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Repetition Priming Across Distinct Contexts: Effects of Lexical Status, Word Frequency, and Retrieval Test

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Abstract

Repetition priming, the facilitation observed when a target is preceded by an identity prime, is a robust phenomenon that occurs across a variety of conditions. Oliphant (1983), however, failed to observe repetition priming for targets embedded in the instructions to an experiment in a subsequent lexical decision task. In the present experiments, we examined the roles of priming context (list or instructions), target lexicality, and target frequency in both lexical decision and episodic recognition performance. Initial encoding context did not modulate priming in lexical decision or recognition memory for low-frequency targets or nonwords, whereas context strongly modulated episodic recognition for high-frequency targets. The results indicate that priming across contexts is sensitive to the distinctiveness of the trace and the reliance on episodic retrieval mechanisms. These results also shed light on the influence of event boundaries, such that priming occurs across different events for relatively distinct (low-frequency) items.

Repetition priming is highly reliable, occurs across a wide variety of stimulus types, and has been found to persist across delays of months or even years (e.g., Kolers, 1976). These priming effects can occur in short-term conditions (i.e., when the prime immediately precedes the target) and in long-term conditions (i.e., when there are several intervening items or events between the prime and the target). The mechanisms thought to underlie the empirical results include accounts that attribute the facilitation to changes in the activation level of abstract representations (e.g., Collins & Loftus, 1975) or models that emphasize the episodic retrieval of earlier traces which are sensitive to the degree of overlap in processing between priming and transfer tasks (e.g., Whittlesea & Jacoby, 1990). Hybrid models that include both retrieval and activation components have also been proposed (e.g., Tenpenny, 1995).

Regardless of the differences between accounts of priming, it is important to note that interest in repetition priming has been heavily influenced by the notion that the observed effects reflect more automatic/implicit processing than controlled/strategic processing. To maximize the role of such automatic processes, while minimizing the contribution of controlled or strategic processing, tasks that encourage speeded responses are the mainstay of priming research (see Tse & Neely, 2005). Although no task is process-pure (Jacoby, 1991), tasks such as lexical decision (LDT), in which speeded word/nonword decision are made, along with appropriate controls, can minimize strategic processing.

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The present experiments focus on the extent to which large changes in context between the priming event and the testing event modulate the size of the priming effect. Particularly relevant to the present study is work by Oliphant (1983), who observed no repetition priming for words initially embedded in the instructions for an upcoming experiment when the same items were later presented in a LDT. However, when repeated in separate blocks of trials within the LDT, these words resulted in reliable repetition priming. Oliphant attributed the absence of facilitation in the cross-context condition to a lack of awareness on the part of participants that some words were repeated. Very simply, the stimuli were less salient when presented in the context of instructions relative to when they were presented earlier in the lexical decision task.

Oliphant's (1983) findings are problematic for many accounts of priming, because most models would predict priming for words presented in different contexts, albeit because of different mechanisms. For example, abstractionist models predict that processing an item should result in some increase in its resting activation level and these changes should occur regardless of the context, as long as the stimulus is re-processed (e.g., Tenpenny, 1995), although it is important to note that most models assume the activation is short-lived, and thus have some difficulty explaining long-term priming (but see Bowers, 2000). From the perspective of traditional activation models, quick dampening of activation (e.g., Anderson, 1983; Dell, 1986) to return items to baseline might be facilitated or cued by a context change, such that active information in one context is perceived to be less or no longer relevant in another context. Retrieval accounts (e.g., Masson & Bodner, 2003; Whittlesea & Jacoby, 1990), which attribute priming effects to the retrieval of earlier episodic traces laid down during the initial processing of an item, would likely predict processing benefits due to changes in the strength of the memory representation. Because these are essentially memory-based accounts, sensitivity to context would serve to refine the search space in memory, as well as maximize the overlap in processing between encoding and retrieval. The effects of processing manipulations (e.g., conceptual or perceptual processing) on retrieval are well-documented in the literature (e.g., Blaxton, 1989; Morris, Bransford, & Franks, 1977). It is important to note that the retrieval processes engaged according to these accounts are not necessarily under conscious control or accompanied by conscious recollection; rather, they reflect the overlap in processes occurring at encoding and at retrieval (Jacoby & Dallas, 1981; Jacoby, 1983).

The retrieval accounts are quite similar to the more general Transfer Appropriate Processing perspective (TAP; Morris, et al., 1977), in which a lack of repetition priming could be due to the different types of processes engaged when reading words in the context of the instructions and performing a lexical decision. The degree to which priming across contexts and tasks depends on the extent to which overlapping processes are engaged at the encoding and retrieval events (Franks, Bilbrey, Lien, & McNamara, 2000). Specifically, reading for meaning is more likely to engage conceptual processes, as the reader focuses on the meaning of the word and how it fits in the surrounding context. During LDT, or when reading words in isolation, relatively more focus is given to perceptual (e.g., orthographic familiarity-based processes) characteristics of the word. Thus, when the priming event is more conceptually driven, less transfer to a task that taps into orthographic familiarity-based processes is likely to occur. According to this account, priming should be maximal when items are presented twice within the same LDT, somewhat reduced when the primes are presented in isolation (e.g., in a word list), and further reduced when the primes were embedded in the context of a meaningful passage.

Stimulus-response learning accounts (e.g., Horner & Henson, 2009; Logan, 1990) also rely on retrieval of earlier episodes to explain long-term priming effects and predict maximal priming for items repeated twice in LDT. According to these models, priming reflects the binding of a stimulus with a response and the fact that retrieving a prior response is more efficient than reprocessing the item and making a decision anew on each encounter. In other words, when a target is repeated in LDT, participants can retrieve their prior response (i.e., word or nonword) rather than using a slower algorithmic process to perform the task. According to this account, the Oliphant (1983) results might be explained by the fact that no response was made to items in the instructions (therefore there would be no stimulus-response based trace to retrieve from memory for the LDT).

Repetition Priming for Words Presented in Different Contexts

Following Oliphant (1983), several investigations of priming effects across context changes have been reported. In many of the studies that followed Oliphant, however, the priming context consisted of a prose passage and participants were given intentional study instructions and told their comprehension of the passages would be tested (e.g., Nicolas, 1996, 1998). Hence, the processing differed markedly from the incidental exposure condition employed by Oliphant, who presented the targets embedded in the instructions. It is possible that giving more intentional encoding instructions would encourage participants to direct more attention to the targets in the priming passages. This, in turn, might result in the creation of a stronger memory trace, thereby raising the question of whether participants are better able to engage in intentional or strategic retrieval of these earlier presented items. Furthermore, most studies did not use LDT, but tasks such as stem and fragment completion or perceptual identification (e.g., Levy & Kirsner, 1989; MacLeod, 1989). Under these conditions, as we will briefly review below, it is possible to obtain significant priming across contexts for some classes of targets.

There are a number of variables that modulate cross-context priming effects. For example, words that are not well integrated in the text are more likely to produce priming effects. As demonstrated by MacLeod (1989), presenting unusual or irrelevant words (i.e., words that did not fit with a sentence's meaning) in passages did result in priming for those items, presumably because the lack of “fit” directed attention to these words and to their specific orthographic features. Thus, these items might have elicited more perceptual encoding relative to words that were processed more fluently in the text and thus showed transfer benefits in tasks that are sensitive to perceptual processing (e.g., stem and fragment completion, LDT). High frequency (HF) words tend to show relatively little cross-context priming (e.g., Levy & Kirsner, 1989; Oliphant, 1983), compared to low frequency (LF) words (e.g., MacLeod, 1989; Nicolas, 1996, 1998; Speelman, Simpson, & Kirsner, 2002). In general, LF words do show larger priming effects than HF words, so this finding is not particularly surprising. It is also possible that LF words draw more attention to their orthographic features during encoding (e.g., Criss & Malmberg, 2008), thereby increasing the amount of transfer to LDT.

The type of transfer task is also important, because tasks that are more susceptible to strategic retrieval of earlier processing episodes or sophisticated guessing (i.e., stem and fragment completion, perceptual identification, word association) tend to show more reliable priming than tasks that require speeded responses and are less likely to encourage participants to use such strategies (i.e., LDT; see Kinoshita, 2001; Tse & Neely, 2005). However, given that relatively few studies have used LDT, this conclusion is somewhat speculative.

