession during the test phase. As a consequence of this arrangement, participants may have developed ad hoc learning strategies that somehow contributed to the results that were observed. This concern is somewhat mitigated given that superficial priming impeded correct positive recognition responses when the prime item was new. Nonetheless, Experiment 3 sought to reproduce the pattern of Experiments 1 and 2 under conditions in which

such strategies would not be a concern. Specifically, this experiment sought to reproduce the pattern with a task in which the participant made no response to the prime item. In addition, the experiment sought to extend the results of Experiments 1 and 2 to a new type of stimulus.

The task for Experiment 3 was the same as for Experiments 1 and 2 except that the prime item was never in the list and no recognition response was required to it. The experiment had the same 72-block structure as Experiment 2 except that the list for each block comprised twelve items. The stimuli for the experiment were proper names (e.g. Harry).

Method

Participants

The participants were 64 students from the same population as was used in previous experiments.

Design

Relationship (Related/Unrelated) and Test Word (Old/New) were manipulated within participants. Crossing these two independent variables produced four experimental conditions. Over the course of the experiment, 18 blocks apiece were assigned to each of the conditions.

Materials

The test pairs were generated from a set of 72 name triples. The first and second words of each triple rhymed (Barry, Harry). The third word had no obvious phonological or orthographic relationship to the first word (Melvin). The rest of the stimuli for the experiment were sampled from a set of 792 names. The stimulus materials were generated as in Experiment 2.

Procedure

The procedure was the same as for Experiment 1, except that the participant simply read the prime word without making a recognition response to it. Specifically, the prime word was presented for 1000 ms, after which pressing the space bar initiated presentation of the test word. The participant was instructed that she/he should read the prime word and make a recognition judgment to the test word and that reading the prime word might help her/him in responding to the test word.

Results

Test word old

Time for correct responses did not vary as a function of whether or not the prime and test word were related [$F(1, 63) < 1$]. Hit rate was lower when the prime and test word were related than when they were unrelated [$F(1, 63) = 13.82$, $MSe = .014$] (see Figs. 6 and 7).

Test word new

Neither time for correct responses [$F(1, 63) < 1$] nor false-alarm rate [$F(1, 63) = 2.57$, $MSe = .008$] varied as a function of whether or not the prime and test word were related.

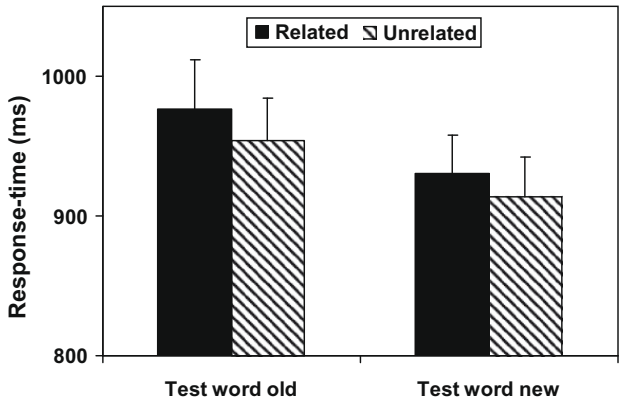

Fig. 6. Experiment 3: time for correct responses to the test word as a function of whether the test word was old or new and whether or not the prime word and test word rhymed.

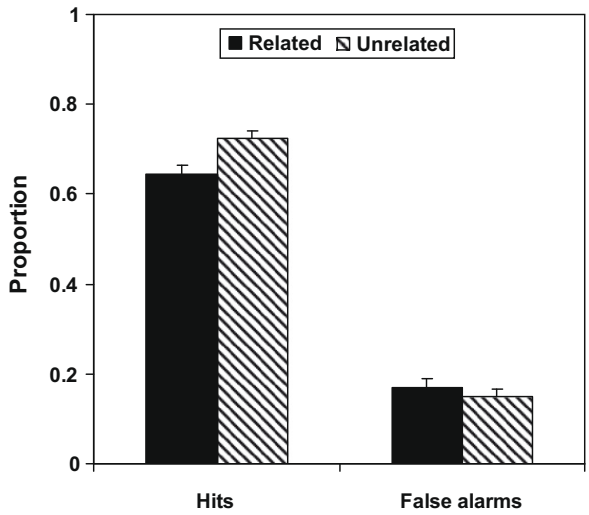

Fig. 7. Experiment 3: proportion of positive responses to the test word as a function of whether the test word was old or new and whether or not the prime word and test word rhymed.

