Memory & Cognition
2006, 34 (5), 1063-1079

Proactive interference and cuing effects in short-term cued recall: Does foil context matter?

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Tehan and Humphreys's (1995, 1996) short-term cued recall paradigm showed that recall in short-term memory is cue driven. In critical trials, the participants studied two blocks of four words each and were required to forget the first block while remembering the second block. A foil in the first block (e.g., *orange*) was related to a target (e.g., *carrot*) in the second block. Proactive interference (PI) was evident when a retrieval cue was used that subsumed the foil and the target (e.g., *type of juice*), but not when a cue was used that subsumed only the target (e.g., *type of vegetable*). Four experiments were performed to examine the extent to which contextual organization in the foil block would enhance or diminish the foil's efficacy in creating PI. A novel condition was included in which the words in the foil block were studied in a phonologically related context but the target was cued semantically, and vice versa with a semantic context and phonological cue. There were no differences in recall accuracy between conditions with and without contextual organization, but reliable increases in foil intrusions were observed when contextual organization was present. Contextual organization enhanced the foil, rather than diminished it, but the strengthened foil generated PI only when the cue subsumed the foil and the target and had no effect when the cue subsumed only the target. The results are consistent with a cue-driven retrieval interpretation of short-term recall.

A recent review of contemporary research in short-term memory (STM) has argued for a reconceptualization of short-term recall as a cue-driven process (Nairne, 2002b). This is contrasted with the traditional view of STM, dubbed the *standard model* by Nairne (2002b), in which recall is driven primarily by rehearsal processes countering the effects of decay over time (e.g., Baddeley, 2000; Baddeley & Hitch, 1974). Recasting short-term recall as a cue-driven process brings the conceptualization of STM closer to what is known about retrieval and forgetting processes in long-term memory (LTM), where interference, and not decay (cf. McGeoch, 1932), is seen as the primary cause of forgetting.

The bulk of the evidence against the standard model has come from studies demonstrating LTM contributions in STM tasks. For example, such attributes of words as frequency (e.g., Hulme et al., 1997; Roodenrys & Quinlan, 2000), lexicality (e.g., Hulme, Maughan, & Brown, 1991), phonological neighborhoods (e.g., Goh & Pisoni, 2003; Roodenrys, Hulme, Lethbridge, Hinton, & Nimmo, 2002), phonotactics (e.g., Gathercole, Frankish, Pickering, & Peaker, 1999), and semantics (e.g., Bourassa & Besner, 1994; Walker & Hulme, 1999) influence immediate serial recall performance. It has been suggested that these attributes can be used as effective retrieval cues in a redintegration or *clean-up* process to reconstruct STM traces from LTM in the event that a direct readout from STM cannot be achieved due to trace degradation (e.g., Nairne, 1990; Schweickert, 1993).

The efficacy of retrieval cues in short-term recall can also be inferred from studies in which the organization of words within and across lists was manipulated. Poirier and Saint-Aubin (1995) showed that when words within a list are derived from the same conceptual class (e.g., *musical instruments*) and the conceptual class changes across lists, immediate recall is better, in comparison with a condition in which each word is from a different conceptual class. This pattern of results has been replicated with rhyme categories (e.g., Fallon, Groves, & Tehan, 1999), which is an interesting finding, given that phonological similarity typically leads to poorer recall (Conrad & Hull, 1964). However, both categorical and phonological similarity have also been shown to enhance performance in order reconstruction tasks (e.g., Nairne & Kelley, 1999; Nairne & Neumann, 1993), particularly when similarity is maintained within lists but not across lists. Taken together, these findings strongly suggest that when an organizational principle is present in the context of a word list, participants are able to make use of this organizational factor as an effective retrieval cue for short-term recall, presumably by restricting the potential memory search set and responses to words that are consistent with the cue or organizational principle.

This work was supported, in part, by Research Support Scheme C-107-000-222-091 and Research Grant R-107-000-048-112, awarded to the first author. We thank Michael Humphreys, Gerald Tehan, and an anonymous reviewer for constructive criticism of an earlier version of the manuscript. Correspondence concerning this article should be addressed to W. D. Goh, Department of Psychology, National University of Singapore, Singapore 117570 (e-mail: psygohw@nus.edu.sg).