Another possible explanation for Oliphant's (1983) failure to observe cross-context priming might be that items presented in text were not processed as distinctive, but were, in a sense, bound to the context in which they originally appeared. In other words, these items were processed more relationally than at an item-level. MacLeod and Masson (2000) compared priming for words presented in a list in rapid serial visual presentation (RSVP) format to the priming observed for words embedded in a text or presented in a list format at a slow presentation rate. Relative to the baseline condition (i.e., the standard word list presentation), RSVP presentation and presentation of targets in a meaningful text equally reduced priming effects for targets. Thus, the degree to which an item receives item-specific processing and is perceived as distinct also appears to influence the likelihood that priming will be observed following presentation in a meaningful text.

In summary, it appears as if cross-context priming can be detected when targets are low in frequency, when they do not fit meaningfully in or are not bound to the context or passage in which they are embedded, and in tasks that are more likely to result in explicit retrieval and/or strategy use. However, because none of the studies following Oliphant (1983) used the same encoding manipulation (i.e., presenting the words embedded in the instructions of the experiment), the question remains open as to whether a single incidental processing event of a target in a context quite different from the transfer task results in any measurable change to its accessibility. An additional open question is whether such changes occur under conditions that minimize the influence of controlled retrieval processes.

Overview of the Methodology

Experiment 1 consisted of a replication and extension of Oliphant (1983) and Experiment 2 consisted of an attempt to test the possible role of episodic retrieval in the LDT more directly. Although Oliphant found no repetition priming from instructions to LDT performance, it is noteworthy that his items were relatively HF words. However, the same items did produce priming when presented twice in separate blocks of trials in the LDT, suggesting that target frequency was not the only factor involved in the elimination of priming. Furthermore, as noted above, most studies used intentional encoding or deeper processing as the priming event, and may not have implemented a sufficiently strong context change such as going from the instructions of the experiment to the experiment per se to provide a strong test of the role of context changes on repetition priming effects. As a control condition, we presented the same targets in a list with intentional study instructions. This encoding condition was selected because it should engage both conceptual and perceptual processes, but does not engage the same operations as a LDT and still occurs in a separate phase of the experiment.

An additional important difference between the present study and prior studies is that no studies using LDT included nonwords in the initial exposure conditions. Although this is probably due to the fact that most of the studies used prose passages for the initial presentation of the targets, it remains unclear whether a potential confound of study status and lexical status might have influenced some of the earlier findings (see Meade, Watson, Balota, & Roediger, 2007; Neely, 1991). Including nonwords in the encoding phase can reduce priming effects, because participants are assumed to be unable to rely on the presence or absence of an episodic trace to bias a word or nonword decision. Specifically, if an episodic trace is available, and only words were primed, then there is a bias to respond word to any stimulus that includes an episodic component. However, when nonwords are also primed, such an episodic retrieval mechanism is no longer helpful because both words and nonwords have episodic traces associated with them (Durgunoglu & Neely, 1987; Neely & Durgunoglu, 1985). In addition to presenting nonwords during encoding, a low ratio of primed to unprimed items can also reduce the role of strategic processing, and so only 16% of the trials consisted of primed items (or correct “old” responses in the recognition test). This ratio of new to repeated words is fairly similar to that used by Oliphant (1983), who had 17 primed words out of 105. We acknowledge that LDT does not guarantee that some strategic episodic retrieval might be occurring, but we believe that, under the appropriate conditions (this issue is further explored in Experiment 2), one can substantially reduce the potential for strategic processing.

In addition, very few studies (e.g., Duchek & Neely, 1989; Nicolas, 1996) have directly compared episodic recognition to measures of priming in this paradigm, and none, to our knowledge, did so following incidental encoding. Thus, the nature of the traces that are laid down during encoding is as yet unclear, as is the issue of whether direct and indirect retrieval tests point to possible dissociations in the role of context in the accessibility of an item (see Meade et al., 2007). Therefore, in Experiment 1, we also tested recognition for the earlier items in a separate group of participants. The recognition test list and the LDT test list were identical, with the exception of the decision (i.e., word/nonword vs. old/new), as were all tasks leading up to the final transfer task.

Experiment 1

Method

Participants—One hundred participants were recruited from the Washington University in Saint Louis psychology participant pool. Sixty-three were administered the LDT and 37 were administered the recognition test. Three participants in the LDT condition were replaced; two because their average RTs exceeded the group mean by over 2.5 standard deviations (SD) and one because of an unusually high error rate (over 41%). One participant in the recognition condition was replaced because he or she was not a native English speaker. Thus, a total of 60 participants contributed to the LDT data set and 36 to the recognition data set. Participants received course credit or $10 for their participation.

Materials

Critical Targets—Forty-eight critical word targets were selected. To ensure that each item served as its own control, the words were divided into three sets of 16 words each and counterbalanced across conditions. Within each of the three sets, half of the words were HF and half LF. Word frequency estimates were derived from the HAL frequency norms available through the English Lexicon Project (ELP, www.elexicon.wustl.edu; Balota et al., 2007). Raw frequency (out of an estimated 400 million observations; see Brysbaert & New, 2009) for HF words ranged from 9693 to 518924 (M = 107952), and for LF words the raw counts ranged from 238 to 3598 (M = 1137). Across sets and frequency, words were matched in orthographic neighborhood size, length, and LDT average response latency based on the norms in the ELP. In addition to the word targets, 24 pseudohomophonic nonword targets (e.g., *brane*, *phraug*) were selected and divided into three sets matched in length and orthographic neighborhood size. The words were selected such that they could be inserted into one of the three sets of instructions to the experiment in a relatively seamless fashion, while permitting the key manipulation of frequency. However, because the nonwords could only be presented as examples in the instructions, some of the word targets were also presented as examples, to make the nonword examples less salient.

Three sets of instructions were created in which the critical targets were presented approximately in the same position in the text across all sets. This constraint resulted in the use of some synonymous words. All participants were exposed to one of the three same sets of instructions, regardless of whether they were in the LDT or recognition test condition (see Appendix). Only the instructions immediately prior to the transfer task differed. The initial instructions oriented participants to the series of tasks they would complete. Embedded in the instructions were 16 target words, eight HF and eight LF, as well as eight nonwords.

Another 16 target words (8 LF, 8 HF) and eight nonwords were presented in a list presented before or after the instructions (see below for details). The third set of 16 words and eight nonwords was not primed and served as baseline.

Fillers—A filler list of equal length and composition to the critical list was created to avoid confounding initial exposure condition (instructions or study list) with recency. For half of the participants, this list was studied before the instructions, and the critical study list was studied after the instructions, whereas, for the other half of the participants, the order was reversed. Sixteen words (8 HF and 8 LF) matched in length, orthographic neighborhood size, and lexical decision RT based on the ELP database were selected. Eight nonwords similar to those used in the critical list were also selected.

An additional 216 items were selected as fillers for the test phase (96 words and 120 nonwords). The word targets and fillers were matched in length, frequency, orthographic neighborhood, and mean lexical decision RT and accuracy from the ELP database. See Table 1 for lexical characteristics of targets and fillers. Overall, targets and fillers did not differ in length ($p = .18$), orthographic N ($p = .23$), log-transformed frequency ($p = .92$), average RT ($p = .98$), or average accuracy ($p = .77$). The nonword fillers were longer ($M = 6.33$) than the nonword targets ($M = 5$), $p < .001$, but orthographic neighborhood size did not differ, $p = .44$.

Procedure

Participants were tested individually. See Figure 1 for a schematic of the sequence of events in the experiment. Upon beginning the experiment, they were presented the first list of items for the memory test. Half of the participants were presented the list of critical targets and half the filler list. Next, the instructions to the lexical decision experiment appeared on the computer screen. Following Oliphant (1983), participants simply read the instructions to the experiment out loud. Half of the participants were then asked to summarize the instructions, to encourage more in-depth processing; however, this manipulation yielded no significant effects and will not be considered further. Participants were then administered a practice LDT consisting of five words and five nonwords matched to the critical targets in the key lexical variables identified above. The purpose of this task, other than familiarizing participants with the procedure, was to provide a brief delay between the instructions and the critical trials.

Following the practice LDT, the second list was presented for an unspecified memory test. This was either the critical list or the filler list, depending on which list participants had been exposed to prior to the instructions. After the last item was presented, participants were prompted to work on a sheet of arithmetic problems for 3 min, to reduce recency effects. Immediately afterwards, the LDT or the recognition test began, depending on the condition. The critical targets were embedded in the final test along with the 216 fillers. The total number of trials was 288 (144 words and 144 nonwords).