Overall

The rate of corrected recognition was lower when the prime and test word were related than when they were unrelated [$F(1, 63) = 20.69$, $MSe = .017$].

Discussion

The pattern of Experiments 1 and 2 was observed under conditions that were not problematic in the manner detailed earlier. In sum, Experiments 1–3 demonstrated a different effect of superficial priming than has been suggested by past studies of fluency (Rhodes & Kelley, 2003; Whittlesea & Williams, 2001). Whereas the implication of the previous fluency experiments that most closely approximated traditional priming procedures is that superficial priming increases the false-alarm rate (Rhodes & Kelley, 2003), superficial priming reduced the hit rate in Experiments 1–3. Why was the effect of superficial priming in Experiments 1–3 different from the implied effect of superficial priming in these fluency experiments? Crucially, the tem-

poral interval between the presentation of the test item and the recognition response to the test item was shorter in Experiments 1–3 than in the fluency experiments. Consider, first, the fact that superficial priming reduced the hit rate in Experiments 1–3 but not in the fluency experiments. In Experiments 1–3, the participant was required to make an overt recognition judgment to the test item immediately after it was presented. When the test item was old, this judgment was more likely to be incorrect when the prime item and test item were superficially related than when they were unrelated. In the fluency experiments, in contrast, participants had the opportunity to make a covert recognition judgment to the test item before the required overt judgment. On the basis of the results of Experiments 1–3, we would assume that the covert judgment was more likely to be incorrect when the prime and test item were superficially related than when they were unrelated. But participants had the opportunity to revise their incorrect judgment before making the final overt judgment. It may have been consequent to this opportunity that superficial priming did not reduce hit rate in the fluency experiments. Consider, second, the fact that superficial priming increased the false-alarm rate in the fluency experiments but not in Experiments 1–3. The longer temporal interval between the presentation of the test item and the recognition response to the item may have allowed the prime item to exert more influence on the test item in the fluency experiments, with the result that a greater sense of familiarity developed for the test item.[1]

The effect of superficial priming in Experiments 1–3 differed from the effect of semantic priming in episodic recognition and from what would be expected on the basis of previous studies of the impact of superficial processing on fluency. Does this priming effect constitute new information about episodic recognition, or can we understand it in terms of currently available principles? Experiment 4 explored the applicability of two such principles.

Experiment 4

One possibility is that the superficial priming effect reflects a process of discounting. Jacoby and Whitehouse (1989) introduced the discounting conception to explain their finding that the effect of identity priming in episodic recognition depended on the temporal interval for which the identity prime was presented; whereas false alarms increased when the interval was 16 ms, false alarms and, to a lesser extent, hits decreased when the interval was 600 ms. Jacoby and Whitehouse proposed that, whereas the identity prime increased the fluency of processing and thus the degree of familiarity attributed to the test word at both intervals, participants were cognizant at some level of the increased familiarity at the long interval, attributed it to the presence of the identity prime, and reduced their rate of positive response accordingly. Huber, Shiffrin, Lyle, and Ruys (2001) developed a more complex conception of discounting in the context of a short-term perceptual identification task. As part of this conception, they introduced the idea that information can be discounted to a degree that is greater or less than optimal (Huber, Shiffrin, Lyle, & Quach, 2002; Huber, Shiffrin, Quach, & Lyle, 2002).

The discounting conception might be used as follows to explain the present priming effect. On trials in which the prime item and test item were related, the participant was aware, at some level, upon processing the test item: (a) that the prime item was related to the test item, (b) that processing the prime item might have increased the fluency with which the test item was processed, and (c) that increased fluency in the processing of the test item might have been interpreted as evidence that the test item was familiar. The participant consequently discounted the perceived familiarity of the test item. In fact, the participant discounted the perceived familiarity of the test item to a degree that was greater than optimal. The participant was consequently less likely than on unrelated trials to make a correct positive response to the test item.