Note—This article was accepted by the previous editorial team, when Colin M. MacLeod was Editor.

The hypothesis that short-term recall is dependent on the efficacy of retrieval cues was directly tested by Tehan and Humphreys (1995, 1996), using an STM cued recall task. This task involved trials in which participants were presented either two blocks of four words or a single block of four words. In the single-block trials, the participants were required to recall the words in that block, but in the two-block trials, the participants were required to forget the first block and recall only words from the second block. The purpose of the single-block trials was to ensure attention to the first block. Figure 1 shows a schematic of the sequence of events in the critical two-block trials. In these trials, the effect of interest was whether the words from the first block would influence recall of the words in the second block. This was manipulated by having a target word in the to-be-remembered second block (e.g., *carrot*) that shared conceptual attributes with a foil word in the to-be-forgotten first block (e.g., *orange*). A further manipulation involved the nature of the retrieval cue that was presented to the participants. In one condition, the cue (e.g., *type of juice*) subsumed both the foil and the target, whereas in another condition, the cue (e.g., *type of vegetable*) subsumed only the target. Retrieval of *carrot* was impaired in the former condition, but not in the latter, demonstrating that whether proactive interference (PI) affected recall depended on the nature of the cue used at retrieval. Tehan and Humphreys (1995, 1996) also demonstrated similar effects, using rhyme categories with this paradigm. These findings are consistent with those of previous research using the release from PI paradigm (Wickens, 1970), which demonstrated that susceptibility to PI is diminished when cues that uniquely discriminated and specified the words in the current trial were utilized (see, e.g., Dillon & Bittner, 1975; Gardiner, Craik, & Birtwistle, 1972).

Thus, the critical factor for determining the efficacy of a retrieval cue appears to depend on the extent to which the cue can provide diagnostic information about the occurrence of the target (Nairne, 2002a). One can think of cues in terms of their *usefulness*. For example, if one was asked to search for a particular individual and was told that this person was a boy in school uniform, this informa-

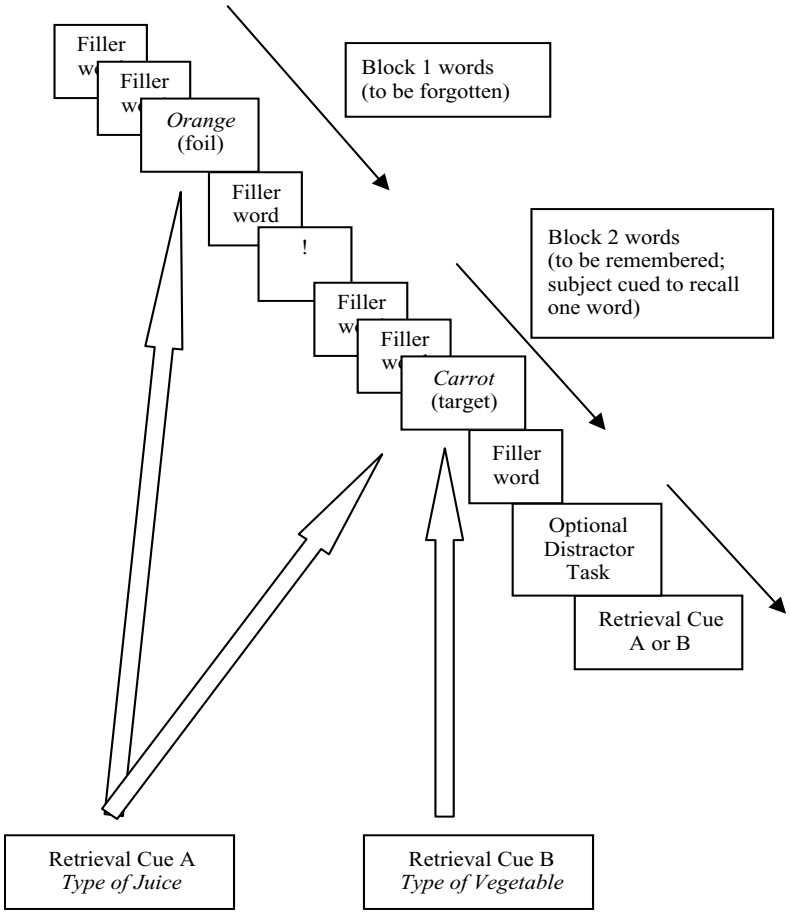

Figure 1. Schematic of a critical two-block trial, with large arrows indicating associative links between the foil, target, and retrieval cues. Proactive interference between *orange* and *carrot* is likely when *type of juice* is used as a retrieval cue, but not when *type of vegetable* is used as a retrieval cue.