Participants in the LDT condition were instructed to make speeded word/nonword judgments, while maintaining a high level of accuracy. Participants who received the episodic recognition test were instructed to respond “old” to any item (word or nonword) that had been presented at any point in the experiment. They were specifically warned that they might have seen some of the words and nonwords in the instructions, and that they should respond “old” to these items. It is important to note that participants in the LDT condition were not told any of the items had been presented in prior phases of the experiment. Responses were made using the computer's keyboard by pressing the A key (word/old) or the L key (nonword/new).

Results

Lexical Decision Data

Response Latencies: Only responses to critical targets are reported. The data from both experiments were initially trimmed as follows. First, incorrect responses were excluded from the response latency analyses. All response times (RT) faster than 250 ms and slower than 2000 ms were considered extreme scores and were omitted from analyses. Next, a mean RT for each participant was computed and all responses more than 2.5 standard deviations (SD) from each subject's mean were omitted as outliers. Across all participants, 11% (6% errors) of responses were excluded. Based on the trimming criteria for extreme scores and outliers, more responses to LF words were excluded ($M = .05$) than to HF ($M = .022$) or to nonwords ($M = .025$), $F(2,118) = 10.8$, $p < .001$. However, the percentage of outliers did not differ as a function of encoding condition, nor as a function of list order, all *p*s > .14. As will be described in detail below, more errors were also made to LF items.

The remaining RT data1 were submitted to a 3 (initial processing context: study list, instructions, vs non-presented) × 3 (target type: HF, LF, nonword) × 2 (list order: filler list first vs. real list first) mixed Analysis of Variance (ANOVA). List order was a between subjects factor; target frequency and priming context were within subjects factors. Because list order yielded no main effects or interactions, all *F*s < 1.0, *p*s > .70, the data reported below are collapsed across this factor. Analyses by participants (F_1) and by items (F_2) are reported for the main findings. A Bonferroni correction was applied for multiple comparisons.

The critical question was whether the initial processing context (i.e., study list or instructions) would influence accessibility of targets in LDT. As shown in Figure 2, priming relative to the non-primed control condition was only observed for LF targets and was equivalent for items presented in the instructions and in the study list. Neither HF words nor nonwords yielded differences in response latencies relative to baseline and the encoding condition had no overall effect, suggesting equivalent priming (or lack thereof) of targets regardless of the context in which they were presented.

These conclusions were supported by the ANOVA, which revealed a significant main effect of target type2, F_1 (2,101) = 65.08, $p < .001$, partial $\eta^2 = .54$, F_2 (2,68) = 21.9, $p < .001$, partial $\eta^2 = .39$. Average response latencies to LF targets were slower ($M = 716$, $SE = 16$) than to HF targets ($M = 624$, $SE = 14$) and to nonwords ($M = 639$, $SE = 15$). The latter two item types did not differ from one another.3

The interaction between target type and original encoding condition was highly reliable, F_1 (3.3, 109) = 6.49, $p < .001$, partial $\eta^2 = .10$, F_2 (4,136) = 4.26, $p = .003$, partial $\eta^2 = .11$. No facilitation was observed for HF targets relative to baseline, in either the study list condition (mean priming effect 3 ms) or the instructions condition ($M = -8$ ms; both *p*s > .37). A small but non-significant trend (15 msec) toward interference for nonword targets presented in the study list condition was observed, $t(59) = 1.4$, $p = .17$ and no interference for nonwords in the instructions ($M = 9$ ms). However, LF targets did show robust facilitation relative to baseline in both the list context ($M = 48$ ms) and instructions condition ($M = 50$ ms), $t(59) = 3.42$, $p = .001$, and $t(59) = 3.4$, $p = .001$, respectively. No other effects were significant.4

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[1] Analyses on standardized RTs revealed highly similar patterns of results in both experiments but are not reported for the sake of brevity.

[2] Reported degrees of freedom are corrected for sphericity (Greenhouse-Geisser corrections are reported).

[3] Although the absence of a lexicality effect between HF targets and nonwords is unusual, a potential explanation is that the nonwords were slightly shorter than the words. Thus, the length confound might have favored faster responses to nonwords (Chumbley & Balota, 1984).

Accuracy: Error data were submitted to the same ANOVA as the latency data. Once again, significant facilitation was only observed for LF targets in both the study list and instructions condition. Both the main effect of frequency and that of encoding condition were significant, F_1 (1.3,72) = 90.6, $p < .001$, partial $\eta^2 = .62$ and F_2 (1,69) = 10.32, $p < .001$, partial $\eta^2 = .23$; and F_1 (2,112) = 6.5, $p = .002$, partial $\eta^2 = .10$ and F_2 (1.7,118) = 8.5, $p = .001$, partial $\eta^2 = .11$, respectively. LF targets resulted in more errors than either HF words or nonwords, which did not differ from one another. In addition, there was clear priming in accuracy, which did not differ as a function of orienting condition.

The target type by encoding condition interaction was again significant in the error analyses, F_1 (2.5,143) = 5.99, $p = .001$, partial $\eta^2 = .10$ and F_2 (4,138) = 9.6, $p < .001$, partial $\eta^2 = .22$. As can be seen in Figure 3, prior processing of LF targets resulted in reliable reductions in errors in both the study list ($M = .05$) and instructions ($M = .06$) conditions, $t(59) = 3.5$, $p = .001$ and $t(59) = 4.3$, $p < .001$, respectively, and did not differ as a function of priming condition, $p = .4$, whereas no such effects were found for HF targets ($M = .006$ in both encoding conditions) or nonwords ($M = -.01$in both encoding conditions), all ps > .25. The slight increase in errors for nonword targets was not reliable, although it is consistent with models of this task that assume that performance in this task can be based on an assessment of familiarity (Balota & Chumbley, 1984). Prior processing of nonwords is expected to increase their familiarity and thus bias a word response, thus one might have expected some inhibitory priming for nonwords.

Recently, Wagenmakers, Zeelenberg, Steyvers, Shiffrin, and Raaijmakers (2004; see also Zeelenberg, Wagenmakers, & Shiffrin, 2004) suggested that priming for nonwords is the result of two opposing processes (also see Forster & Davis, 1984). Basically, their account incorporates both a fast-acting familiarity component and a slower-acting episodic retrieval component. In the present experiment, the absence of an overt response during the encoding phase reduced any contribution of the retrieval mechanism, effectively resulting in null priming effects. Future studies might further investigate this idea by including a condition in which nonwords are repeated in the LDT, to assess whether the facilitatory retrieval process can emerge.

It is also interesting to note that, as was the case for LF words, priming for nonwords did not differ as a function of encoding context. It is possible that the manner in which the nonwords were embedded in the instructions (i.e., as examples of the types of stimuli; see Appendix) might have made the priming more similar to the list presentation condition (although we note this cannot account for the results for LF words). In sum, our results do not offer strong support for the current accounts of nonword priming although they do suggest these items are relatively insensitive to context, thus rendering them somewhat similar to LF words. It is also possible that the use of pseudohomophones renders the effects more ambiguous, as the influence of the baseword might have differential effects on priming relative to pronounceable nonwords. Clearly, future work in this area is necessary to fully specify the conditions under which repetition priming for nonwords is facilitatory or inhibitory.

In sum, the results of the LDT are quite clear. LF targets produced robust priming due to prior processing regardless of encoding context, whereas HF targets and nonword targets showed no such benefit. The facilitation observed for LF targets was evident in the analyses

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[4] Because of substantial differences in baseline RTs (i.e., RTs to control items) between LF and HF targets, we also conducted an analysis on proportional measures of priming (i.e., (control RT – repeated RT)/control RT; see Schnyer et al., 2007), and also z-scored transformed analyses (see Faust et al., 1999). Only an effect of frequency emerged, $F(2,118) = 9.33$, $p < .001$, partial $\eta^2 = .14$. Significant priming was found for LF items (M = .05), but no priming for HF words or nonwords ($M = -.01$ and $M = -.03$, respectively). The effect of encoding condition and the interaction were not reliable, both Fs < 1.0, ps > .40. Thus, the priming effect as a function of frequency was not due to baserate differences in RTs.

by participants and in the analyses by items and was present in both errors and response latencies. One implication of these results is that the null effects reported by Oliphant (1983) were, at least in part, due to the frequency of the targets used in that study, which, as noted above, was relatively high. Thus, Oliphant's null priming effect for words presented in the instructions appears to be frequency-modulated.