Another possibility is that the priming effect reflects habituation in the familiarity assessment process. Huber and O'Reilly (2003) used this idea to account for results observed in short-term perceptual identification. Their model produces discounting-like behavior without appealing to a strategic discounting process. In the Huber and O'Reilly model, the stimuli for the perceptual identification task are represented by neural units. At a given moment, the level of *output activation* for each neural unit depends on the level of its *pre-synaptic activity* and the level of its *synaptic resources*. At a given moment, the synaptic resources for each unit are subject to a level of *depletion* that depends on the degree to which the level of output activation at the unit has been greater, in the recent past, than the unit's threshold. As a consequence of this arrangement, each unit is habituated, at a given moment, to the degree that it has produced output activation in the recent past. This sort of habituation process has been used to account for patterns of priming in perceptual identification (Huber, 2008; Huber, Clark, Curran, & Winkielman, 2008).

The habituation conception might be used as follows to explain the present priming effect. On trials in which the prime item and test item were related, the unit(s) representing the test item produced output activation when the prime item was processed, with the result that the synaptic resources of these units became depleted. As a consequence, when the test item was processed, these units produced less output activation, and the test item was consequently less likely to be judged familiar than on unrelated trials.

In Experiment 4 we sought evidence against the discounting and the habituation interpretations of the priming effect of Experiments 1–3. The experiment resembled Experiment 3 except that the first letter was removed from each prime item and replaced with a blank. As in Experiment 3, the participant simply read the prime item, and made no recognition response to it. Readers concerned about the capacities of participants for reading these non-word prime items can rest assured that evidence will be presented later that participants actually did read the items.

[1] As to why the increase in familiarity was reflected in false alarms and not hits, we note that priming effects from manipulations of fluency are generally larger for new than old items (Jacoby & Whitehouse, 1989).

We reasoned that, if the discounting or the habituation interpretation were correct, Experiment 4 should produce the same pattern of results as Experiment 3. This followed because discounting and habituation are driven by overlap between the prime item and the test item and because the amount of overlap between the two items should not decrease if we removed mismatching letter. The experiment tested this prediction.

Because the results from an initial version of the experiment were compromised by a speed-accuracy-tradeoff, a response signal was used in an attempt to control the speed of responding and concentrate the effect of the experimental manipulation in the hit- and false-alarm-rate data. The response interval was set so that response times would match the average response time for Experiment 3 (thus responses were not speeded beyond the level observed when participants are encouraged to respond quickly without sacrificing accuracy).

Method

Participants

The participants were 31 students from the same population as was used in previous experiments.

Design

The design was the same as for Experiment 3.

Materials

The materials were the same as for Experiment 3 except that the first letter of each prime item was removed.

Procedure

The procedure was as for Experiment 3 except that the timing of the participant's response was controlled with a response signal. Six hundred milliseconds after the test item appeared, four asterisks appeared at the bottom of the screen. The participant attempted to make his/her response concurrently with the appearance of the asterisks. If the interval between the appearance of the test item and the participant's response was less than 600 ms, the message "TOO FAST" appeared at the bottom of the screen and remained there until the participant pressed the space bar. If the interval was greater than 850 ms, the message "TOO SLOW" appeared in the same manner.

Results

Test word old

Hit rate did not vary as a function of whether or not the prime item and test item were related [$F(1, 30) < 1$]. Time for correct responses was shorter when the prime item and test item were related than when they were unrelated [$F(1, 30) = 6.26$, $MSe = 19{,}579$] (We report the response-time data because, as is often the case, the response signal was not successful in completely controlling response time) (see Figs. 8 and 9).

Test item new

False-alarm rate did not vary as a function of whether or not the prime item and test item were related [$F(1, 30) < 1$].