tion would most probably be very helpful for identifying such a person in a room full of adults. However, the same cue would practically provide no distinctive information about the target in the setting of a school cafeteria. In other words, the efficacy of a cue would be highest if it uniquely matched the target and little else.

Tehan and Humphreys (1998) extended their earlier findings with this paradigm by demonstrating that PI can also be increased when a target (e.g., *cat*) is accompanied by an unrelated filler word (e.g., *log*) in the second block that rhymes with the foil (e.g., *dog*) in the first block. PI also increased when the unrelated fillers in the second block contained phonemes of the foil (e.g., *dart*, *mop*, or *fig*). Such findings suggest that fillers that share phonemic features with the foil may result in increased activation of the foil, so that participants will be more likely to incorrectly recall the foil, instead of the target, when the retrieval cue subsumes both the foil and the target. Manipulating the properties of the fillers in the target context appears to strengthen the foil. This suggests that the context in which the target appears may also be important in determining susceptibility to PI and the efficacy of retrieval cues in the short-term cued recall task.

An interesting follow-up to this study would be to determine whether foil context, rather than the target context, will have any effects on PI. Placing the contextual items in the foil block may result in effects that are different from those found by Tehan and Humphreys (1998), because the foil is now being studied together with the contextual items and the task is to forget and inhibit this set of items. In the earlier study, the contextual items were in the target block, and the task was to remember an item from this block, as determined by the cue. Hence, any features of words within the target block ought to receive less inhibition.

One possibility is that foil context may diminish, rather than enhance, susceptibility to PI. There are two possible rationales for this prediction. One comes from the earlier observation that when words within lists were organized according to a rhyme or semantic dimension (Fallon et al., 1999; Nairne & Kelley, 1999; Nairne & Neumann, 1993; Poirier & Saint-Aubin, 1995), recall performance was superior, in comparison with word lists lacking such an organization. As has been noted, item similarity may provide a categorical cue that aids retrieval. In turn, the particular dimension that organizes the words within the list may enhance the saliency of that specific attribute of the words and may diminish other attributes. To give a concrete example, a word list comprising *loo*, *shoe*, *flu*, and *zoo* may raise the salience of the rhyme dimension, and the semantic attributes of each word may be relatively less salient.

A second rationale for predicting diminished PI effects is based on differential effects found when extralist or intralist cues are used. For example, recall for targets that have many associates is worse than that for targets with fewer associates when cues that were not previously studied are used, but this effect disappears when cues previously studied with the targets are used (e.g., Nelson, Bennett, Gee, Schreiber, & McKinney, 1993). The argument is that with intralist cuing, only the link between the studied cue–target pairing is activated and all other irrelevant associates are inhibited (Nelson et al., 1993; see also Nelson, McKinney, Gee, & Janczura, 1998). If item similarity can automatically provide a categorical cue, one could argue that this cue is akin to an intralist cue, in the sense that it was generated during the study of the words in the foil block. If the foil context emphasizes the rhyme dimension, the link between the rhyme and the words will be activated, and links with other attributes, such as semantic properties, may be inhibited. Consequently, it will be harder to cue the foil with an extralist cue that subsumes a different dimension, and this, therefore, will lead to fewer problems in retrieving the target in the second block. It should be noted that focusing on the rhyme dimension does not necessarily mean that semantics will not be encoded, since Nelson et al. (1993; see also Nelson, Walling, & McEvoy, 1979) reported that target set size effects did not disappear when rhyme pairs were studied (e.g., *seep–weep*) that were subsequently cued semantically (e.g., *cry*), although overall recall was worse, in comparison with a control condition.