Recognition Data—The proportions of old responses in the recognition test were submitted to the same analyses as the LDT data. If the recognition test mirrored the LDT test, one would expect strong memory for LF targets and poor performance on HF targets, with no effect of encoding context, (i.e., instructions vs. study list). If the counteracting effects of familiarity and task demands drove the slight increases in nonword RTs and errors in LDT, some memory for these items would be expected as well. It should also be noted that control items were distracters here and so should produce fewer "old" responses (i.e., false alarms).

As can be seen in Figure 4, the results of the recognition test are quite different from the lexical decision results, especially for the HF words. Indeed, both LF targets and nonwords produced high hit rates compared to false alarms to the control items for items presented in the instructions, $t(35) = 8.1$, $p < .001$ and $t(35) = 12.5$, $p < .001$, respectively, and for items presented in the study list, $t(35) = 9.5$, $p < .001$ and $t(35) = 11.4$, $p < .001$, respectively. Neither LF nor nonword targets were influenced by the encoding condition, both ps > .10. In contrast, HF targets in the study list condition were much better recognized than in the instruction condition, $t(35) = 5.5$, $p < .001$. Indeed, HF targets presented in the instructions only yielded slightly more old responses than did control items, $t(35) = 2.3$, $p = .03$ (not significant following a Bonferroni correction).

These findings were also confirmed by the results of the overall ANOVA. As was observed in the LDT, list order yielded no main effect nor did it interact with any other factor, all Fs < 1.0, ps > .20, thus the data are collapsed across this factor. Both the main effect of target type and that of encoding condition were significant, $F(2,70) = 9.44$, $p < .001$, partial $\eta^2 = .21$, and $F(2,70) = 101.6$, $p < .001$, partial $\eta^2 = .74$, respectively. The interaction was also highly significant, $F(4,140) = 22.62$, $p < .001$, partial $\eta^2 = .39$.

Discussion

Experiment 1 yielded strong priming effects in lexical decision performance for LF words that were earlier embedded in instructions for the experiment; however, there was no evidence of priming for the HF words. Hence, one can obtain persistent priming effects across distinct contexts under conditions that minimize strategic processing, clearly engage different component processes, and when no overt response is required to the prime. However, these effects are localized to LF words. These results are compatible with Oliphant (1983) who found no evidence of priming for relatively HF words, and extend these pattern to a situation in which nonwords were also embedded in the instructions, thereby eliminating the lexicality by priming confound present in prior studies. Interestingly, the repetition effects for LF words were as large in the instruction condition as in the study list condition, suggesting that the relative amount of conceptual or perceptual processing was not modulating the priming effects. In addition, it seems reasonable to assume that targets presented in the study list received more distinctive, item-specific processing than those in the instructions, yet, once again, the lack of any difference between the two encoding conditions raises questions concerning the role of distinctiveness (e.g., MacLeod & Masson, 2000), at least for LF words.

Turning to the episodic recognition results, it is important to note that here we find large effects of the encoding condition (and type of processing). In particular, HF targets produced much better memory (approximately 22%) when earlier embedded in the study list condition, compared to the instructions condition. This was not the case for either nonwords or LF words, where both classes of items produced large memory effects and were relatively immune to the earlier encoding context, again consistent with the notion that encoding instructions and type of processing played a relatively small role for these items. It appears that HF targets can benefit from intentional encoding and item-specific processing, but these benefits emerge only under conditions of intentional retrieval.5

It is also informative to directly compare lexical decision performance and recognition performance. As noted, there was no evidence of priming in lexical decision for either nonwords or HF words, but clear evidence of priming for the LF words. In contrast, memory performance was quite high for HF words in the list context, and nonwords and LF words independent of encoding context. Because the encoding conditions and the list composition structure at the time of test were identical for the LDT and recognition test, with the only difference being the instructions given to participants immediately before the test, these data point to a dissociation between measures of direct (i.e., recognition) and indirect (i.e., lexical decision) memory. Importantly, because there was a clear dissociation between the LDT and the episodic recognition test, one might argue that the priming observed in the LDT is not simply due to the retrieval of episodic traces. However, one important dimension in which the two tasks differ is in terms of potential response bias. In LDT, there was an equal number of words and nonwords, hence, there should be no bias to respond word or nonword. However, in recognition, the vast majority of items were new, thus raising the possibility that participants might have been biased to respond “new.” 6 However, given that the hit rates were well above chance, $t(35) = 4.2$, $p < .001$ (averaged across all conditions, the mean hit rate was 61%,) and the false alarm rate to fillers was 15% for nonwords and 20% for words, it seems that such a potential response bias was not entirely responsible for the observed results. Of course, it is also possible that the type of decision (word/nonword vs. old/new) could explain the observed dissociation (Whittlesea & Price, 2001). In the General Discussion we examine the differences between LDT and recognition in the present study.

Experiment 2

The second experiment further addressed the difference in the pattern of results in lexical decision and recognition memory. We argued that the inclusion of the nonwords in the instructions should have minimized the utility of episodic retrieval in the lexical decision task. Indeed, only the LF words produced priming in the lexical decision task, and yet both HF words in the list context condition and the nonwords in both list context and instruction conditions produced traces that strongly modulated later recognition memory performance. The robust priming effect observed for LF words appears to be consistent with abstractionist models that assume that such items undergo a large change in activation levels due to prior processing and that this change is insensitive to the specific context in which it occurs, although these accounts have some difficulty accommodating the long-term priming effects observed here, as it seems unlikely that changes in activation would persist across the delays and intervening items in the present study. Alternatively, the effects could be due to the operation of a retrieval process (e.g., Masson & Bodner, 2003). If LF words are more difficult to process and draw more attention, thereby resulting in strong traces, and these

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[5] One slightly surprising finding in the recognition test was the absence of any order effects for targets in the study list condition. Because of the well-documented effects of interference effects in memory (see Anderson & Neely, 1996 for a review), one might have expected differences in memory performance depending on the order in which the study list was presented. One possibility is that there were both effects of retroactive interference on the list when it was studied before the instructions and of proactive interference when it was studied second, basically equating the two conditions. The relative primacy and recency benefits might have further equalized performance.

[6] We thank Glen Bodner for pointing this out.

targets therefore require more processing in both the instructions and study list contexts, then the equivalent priming effects for both encoding conditions would be expected. Similarly, nonwords might require additional processing resources in both conditions. This explanation could accommodate the lack of context effects in both LDT and recognition for these classes of items. However, for HF items that have high resting activation levels (and therefore undergo less of a change due to recent processing) or have more available traces in memory (and are therefore less sensitive to a single additional episode), retrieval accounts of priming might be more viable than activation accounts. Specifically, such accounts would predict priming for HF items when a strong trace is laid down and there is more demand for strategic retrieval of such traces to occur. It is possible that the elimination of the priming effects for HF words in lexical decision could be due to the inclusion of the nonwords during the encoding task, which minimized the contribution of episodic traces during that task.

In order to test this hypothesis, in the second experiment we removed the nonwords from the initial encoding episode to examine if one can now obtain priming for HF words, due to an increased reliance on strategic retrieval in the lexical decision task. If indeed this were the case, then one would have further evidence that the results from the LDT task in Experiment 1 were not due to strategic or conscious retrieval mechanisms. Such a manipulation should not have an effect on activation levels of targets; therefore, from an activation account, no difference between Experiments 1 and 2 was expected. As we noted above, one concern about prior studies using the Oliphant-type paradigm was that many used tasks that are potentially more susceptible to contamination from direct or intentional retrieval (e.g., stem or fragment completion). The use of LDT minimizes the use of strategic processing, when nonwords are embedded in the earlier episodic encoding phase. However, it is important to note that the proportion of primed trials was still very low and that strategic use of episodic traces does not necessarily imply intentional, conscious retrieval.

Method

Participants—Thirty participants from the same pool as those tested in Experiment 1 were recruited. They received course credit or $10 for their participation.

Materials—The same materials used in Experiment 1 were used, with the exception that all nonwords were removed from both study lists (the filler list and the critical target list) and from the instructions. This change resulted in shorter study lists (16 items total instead of 24) and shorter instructions. The LDT test was identical.

Procedure—Participants were tested individually. The order of the tasks was identical to that employed in Experiment 1.

Results

Response Latency Data—Overall, 10% of trials were excluded from analyses (3% of as outliers based on the RT trimming procedure and 7% as errors). The percentage of outliers did not differ as a function of target frequency, encoding condition, or list order, all Fs < 1.7, ps > .18.