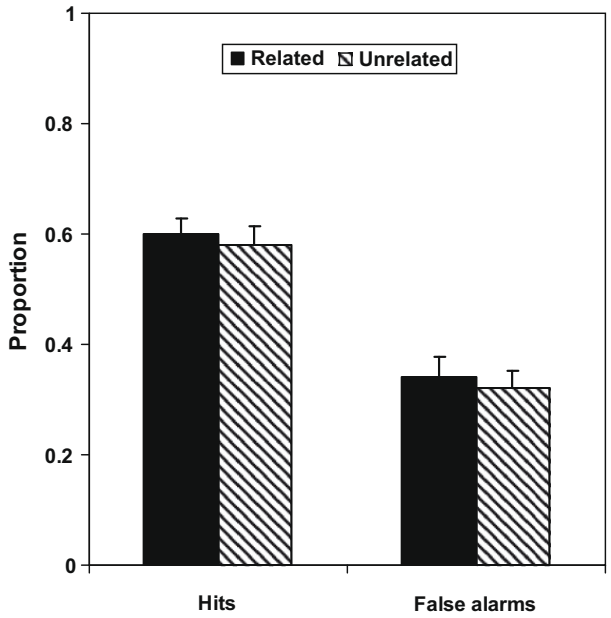

Fig. 8. Experiment 4: proportion of positive responses to the test item as a function of whether the test item was old or new and whether or not the prime item and test item were related.

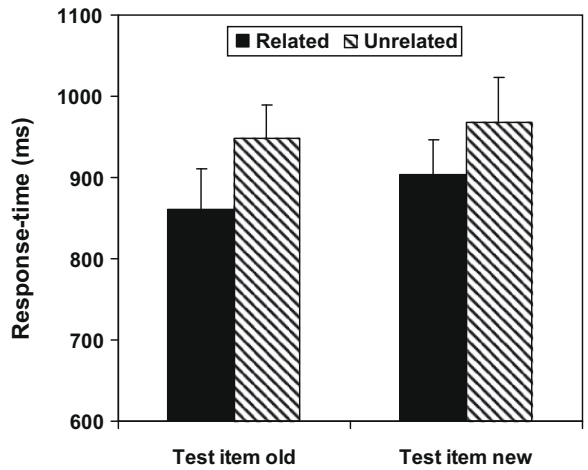

Fig. 9. Experiment 4: time for correct responses to the test item as a function of whether the test item was old or new and whether or not the prime item and test item were related. Response times include the 600 ms that elapsed before the response signal was presented.

Time for correct responses did not vary as a function of whether or not the prime item and test item were related [$F(1, 30) = 2.76$, $MSe = 22{,}821$].

Overall

Corrected recognition did not vary as a function of whether or not the prime item and test item were related [$F(1, 30) < 1$].

Discussion

The superficial priming effect of Experiment 3 was not observed; priming did not reduce the hit rate. Rather, priming reduced the time for correct positive responses.

Notice that the latter result implies that participants processed the prime item and did not simply ignore it.

Experiment 5

Experiment 5 sought to reinforce the results of Experiment 4. The experiment resembled Experiment 3 except in the following respects: (a) whereas the prime word and the test word were either related or unrelated in Experiment 3, the prime word and the test word were either identical or unrelated in Experiment 5. (b) Whereas Experiment 3 used short lists, Experiment 5 used long lists (as in Experiment 1) (this change was necessary to camouflage the trials on which the prime word and test word were identical; long lists allowed the presentation of many filler pairs, in the context of which the prime word and the test word were identical in only 6% of the test pairs). (c) Whereas the prime word was never old in Experiment 3, the prime word was always old when the test word was old for the experimental pairs of Experiment 5, and, across all experimental and filler pairs, the prime word was old 50% of the time (this change was necessary because, for obvious reasons, the prime word was always old when the prime word and test word were identical and the test word was old). Thirty participants were run in the experiment. A response signal was not used.

The rationale for the experiment was the same as for Experiment 4 except that Experiment 5 had the added virtue of: (a) providing complete overlap between the prime item and test item in the related condition and (b) avoiding: (1) questions arising in Experiment 4 with respect to how participants could read the prime item and (2) questions regarding the response signal procedure.