In the context of Tehan and Humphreys's (1995, 1996) cued recall task, suppose that *shoe* is a foil for the target *boot* and the retrieval cues are either *type of footwear* (subsumes *shoe* and *boot*) or *part of a car* (subsumes only *boot*). A foil block with rhyming words may diminish PI effects and raise the semantic retrieval cue's efficacy even when it subsumes *both* the target and the foil. The influence of a potentially interfering foil may be reduced by focusing on an incompatible dimension (the rhyme in this example) or by the inhibition of other features and properties that are incompatible with the studied foil context.

Of course, another possibility is that the foil will be strengthened, as was found by Tehan and Humphreys (1998), if fillers in the foil block share properties with the foil. The logic is that these shared features result in an increase in foil activation that, consequently, causes greater interference with the target when a retrieval cue that subsumes both is given. Hence, the likelihood of the foil's being retrieved is enhanced. A replication of Tehan and Humphreys's (1998) findings would support their view that all the features of studied words in memory will be automatically activated and will be simultaneously available for retrieval, despite the fact that this block of words had to be forgotten or inhibited.

Both the prediction of PI enhancement and the predictions of diminished PI suggest that cue–target diagnosticity depends also on the nature of the fillers in the foil block. However, a final possibility is that PI effects are not enhanced or diminished under such manipulations, which would suggest that cue–target diagnosticity depends entirely on the dimension that the retrieval cue emphasizes, regardless of other dimensions or contextual information that may organize the words in the foil block.

The proposed manipulations may also shed some light on the extent to which short-term cued recall depends on encoding and retrieval processes. Tehan and Humphreys (1996) rejected the possibility that an encoding explanation could be used to explain their results—that is, that

the participants encoded the similarity between the targets and the foils, and this resulted in increased PI. Among the reasons for this rejection was that all the items except for the foil and the target were unrelated and inherently multidimensional. Consequently, the participants were unlikely to encode the precise relationship between the foil–target pair within the constraints of the experimental procedure.

We suggest that a strong test of whether encoding processes contribute to recall is to orient participants to a dimension shared by all the words in the foil block that is incompatible with the retrieval cue and examine the effect on the degree of PI observed. If the participants do encode the rhyme category in the foil block and recall does not vary with foil context, PI effects can be unequivocally attributed to retrieval processes, since such a result would imply that the encoding context does not matter. However, if PI effects vary with foil context, it may suggest that encoding also has some influence on PI effects in cued recall.

EXPERIMENT 1

Experiment 1 introduced a novel condition, manipulating rhyming and nonrhyming fillers, into the first block in the STM cued recall paradigm described in Tehan and Humphreys (1995, 1996). Table 1 depicts the structure of the critical two-block trials. In the control (or no-interference) conditions, all the words except the target were unrelated to the retrieval cue. In the rhyming conditions, all the fillers were semantically unrelated but rhymed with the foil, whereas in the nonrhyming conditions, the fillers were semantically unrelated and did not rhyme with the foil. In the same-category conditions, the retrieval cue subsumed both the foil and the target, whereas in the different-category conditions, the retrieval cue subsumed only the target.

Following the logic of Tehan and Humphreys (1995, 1996), differential recall performance between the same- and the different-category conditions, relative to the relevant control conditions, would indicate the degree of PI effects. The extent to which foils are recalled instead of targets (classified as Block 1 intrusion errors) would also be strong indicators of PI. We expected to replicate Tehan and Humphreys's (1995, 1996) findings in the nonrhyming conditions: When a same-category cue subsuming the foil and the target was presented, performance would be impaired; however, no impairment should be evident when the different-category cue subsuming only the target was presented. In the novel rhyming conditions, the extent to which the rhyme category influenced the PI effect could be observed by examining the differences in the degree of PI, relative to the nonrhyming conditions.

Method

Participants. Forty-four introductory psychology students participated for course credit.

Design and Materials. Sixty monosyllabic foil–target pairs were created by selecting two nonrhyming members from each of 60 unique categories. Forty-five of the pairs were sampled from the Battig and Montague (1969) and McEvoy and Nelson (1982) norms, whereas the rest were created by the authors. Following Tehan and Humphreys (1996), most of the foils were the more dominant instance of the category, whereas the targets were selected so that they could be conceived of as instances of alternative categories. The rhyming fillers of the foils were obtained from the Nelson, McEvoy, and Schreiber (1998) norms and were semantically unrelated to the foil–target pairs and the recall cues. These words are listed in the Appendix, along with the recall cues for the same- and the different-category conditions.