RT data were initially analyzed including list order as a factor in the ANOVA. Because this factor resulted in no significant effects or interactions, all Fs < 1.3, ps > .28, the data reported below are based on analyses collapsed across the order variable. The response latency results yielded significant priming for LF targets and no difference as a function of original processing context (instructions vs. word list). However, HF targets did show a small (15 ms averaged across both encoding conditions) trend in the predicted direction. The

ANOVA yielded two significant main effects and no interaction: F_1 (1,29) = 114, $p < .001$, partial $\eta^2 = .8$, and F_2 (2,46) = 25, $p < .001$, partial $\eta^2 = .35$, for the effect of target frequency; and F_1 (2,58) = 7.4, $p = .001$, partial $\eta^2 = .20$, and F_2 (2,92) = 4.88, $p = .01$, partial $\eta^2 = .1$, for the effect of encoding condition; and $F(2,58) = 2.2$, $p = .12$, for the interaction. Responses to HF words were faster than to LF words, and primed items were responded to faster than control items (see Figure 5).

Although there was not a reliable condition by target frequency interaction, follow-up comparisons revealed significant priming for LF targets in both the instruction condition (M = 60 ms) and the study list condition (M = 44 ms) relative to baseline, $t(29) = 3.09$, $p = .004$ and $t(29) = 3.21$, $p = .004$, respectively, whereas no significant priming effects were found for HF targets (M = 17 ms in the instruction condition and M = 14 ms in the study list condition, both ps > .20). The lack of an interaction in this experiment, compared to the robust interaction in Experiment 1, is consistent with the trend toward facilitation for the HF words, although it was not significant.7

Accuracy Data—The same analyses were conducted on the error rates. As can be seen in Figure 6, overall error rates were higher for LF targets than for HF targets. Prior presentation of an item resulted in significantly fewer errors relative to the control condition. However, as indicated by a significant frequency by encoding condition interaction, the reduction in errors was greater for LF than for HF targets. Importantly, however, the facilitation relative to baseline was significant for HF targets in the study list ($M = .05$), $t(29) = 3.2$, $p = .003$, and in the instructions ($M = .04$), $t(29) = 2.3$, $p = .024$. Facilitation was also observed for LF targets relative to baseline for targets in the study list ($M = .11$), $t(29) = 3.8$, $p = .001$, and for targets in the instructions ($M = .12$), $t(29) = 4.2$, $p < .001$. Thus, removing nonwords from the priming conditions did allow facilitation to be observed for HF targets, albeit primarily in the accuracy data, although a similar trend was observed in the RT data.

The results from the overall ANOVA on the error rate data indicated that the main effects of frequency, F_1 (1,29) = 73.4, $p < .001$, partial $\eta^2 = .72$, and F_2 (1,46) = 9.9, $p = .003$, partial $\eta^2 = .18$, encoding condition, F_1 (2,58) = 17.8, $p < .001$, partial $\eta^2 = .38$, and F_2 (2,92) = 11.04, $p < .001$, partial $\eta^2 = .19$, were reliable. The interaction was also reliable, albeit only in the analyses by participants, F_1 (2,58) = 3.7, $p = .03$, partial $\eta^2 = .11$, and F_2 (2,92) = 2.3, $p = .106$, partial $\eta^2 = .05$. Once again, there was no difference between the study list and the instructions conditions, $p = .26$ for HF targets and $p = .86$ for LF targets.

Comparison of Experiments 1 and 2—To determine whether the presence of the nonwords modulated the priming effects across experiments, we conducted a separate ANOVA, in which Experiment (1 or 2) was included as a factor. The analysis on response latencies did not yield either a main effect of experiment, $F(1,88) < 1.0$, nor did this factor interact with any other factor, all Fs < 1.6, all ps > .2. Although there was not a reliable experiment by condition interaction, it should be noted that the priming effects, averaged across encoding condition, did increase by 5 ms for the LF words and by 17 ms for the HF words in Experiment 2 compared to Experiment 1, as might be expected if participants relied more heavily on the episodic traces to make a word/nonword decision. In other words, removing the nonwords from the encoding phase was expected to allow participants to use any episodic trace to bias a word decision and under these conditions, even the relatively weak traces laid down by HF targets reflected benefits of prior processing.

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[7] Analyses on proportional RTs revealed a non-significant effect of word frequency, $F(1,29) = 2.63$, $p = .12$, partial $\eta^2 = .08$. Overall, for LF targets the priming effect was .06, for HF words it was .02. The effect of encoding condition was not significant, F <1, nor was the interaction, F < 1. However, follow-up t-tests revealed significant priming only for LF targets in both the instructions and study list conditions, $t(29) = 2.8$, $p = .009$, and $t(29) = 2.8$, $p = .008$, respectively. Priming for HF targets was not significant, both ts <1. ps > .35

Turning to the accuracy analyses, for the HF words, there was a main effect of encoding condition, $F(2, 176) = 8.4$, $p < .001$, partial $\eta^2 = .09$; experiment, $F(1, 88) = 4.3$, $p = .04$, partial $\eta^2 = .05$; and a reliable encoding condition by experiment interaction, $F(2, 176) = 4.4$, $p = .04$, partial $\eta^2 = .05$. Importantly, the interaction indicates that there was a reliable increase in the effect of encoding condition when lexical status could be used to engage a retrospective retrieval process in Experiment 2, but not in Experiment 1, where nonwords were also included in the study list and in the instructions. Although there was a small numerical increase in error rates for LF targets in Experiment 2 ($M = .15$) relative to Experiment 1 ($M = .136$), this difference was not reliable, $F < 1.0$, nor was there any interaction between encoding condition and experiment for LF targets, $F < 1.0$.

We also examined whether there were any effects of priming the nonwords on RTs and accuracy. According to the familiarity/meaningfulness account (e.g., Balota & Chumbley, 1985), priming nonwords should increase their familiarity, thereby slowing RTs and increasing error rates. Thus, we compared performance on RTs and errors across experiments. Because nonwords were not primed in Experiment 2, we averaged the RTs and error rates across the two encoding conditions (study list and instructions) in both experiments to compare performance on the same items when they were primed and when they were not. Neither in RTs, $t(88) < 1$, $p = .26$, nor in errors, $t(88) < 1$, $p = .71$, was there strong evidence that priming nonwords affected processing, although RTs were indeed 27 ms slower in Experiment 1 than in Experiment 2.

General Discussion

The results of the present experiments are straightforward. Presenting LF or nonword targets in the instructions to an experiment (i.e., in an incidental encoding task) results in the same changes in the accessibility of those items (as reflected in a later episodic recognition test) that occurs when the targets are intentionally studied. In addition, LF words produce large priming effects in lexical decision performance, under conditions that minimize strategic retrieval processes. In contrast, HF targets only reflect changes in accessibility following intentional encoding and under conditions of intentional retrieval (i.e., the recognition data from Experiment 1) or when retrospective processes are more likely to be engaged (i.e., the error data in Experiment 2).

Relationship to Prior Studies Using Oliphant-type Paradigms

These findings support the idea that one can obtain repetition priming in the LDT for LF words across quite distinct contexts. The priming effects for LF targets are consistent with prior reports (e.g., MacLeod, 1989; Nicolas, 1996), although none of the previous studies have embedded the items within the instructions to the experiment. The absence of priming effects for HF words in Experiment 1 is consistent with the original work by Oliphant (1983). Because frequency and priming interact in LDT (e.g., Balota & Spieler, 1999), this effect is clearly not novel. More important is the fact that this is the first report of priming across distinct contexts in LDT for incidentally processed words (in the instructions) when lexicality and priming status were not confounded (Experiment 1). Because most prior studies directed readers' attention to the text more directly and never primed nonwords, these results provide stronger evidence in support of context-independent changes in target accessibility. Further, because the present study used LDT instead of stem or fragment completion or perceptual identification, the results of Experiment 1, in particular, are less likely due to strategies such as sophisticated guessing or intentional retrieval. The high ratio of unprimed to primed items in LDT also should have further reduced the advantages of such mechanisms.

It is also noteworthy that no other studies have systematically reported comparisons of direct and indirect tests. Although the results for LF and nonword targets were generally consistent in both test types (i.e., strong memory traces and/or changes in accessibility), the results for HF targets are indicative of clear dissociations between test types, as described above.