Results

Test word old

Time for correct responses was shorter when the prime word and test word were identical than when they were unrelated [$F(1, 29) = 59.51$, $MSe = 14{,}856$]. Hit rate did not vary as a function of the relationship between the prime word and the test word [$F(1, 29) < 1$] (see Figs. 10 and 11).

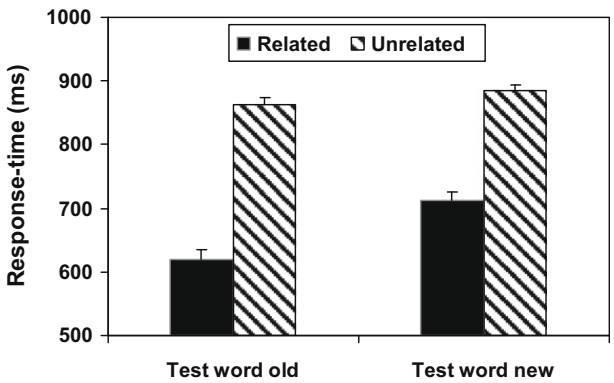

Fig. 10. Experiment 5: time for correct responses to the test word as a function of whether the test word was old or new and whether the prime word and test word were identical or unrelated.

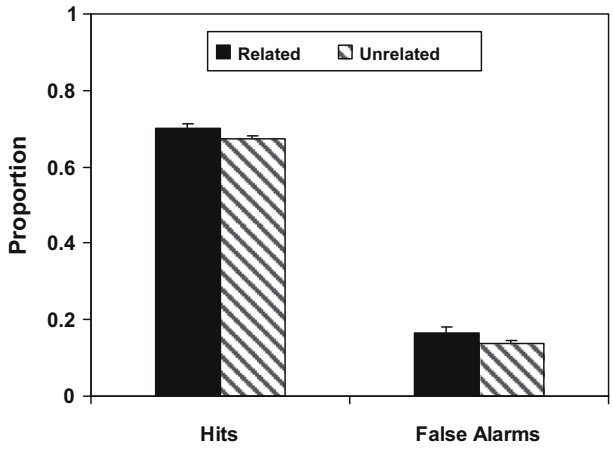

Fig. 11. Experiment 5: proportion of positive responses to the test word as a function of whether the test word was old or new and whether the prime word and test word were identical or unrelated.

Test word new

Time for correct responses was shorter when the prime word and test word were identical than when they were unrelated [$F(1, 29) = 12.80$, $MSe = 34{,}209$]. False-alarm rate did not vary as a function of the relationship between the prime word and the test word [$F(1, 29) < 1$].

Overall

Corrected recognition did not vary as a function of the relationship between the prime word and the test word [$F(1, 29) < 1$].

Discussion

As in Experiment 4, the superficial priming effect of Experiments 1–3 was not observed; priming did not reduce the hit rate. Rather, priming reduced the time for correct positive and correct negative responses. As before, the latter result implies that participants processed the prime word. The results of Experiments 4 and 5 do not support the discounting or the habituation interpretation of the priming effect of Experiments 1–3. We will discuss other aspects of the results of these experiments shortly.

General discussion

In five experiments, we observed two distinct effects of superficial priming in episodic recognition. In Experiments 1–3, the hit rate to the test item was lower when the prime item and test item were related than when the prime item and test item were unrelated. From the fact that this priming effect occurred in the hit-rate data, we infer that it reflected interference with the recognition process. From the fact that the effect did not occur in Experiments 4 and 5, we infer that it did not reflect a process of discounting or habituation. More generally, from the fact that the effect occurred in Experiments 1–3 but not in Experiments 4 and 5, we infer that the effect depended on the test item's sharing many but not all of the related prime item's features.