The words were randomly divided into six word lists, with each list comprising 10 foil–target pairs and the corresponding rhyming fillers. Seventy nonrhyming fillers were added to each list for use as unrelated fillers. All of these fillers had characteristics similar to those of the critical items—all were monosyllabic, and 97% were nouns—but were not semantically related to the critical items within each list. Each list of 120 words, therefore, comprised 10 foils, 10 targets, 30 rhyming fillers, and 70 nonrhyming fillers. The lists were equated for average word frequency, on the basis of the Kučera and Francis (1967) counts. The average log frequency for the six lists ranged from 1.95 to 2.01 (overall $M = 2.00$, $SD = 0.60$); a one-way between-subjects ANOVA run across lists was not significant ($F < 1$). Another 120 fillers were selected for the 30 one-block trials of four words each. Ten of these trials comprised fillers that rhymed within list, whereas 20 included nonrhyming fillers. This 1:2 ratio is identical to the 2:4 ratio of the number of conditions in the two-block trials that included rhyming and nonrhyming fillers in the first

Table 1
Structure of Critical Two-Block Trials in Experiment 1

		Control	Nonrhyming	Rhyming
Block 1 (foil block)	Filler	x	x	loo
	Foil/filler	x	shoe	shoe
	Filler	x	x	flu
	Filler	x	x	zoo
	Block separator	!	!	!
Block 2 (target block)	Filler	x	x	x
	Target	boot	boot	boot
	Filler	x	x	x
	Filler	x	x	x
	Distractor task			
	Recall cue			

Note—In the same-category conditions, *type of footwear* was presented as the recall cue, which subsumed both the foil and the target. In the different-category conditions, *part of a car* was presented as the recall cue, which subsumed only the target: x represents an unrelated filler word. The distractor task was a math verification problem.

block. This was to ensure that the participants could not predict one- and two-block trials on the basis of list organization.

The experiment was run completely within subjects. To counterbalance lists across conditions, a 6 × 6 balanced Latin square was used to rotate the six lists among the six experimental conditions, which were formed by crossing the three rhyming conditions (control, nonrhyming, or rhyming) with the two retrieval cue category conditions (same or different). The program controlling the experiment selected the appropriate types of fillers and recall cues, depending on the condition each list was assigned to. For each participant, the 30 one-block and 60 two-block trials comprising all six conditions were randomly interspersed throughout the experiment so that the participants would have no prior knowledge and could not anticipate the number of blocks in each trial or the nature of the conditions. Following Tehan and Humphreys (1995, 1996), the foils and targets always appeared in the same serial position within their blocks, with half in the second serial position and half in the third serial position. The first and last serial positions were not used, in order to avoid primacy and recency effects.

Procedure. The participants were told to commit the most recently presented block of four words to memory. Thus, for a two-block trial, the participants were to memorize the first block, but if a block separator, in the form of an exclamation mark (!), appeared after the first block, the participants were required to forget the words in the first block and memorize only the words in the second block and recall the word indicated by the recall cue. For one-block trials, the recall cue instructed the participants to perform serial recall of all the words. The participants were told to treat all blocks as one-block trials, until they learned otherwise from the appearance of the block separator.

Each trial began with a READY prompt centered on the computer monitor for 2 sec. The words were then displayed individually at a rate of one word/sec. The participants were instructed to silently articulate each word as it was presented. At the end of the trial, a distractor in the form of a math verification task (e.g., "Is (8/2) + 6 = 11?") was presented. The participants responded *yes* or *no*, using preassigned keys on the keyboard. Once a response had been detected, the recall cue was displayed. For one-block trials, the cue was "Recall all words"; for two-block trials, the cue relevant to the experimental condition was displayed. The participants wrote their responses on prepared answer sheets and initiated the next trial by pressing the enter key. The participants were allowed a short break at the end of every 30 trials. A practice block of 2 one-block trials and 3 two-block trials, using words that were not part of the experimental trials, was conducted at the beginning of the session to familiarize the participants with the task and procedure.