Word Frequency Effects in Cross-context Repetition Priming and Recognition

It is important to emphasize here that although the encoding context (list vs. instructions) did not produce an effect on later performance for LF words and nonwords, there was a large influence of encoding context on the recognition performance for the HF words. Specifically, the HF words were only slightly above baseline for the instruction condition (in fact, the difference between hits and false alarms was 6%, not significant following a Bonferroni correction for multiple comparisons), but produced substantial memory for the list encoding instructions (a highly significant difference of 28%). Hence, this is clear evidence of a strong modulating role of contextual changes for the memory for HF items. As noted by Reder et al. (2000), HF words, by definition, tend to occur in multiple contexts, such that a single presentation in any context (e.g., list or instructions) may not result in measurable changes in these items' accessibility and in weaker binding to a specific context. Indeed, HF words occur in more contexts than LF words, and contextual diversity is correlated with word frequency (Adelman, Brown, & Quesada, 2006), such that HF words may be more easily integrated with a context than LF words. Thus, in a priming task, little or no changes in accessibility may occur and, similarly, the effects of the encoding context might be weak. However, under intentional retrieval conditions, when context information is more likely to be directly reinstated, then memory for these items can be clearly detected, and, as observed here, specifically for those items which are processed in such a way that allows them to be better bound to the specific encoding context (i.e., a study list). In contrast to what occurs for HF targets, items that have relatively distinct representations a priori (i.e., LF words and nonwords) appear to be immune to the same contextual changes. Because LF words tend to appear in fewer contexts, a single presentation is likely to result in substantial increases in accessibility relative to baseline and create strong bindings between the item's node and a context or episode node (see Reder et al., 2000). Interestingly, in the present data, these items seem to be equally encoded regardless of the specific context, suggesting that the increased accessibility due to processing, although it may retain contextual information, is strong enough to result in robust priming and memory effects.

List Context Effects in LDT and Recognition

One possible explanation for the large effect in recognition for HF words as a function of encoding condition is that it was influenced by the presence of the pseudohomophones. This could have affected the results in two ways. First, if the baseword frequency of the pseudohomophones (i.e., the frequency of the homophone words) was closer in frequency to HF than LF word targets, this might have created a list context effect such that the average list frequency was higher, potentially making the HF items of slightly lower average frequency (e.g., McCabe & Balota, 2007) and hence better recognized (also see Bodner & Lindsay, 2003, for similar list context effects). However, the baseword frequency of the nonwords used in the experiments was 9.4, which was intermediate between LF words (M = 6.7) and HF words (M = 11.1). Thus, it seems that the net effect of the nonwords would not have substantially influenced the overall frequency of the encoding context.

It is also possible that removing the nonwords from the priming contexts in Experiment 2 might have increased reliance on semantic memory, rather than decreasing reliance on episodic traces. For example, if removing the nonwords allowed participants to focus more on the meaning of the stimuli and less on orthographic information (in fact, the orthographic neighborhood of the nonwords was significantly lower than that of either class of words), including the nonwords might have directed attention more to the perceptual characteristics of all stimuli. If participants attended more to semantics and less to orthography in Experiment 2 due to the absence of the nonwords during encoding, then it is possible that the HF words benefitted sufficiently from the priming event to show some facilitation, as HF words are often more meaningful than LF words (Colombo, Pasini, & Balota, 2006). Hence, the small but reliable priming effect observed in Experiment 2 might be a result of different processing during encoding, rather than different processes being engaged at retrieval. If that were the case, however, one might have expected an increased effect of word frequency in Experiment 2, since this variable is sensitive to deep vs. shallow encoding manipulations (see Duchek & Neely, 1989), however, as noted, frequency did not interact with experiment.

An alternative account is that participants might have focused on meaning of the pseudohomophones during encoding in the instructions condition but less so in the study list condition (during which they might have focused more on the distinctive orthography of these items). Thus, it is possible that, during the recognition test, the benefit of encoding items while attending to distinctive orthography would yield substantial benefits for all items, but especially for the harder to recognize HF words, whereas the more meaning-based processing would reduce performance, albeit less so for LF than HF words. However, recognition memory for nonwords did not differ as a function of encoding condition, suggesting this explanation also is not fully viable.

Constraints on Accounts of Repetition Priming

One interpretation of the large context independent repetition effects for LF words and nonwords is that these effects are the result of the activation during encoding that produces changes in accessibility that persist across relatively long lags and numerous intervening items and is not simply due to retrospective episodic retrieval processes. According to an activation perspective, the null priming for HF words is due to the fact that these items were already near an activation threshold and so the encoding phase did not change their later accessibility. Furthermore, the absence of any context (list vs. instructions) for LF words suggests that activating these items during encoding is sufficient to alter their accessibility levels and that such changes persist until the time of the final test. The absence of context effects for LF targets is somewhat surprising. The fact that incidental encoding in a context that should have biased readers to attend to the meaning of the targets resulted in equivalent facilitation as intentional study of items presented in isolation in a task that relies heavily on orthographic familiarity based codes was not fully expected, although, as noted above, it is consistent with models of repetition priming that attribute priming to changes in the accessibility levels of abstract, context-independent representations (e.g., Bowers, 2000) as well as with those accounts that attribute priming to the contribution of episodic traces (e.g., Masson & Bodner, 2003). If anything, the latter accounts might have an easier time accommodating the present results because changes in accessibility due to activation is generally assumed to be short-lived and the priming effects observed here persisted over fairly long intervals and many intervening items.

The present experiments also indicate that the engagement of retrieval processes depends on several factors (e.g., word frequency, encoding task, list context). In Experiment 1, when nonwords were part of the encoding environment, there was no hint of priming for nonwords or HF words in the lexical decision task. However, under identical encoding and test formats, when recognition memory was tested, thus requiring episodic retrieval, participants produced substantial memory for both nonwords and HF words. Strong memory for the HF words was observed only in the list context condition, and not in the instructions condition (see Figure 4). If episodic memory traces contributed to the lexical decision priming for LF words then one might have expected such priming for HF words under the list conditions, since the HF words produced strong episodic traces that clearly drove recognition performance. Such findings support the notion that these items require the engagement of intentional encoding and retrieval processes to show facilitation (also see Meade et al., 2007). The second important observation here is that when strategic retrieval was rendered more likely in LDT by eliminating the nonwords from the encoding phase in Experiment 2, there was evidence of priming in accuracy even for the HF words, thereby again supporting the contribution of retrieval mechanisms.

The LDT/recognition dissociation, however, also suggests an alternative interpretation of the data. Specifically, it is possible that, rather than supporting the absence of a contribution of episodic traces in the LDT, as we suggested above, the different patterns reflect fundamental differences in tasks and the judgments required to perform them. As suggested by Whittlesea and Price (2001), participants can use an analytic or non-analytic mode of judgment when analyzing the fluency with which an item is processed. In the analytic mode, which is more likely to be engaged when performing a recognition task, participants might interrogate each item for evidence of prior study, perhaps focusing on distinct features. Under these conditions, processing fluency may not be a valid predictor of an item's status. In the non-analytic mode, there is no such requirement: To make a lexical decision accurately, participants can use fluency of processing as a cue (by their very nature, words are processed more fluently than nonwords). Thus, when the encoding conditions include factors that are more likely to direct attention to specific features (i.e., when the psuedohomophones are included), HF words, which are processed fluently regardless of priming, show little or no effects in LDT. However, LF words and nonwords, which undergo large changes in fluency as a result of a priming episode, do manifest effects of prior processing (albeit as a trend towards interference for the nonwords). In the recognition test, the increased attention to specific features does support an analytic mode, thus resulting in better memory for HF words, at least those included in the study list. In sum, from this perspective, the present results are consistent with retrieval accounts of priming: Episodic traces support both LDT and recognition performance and the dissociations reveal, rather than differences in accessibility, differences in retrieval demands.[8]

Event Boundaries

An additional explanation of Oliphant's results, which is not mutually exclusive of the above accounts, might rely on recent work suggesting that both perception and memory are structured according to existing event boundaries (see Zacks & Tversky, 2001). According to this account, boundaries between events serve as cues that can influence the relevance of stimuli within and across event boundaries. Once a boundary has been crossed, pre-boundary stimuli are less likely to be currently relevant than post-boundary stimuli, and therefore their accessibility or activation level might decrease. There is evidence from text comprehension studies that reading times increase when an event boundary is perceived,

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[8] There are other possible mechanisms of priming to consider. For example, TAP accounts of priming attribute facilitation in repetition priming to the overlap in component processes (e.g., conceptual, perceptual processing) between the priming event and the transfer task, with maximal priming occurring when the two tasks are identical (Bransford et al. 1977). In the present study, there was no clear evidence that differences in processing (i.e., conceptual vs. perceptual) modulated priming in LDT for LF or nonword targets, suggesting that for certain classes of items some other factor might be more critical. Perhaps these classes of items capture sufficient attention that they received more perceptual-level processing than HF targets. The attention to orthographic features of the LF targets would have facilitated performance on the LDT whereas HF words might be more likely to result in automatic processing and less sensitive to task-dependent processes (see Franks et al., 2000). Thus, it seems that a simple TAP account cannot fully accommodate the present data, without positing some additional mechanism or component process that is sensitive to target frequency.