In Experiments 4 and 5, time for correct responses to old test items was shorter when the prime item and test

item were related than when they were unrelated. In Experiment 5, time for correct responses to new test items was shorter when the prime item and test item were related than when they were unrelated; a similar, non-significant pattern was present in the means for Experiment 4. This priming effect probably did not reflect the recognition process. The results suggest that the presence of a prime–test relationship facilitated performance regardless of whether the test item was old or new. It is difficult to see how the presence of a prime–test relationship could have facilitated recognition processing to both old and new test items. For example, if the test item was processed more fluently when a relationship was present, and if fluent processing was attributed to familiarity, the presence of a relationship should have impeded correct negative responses at the same time that it facilitated correct positive responses. It seems likely, then, that this priming effect reflected facilitation in the perceptual processing of the test item, prior to the point of recognition processing. This is probably why the effect showed up in the response time but not the hit- and false-alarm-rate data.

From the fact that the response-time priming effect occurred in Experiments 4 and 5, but not in Experiments 1–3, we infer that the effect depended on the test item's sharing all of the related prime item's features. Previous work gives some sense as to why this was so. Van Assche and Grainger (2006) observed more lexical decision priming when the test item shared all of the related prime item's letters than when the test item shared all but two of the related prime item's letters. To explain their results, Assche and Grainger proposed that, whereas perceptual processing of the test item is facilitated to the extent that the test item shares the related prime item's letters, perceptual processing of the test item is inhibited to the extent that the prime item and test item have mismatching letters. We appeal to similar ideas in explaining the present results: Thus, whereas time for correct responses to the test item was reduced in Experiments 1–5 because the test item shared many of the related prime item's letters, time for correct responses to the test item was increased in Experiments 1–3 because the prime item and test item had one mismatching letter. In addition, time for correct positive responses may have been increased in Experiments 1–3 because the recognition process was impeded in those experiments (in other words, because the effect in the hit-rate data was accompanied by a parallel response-time effect). As a result, whereas a response-time priming effect was observed in Experiments 4 and 5, response time did not vary with relatedness in Experiments 1–3.

Superficial priming produced a different effect on the episodic recognition process than has previously been observed for semantic priming. Recall that for Ngo et al. (2007), semantic priming impeded correct negative responses and had no effect on positive responses. That superficial and semantic relationships affect the episodic recognition process differently has been known for some time. Differences were first noted in studies of the effects of recognition distracters (Bencomo & Daniel, 1975; Bruder & Silverman, 1972; Hermann, McLaughlin, & Nelson, 1975). More recently the impact of manipulations that enhance superficial but not semantic fluency have been found to depend on the match between perceptual features at study and test (Miller, Lloyd, & Westerman, 2008; Thapar & Westerman, 2009).

As to why superficial and semantic priming affect the episodic recognition process differently, we can only speculate at this point. On one hand, the difference may reflect a difference in the way that superficial and semantic relationships are mentally represented. This sort of representational account has been proposed for differences in the effects of superficial and semantic priming in perceptual identification; such differences have been attributed to differences in the connectivity and thus the rate of information integration at the superficial and semantic levels (Huber, 2008).

Alternatively, the difference may reflect a difference in the memory processes associated with the superficial and semantic levels of representation. According to the Conjoint Recognition model of recognition, recollection is supported by superficial traces whereas familiarity-based recognition is supported by semantic traces (Brainerd, Reyna, & Mojardin, 1999). In this context, it is worth noting that Ngo et al. (2007) interpreted their finding that semantic priming impeded correct negative responses and had no effect on positive responses as reflecting the operation of familiarity-based recognition (Brainerd et al., 1999; Norman & O'Reilly, 2003; Reder et al., 2000; Yonelinas, 2002). Specifically, Ngo et al. proposed that semantic priming increased the likelihood of positive familiarity assessment, and that the increased likelihood impeded correct negative responses but had no effect on positive trials because responses on these trials reflected primarily recollection. They supported their interpretation by showing that, when they revised their procedures such that familiarity assessment would be expected to play a larger role on positive trials, semantic priming facilitated correct positive recognition responses. In light of these previous results, we must consider the possibility that the present hit-rate priming effect reflects the operation of the recollection process. Obviously, further work is needed here.

In conclusion the effect of superficial priming in episodic recognition is different from the effect of semantic priming in episodic recognition. The priming effect probably cannot be attributed to a process of discounting or to habituation in the familiarity assessment process.

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