Results

One participant did not complete the experiment, and another failed to follow instructions and performed serial, instead of cued, recall for all the conditions. These participants were not included in the analyses. Serial recall performance in the one-block trials was useful in serving as an accuracy check to ensure that the participants were, indeed, paying attention to the first block. This was obviously crucial for any PI effect to materialize, because if the participants ignored the first block, the foil would naturally have no effect on cued recall. We adopted a criterion of minus two *SD*s from the average serial recall rate in the one-block trials ($M = .68$, $SD = .18$), to screen out the participants who were not paying attention to the first block of words. One participant failed to meet this criterion. Thus, the subsequent analyses include the scores from 41 participants. We also examined the proportion of accurate responses in the distractor task and found it to be very high ($M = .95$, $SD = .06$), indicating that the participants were conscientiously verifying the math equations.

Recall performance is summarized in Table 2. Errors were classified as Block 1 intrusions (recall of words from the first block that were in the same serial position as the target), omissions (no response), or item errors (other words).

Recall analyses. A 2 (cue: same category or different category) × 3 (filler: control, nonrhyming, or rhyming) repeated measures ANOVA on recall rates revealed a significant interaction [$F(2,80) = 4.77$, $MS_e = 0.01$, $p < .05$]. The source of the interaction is a significant simple main effect of filler with same-category cue [$F(2,80) = 3.32$, $MS_e = 0.02$, $p < .05$], but not with different-category cue [$F(2,80) = 1.12$, $MS_e = 0.01$, n.s.]. The latter result indicates that there were no differences in recall rates regardless of the nature of the foil block when the retrieval cue subsumed only the target, which replicated the results from Tehan and Humphreys (1995, 1996): When the retrieval cue subsumed only the target, no PI effect was observed.

Within the same-category cue conditions, three additional comparisons were used to determine whether recall probability depended on the nature of the fillers in the foil block. The first comparison compared performance in the nonrhyming condition with that in the control condition. This established the presence of a PI effect and replicated the results found in Tehan and Humphreys (1995, 1996). The difference was marginally significant [$F(1,40) =$

Table 2
Mean Correct Recall and Error Rates in Experiment 1

			Type of Error					
	Recall		Block 1 Intrusions		Omissions		Item	
Condition	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Same-category retrieval cue								
Control (no interference)	.80	.18	.00	.02	.10	.15	.12	.11
Nonrhyming fillers	.74	.24	.06	.09	.10	.15	.09	.09
Rhyming fillers	.74	.20	.10	.13	.06	.10	.09	.09
Different-category retrieval cue								
Control (no interference)	.81	.17	.00	.00	.10	.14	.10	.13
Nonrhyming fillers	.83	.17	.00	.02	.08	.13	.09	.10
Rhyming fillers	.85	.16	.01	.03	.10	.17	.08	.10

4.07, $MS_e = 0.02$, $p = .05$], indicating that the expected PI effect was observed: When the retrieval cue subsumed both the foil and the target, recall was impaired. In the second and third comparisons, performance in the novel rhyming condition was compared with that in the control and nonrhyming conditions, respectively. These were done to determine whether the rhyme context in the foil block would have enhanced or diminished the PI effect. Recall impairment using rhyming fillers was reliable, in comparison with the control condition [$F(1,40) = 5.46$, $MS_e = 0.01$, $p < .05$], but there was no reliable difference in the magnitude of the PI effect when rhyming or nonrhyming fillers were used in the foil block ($F < 1$). Therefore, no evidence of an enhancement or attenuation of the PI effect due to rhyming fillers was found in the recall rate measures.