Another account of repetition priming in LDT is some variant of stimulus response learning (see Horner & Henson, 2009; Logan 1990). Specifically, for positive transfer to be observed in LDT, it might be required that at some level participants code the stimuli in the text as words or nonwords. Because the instructions to Experiment 1 included nonwords and several examples were given, it is possible that some covert classification of items did occur. In Experiment 2, nonwords were not included in the instructions or in the study list, yet the pattern of results was quite similar, suggesting that stimulus/response learning cannot fully accommodate these data, unless the assumption of covert coding of responses occurs consistently, at least for LF targets and nonwords and is similar regardless of encoding context.

suggesting that additional processing operations are involved to cross the event (see Kurby & Zacks, 2008). Zacks, Speer, Swallow, Braver, and Reynolds (2007) found that memory for events was worse following an event boundary than for events occurring within the same event. According to an event boundary account, the boundary between the instructions and the transfer task is more likely to be distinctive and influence any priming than the boundary between the study of a passage or list in what is clearly part of the experiment proper and the transfer task. Another way of conceptualizing this might be that, in the latter condition, participants are in "experimental mode" and consider all tasks to be related. If participants perceive the priming passage as part of the experiment proper, it is possible that the boundary event is somehow less salient.

Thus, prior studies reporting priming for words presented in a text context might have had less marked boundaries (e.g., MacLeod, 1989; Nicolas, 1996, 1998). Reading the instructions is less likely to be perceived as a "task" (see Oliphant, 1983). We note, however, that the interpretation of prior studies based on the nature of the boundaries separating the priming context from the transfer task was generally confounded with word frequency, with Oliphant using relatively HF targets and other studies using LF targets. In this light, the present results clearly indicate that word frequency does play a large role in whether priming will be observed or not and produce difficulties for the power of event boundaries, since for LF targets, encoding context did not matter. Of course, it is possible that the transition from the instructions to the LDT was not a significant enough change in event structure to modulate the effect for these items, although this seems unlikely given the fact that there were several intervening events or tasks between the instructions and the final test (e.g., the filler math problems, the second study list). Furthermore, and more importantly, episodic memory for HF words was strongly modulated by context in Experiment 1, with memory for the HF words reliably above baseline only in the list context condition and not significantly so in the instruction condition. Hence, there was a clear influence of context, but it was restricted to the HF words under direct retrieval conditions (also see Meade et al., 2007). Thus, event boundary accounts also have some difficulty accommodating these results and may need to examine the role of frequency of a given target event in the persistence across boundaries.

Conclusion

In sum, the present studies address some of the inconsistencies in the literature regarding priming and memory for words embedded in very distinct contexts. Importantly, these results indicate that whether context modulates these effects depends on the frequency of the targets and on the engagement of retrieval mechanisms either explicitly engaged by an episodic recognition task (Experiment 1) or implicitly engaged by the absence of nonwords during the orientation task (Experiment 2). In the case of LF words, these items produce large and robust changes in accessibility that transcend the current contextual manipulations, whereas, for HF words there was no evidence of non-strategic priming in the LDT, but robust context sensitivity in episodic recognition. These results suggest that any general model of priming will need to incorporate the similarity across events, the relative distinctiveness of the traces, and the retrieval demands instantiated by the retrieval task.

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Appendix A: Instructions for Experiments 1 and 2

Stimuli in bold format are the critical targets in each set. Across participants, each target appeared an equal number of times in the instructions, in the study list, or only once in the LDT (baseline condition). In Experiment 2, the same instructions were used, but the nonwords were removed.

Set 1

Welcome to the study. We appreciate you coming in! In today's **session**, you will be completing a series of tasks.

Should you have **additional** questions at any point, your experimenter will be on **hand** to assist you. Please do not hesitate to ask.

When you start, you will be presented a list of items for a memory test. The stimuli will consist of both real English words, such as **tuba**, **lice**, **house**, **car** and letter strings that resemble words, and may sound like real words if you read them aloud, but are not real words (e.g., **brane**, **phraug**, mune, komet). Try your best to remember these items.

After you have studied the list, there will be an **intervening** phase before the memory test, during which you will be making lexical decisions to individual stimuli. The stimuli will appear one at a time and will be words and nonwords. If the stimulus on the screen is a word, such as **seam** or **huts**, please press the “A” key. If the stimulus is not spelled like a real English word (even though it may sound like one if you read it aloud), please press the “L” key. For example, you might see something like **takel**, **gurl**, or **bawtle**. It is very important that you pay close attention to the spelling of these items. Some of them might be easier to classify as a misspelled word, like **phauther**, as it looks sort of funny, but some might be more difficult, like **kyte** or **kur**;, because they look more like real English words.

It is **imperative** that you try to be as fast and as accurate as **feasible**. Try to find a balance in which you can be fast while maintaining a high level of accuracy.

After you have completed the lexical decision test, you will be given a memory test for the items in the **first** list.

We will **commence** with a short practice lexical decision task, to make sure you understand the instructions. Before we begin, please make sure you are sitting directly in front of the monitor, with your **fingers** resting comfortably on the appropriate keys (A and L). Press the A key for a word and the L key for a nonword.

Set 2

Welcome to the **experiment**. We appreciate you coming in! In today's study, you will be completing a series of **measures**.

Should you have any questions at any point, your experimenter will be on outside the **office** to assist you. Please do not hesitate to ask **immediately**.

When you start, you will be presented a list of items for a memory test. The stimuli will consist of both real English words, such as **berth**, **lint**, **money**, **man** and letter strings that resemble words, and may sound like real words if you read them aloud, but are not real words (e.g., **burds**, **phrum**, mune, komet). Try your best to remember these items.

After you have studied the list, there will be an **interpolated** phase before the memory test, during which you will be making lexical decisions to individual stimuli. The stimuli will appear one at a time and will be words and nonwords. If the stimulus on the screen is a word, such as **gull** or **cabs**, please press the “A” key. If the stimulus is not spelled like a real English word (even though it may sound like one if you read it aloud), please press the “L” key. For example, you might see something like **tikel**, **gaim**, or **battel**. It is very important that you pay close attention to the spelling of these items. Some of them might be easier to classify as a misspelled word, like **cloo**, as it looks sort of funny, but some might be more difficult, like **fether** or **kopy**, because they look more like real English words.

It is **pivotal** that you try to be as fast and as accurate as you can. Try to find a balance in which you can be fast while **sustaining** a high level of accuracy.

After you have completed the lexical decision test, you will be given a memory test for the items in the **earlier** list.

We will start with a short practice lexical decision task, to make sure you understand your **directive**. Before we begin, please make sure you are sitting directly in front of the monitor, with your indexes resting comfortably on the appropriate keys (A and L) and your wrists comfortably on the **table**. Press the A key for a word and the L key for a nonword.

Set 3

Welcome to the study. We appreciate your **participation**! In today's study, you will be completing **several** tasks.

Should you have any questions at any point, your experimenter will be on outside the **door** to assist you with the **information** you require. Please do not hesitate to ask.

When you start, you will be presented a list of items for a memory test. The stimuli will consist of both real English words, such as **stub**, **mugs**, **water**, **dog** and letter strings that resemble words, and may sound like real words if you read them aloud, but are not real words (e.g., **bleek**, **frekle**, mune, komet). Try your best to remember these items.

After you have studied the list, there will be a phase in the **interim** before the memory test, during which you will be making lexical decisions to individual stimuli. The stimuli will appear one at a time and will be words and nonwords. If the stimulus on the screen is a word, such as **sill** or **tubs**, please press the “A” key. If the stimulus is not spelled like a real English word (even though it may sound like one if you read it aloud), please press the “L” key. For example, you might see something like **topik**, **grae**, or **beest**. It is very important that you pay close attention to the spelling of these items. Some of them might be easier to classify as a misspelled word, like **phree**, as it looks sort of funny, but some might be more difficult, like **crait** or **kome**, because they look more like real English words.

It is **decisive** that you try to be as fast and as accurate as you can. Try to find an **equilibrium** in which you can be fast while maintaining a high level of accuracy.

After you have completed the lexical decision test, you will be given a memory test for the items in the **previous** list.

We will start with a short practice lexical decision task, to make sure you **comprehend** the task. Before we begin, please make sure you are sitting directly in front of the monitor, with your indexes resting comfortably on the appropriate keys (A and L) on the **keyboard**. Press the A key for a word and the L key for a nonword.

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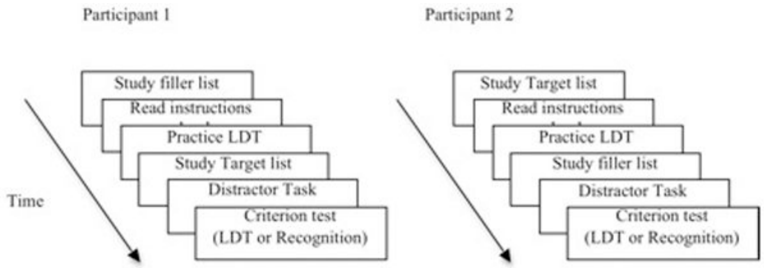

Figure 1.
Sequence of events in Experiment 1.

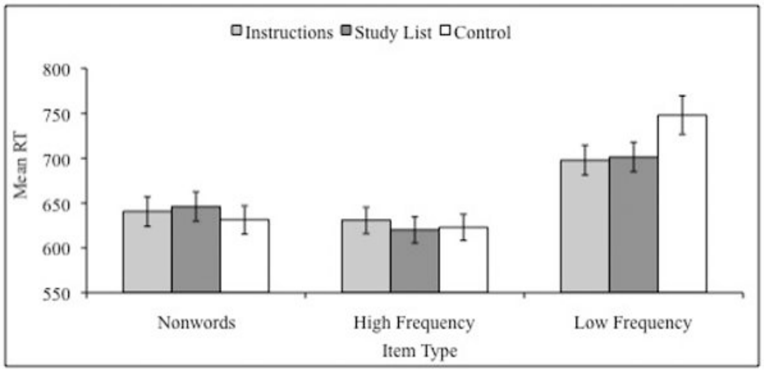

Figure 2.

Average response latencies as a function of encoding condition and target type in Experiment 1 (Error bars represent the standard error of the mean).

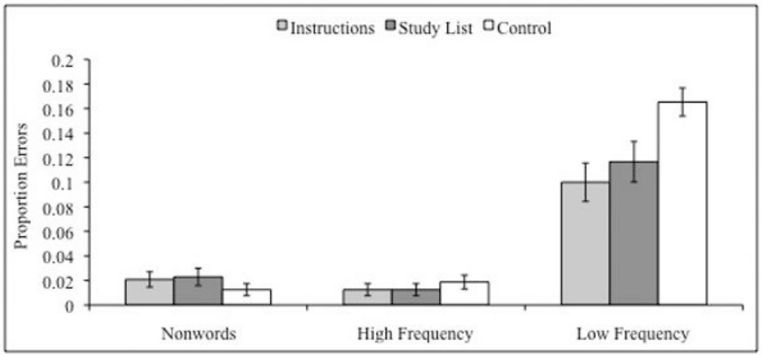

Figure 3.
Average error rate as a function of encoding condition and target type in Experiment 1 (Error bars represent the standard error of the mean).

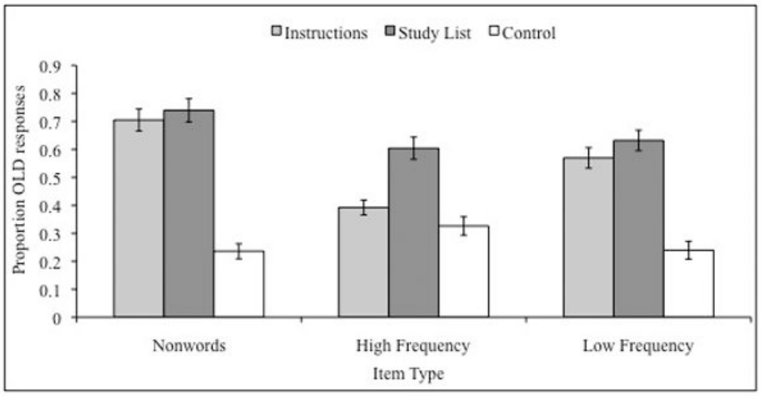

Figure 4.
Proportion of “old” responses as a function of target type and encoding condition in Experiment 1 (Error bars represent the standard error of the mean).

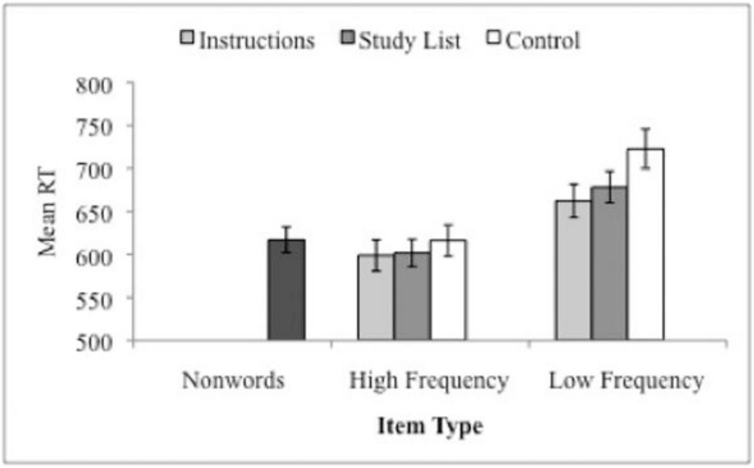

Figure 5.
Mean response latency as a function of word frequency and encoding condition in Experiment 2 (Error bars represent the standard error of the mean).

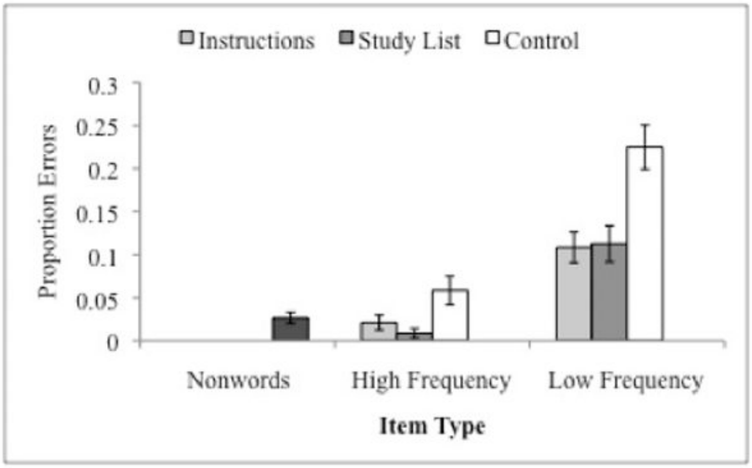

Figure 6.
Average error rates as a function of target frequency and encoding condition in Experiment 2 (Error bars represent the standard error of the mean).

Table 1

Lexical Characteristics of the Stimuli used in Experiments 1 and 2 (Standard Deviations in Parentheses)

	Length	Orthographic N	Log HAL Frequency[ǂ]	Mean RT[*]	Mean Accuracy[*]
Targets					
Low Frequency	6.67 (2.88)	5.88 (6.48)	6.72 (.80)	740 (97)	.87 (.14)
High Frequency	6.96 (2.96)	5.5 (8.75)	11.06 (1.05)	625 (73)	.98 (.02)
Nonwords[**]	5 (.98)	3.67 (2.82)			
Fillers					
Low Frequency	7.04 (2.88)	4.29 (4.71)	6.93 (.80)	741 (109)	.93 (.11)
High Frequency	6.54 (2.88)	5.04 (6.82)	10.88 (.83)	624 (57)	.98 (.03)
Nonwords	6.33 (2.20)	3.02 (4.08)			

[ǂ] HAL frequency counts are based on approximately 400 million observations (Brysbaert & New, 2009). The table presents log-transformed frequency estimates

[*] Estimates obtained from the ELP database

[**] Nonwords did not serve as targets in Experiment 2 because they were not primed