Error analyses. The error analyses were conducted with a 3 (error: Block 1 intrusions, omissions, or item errors) × 2 (cue) × 3 (filler) repeated measures ANOVA. We acknowledge that this may not be entirely appropriate, given that, as was expected, there were very few Block 1 intrusions in the different-category cue conditions and the control condition for the same-category cue. We therefore supplemented the ANOVA results with the relevant nonparametric tests for the critical comparisons. The critical comparison is between the rhyming and the nonrhyming fillers conditions for Block 1 intrusions when same-category cues are used. This comparison is the most critical, since it will indicate whether the novel rhyming filler condition resulted in greater or fewer foil intrusions, in comparison with the interference level in the standard nonrhyming filler condition, and, correspondingly, will give direct evidence for enhanced or diminished PI as a function of contextual organization. This was tested with a Wilcoxon test. Other relevant comparisons include comparing the three filler conditions for omissions and item errors to determine whether there were differential effects due to the nature of the fillers. These were tested with Friedman tests. In the majority of cases, both parametric and nonparametric tests revealed identical results.

The ANOVA revealed a significant three-way interaction [$F(4,160) = 4.16$, $MS_e = 0.01$, $p < .01$]. Analyses of the error × filler simple interactions for each cue condition showed that the simple interaction was significant with same-category cue [$F(4,160) = 8.20$, $MS_e = 0.01$, $p < .001$], but not with different-category cue ($F < 1$). The latter result indicates that the proportion of errors did not depend on the nature of the fillers when the retrieval cue subsumed only the target and, thus, will not be considered further.

Within the same-category cue conditions, we analyzed the simple main effect of filler for each of the three error types to establish whether the error rates depended on the nature of the fillers, followed by paired *t* tests, where necessary, to identify specific differences. The simple main effect of filler was significant for both Block 1 intrusions [$F(2,80) = 15.43$, $MS_e = 0.01$, $p < .001$] and omissions [$F(2,80) = 3.43$, $MS_e = 0.01$, $p < .05$], but not for item errors [$F(2,80) = 1.02$, $MS_e = 0.01$, n.s.]. Specific comparisons showed that the greatest number of Block 1 intrusions occurred with rhyming fillers, followed by nonrhyming fillers, and the control condition [all ts$(40) > 2.29$, ps $< .05$]. The Wilcoxon test ($Z = 2.22$, $p < .05$) confirmed these findings, with 18 participants showing more Block 1 intrusions in the rhyming than in the nonrhyming conditions, 8 with the opposite pattern, and 15 ties. These findings showed that rhyming fillers increased the number of foils incorrectly recalled. For omissions, there were fewer errors in the rhyming condition than in the nonrhyming and control conditions [both ts$(40) > 2.04$, ps $< .05$], with no difference between the latter two ($t < 1$). However, the Friedman test was not significant for omissions or for item errors [both $\chi^2(2, N = 41) < 3.55$, n.s.].

Discussion

Taken together, the findings can be summarized as follows. In terms of recall accuracy, when the retrieval cue subsumed the foil and the target, target recall was impaired. Whether the foil block included rhyming or nonrhyming fillers did not seem to matter. However, when the degree of Block 1 intrusion errors is considered, having fillers that rhymed with the foil in the first block increased the probability that an incorrect foil response was made, relative to the probability of a foil intrusion when no rhyming fillers were included. These patterns of results are similar to the findings of Tehan and Humphreys (1998), where a rhyme in the second block increased the probability of Block 1 intrusion errors. The present results extend the previous work by demonstrating a similar effect when the rhyming fillers are included in the foil block and support the view that shared features among the fillers strengthen foil activation and cause increased interference for targets. When the cue subsumes the foil and the target, cue–target diagnosticity depends on both the dimension emphasized by the retrieval cue and the context in which the foil is studied. We will defer comment on the implications for encoding and retrieval processes until the General Discussion section.

EXPERIMENT 2A

Experiment 2A reversed the roles of the semantic and phonological dimensions in the experimental design in order to test the generality of the findings from Experiment 1. If cue–target diagnosticity depends on both the dimension emphasized by the retrieval cue and the nature of the foil block, we would expect the same pattern of results as that obtained in Experiment 1.

Table 3 depicts the structure of the critical two-block trials. The foil block now comprised words that were all semantically related—for example, *crane*, *duck*, *stork*, or *swan*—or unrelated. If the target in Block 2 was *buck*, the retrieval cues were either the rhyme portion that was shared by the foil and the target (e.g., *rhymes with luck*; subsumes both the foil *duck* and the target *buck*) or the onset-nucleus portion of the target (e.g., *sounds like the beginning of butt*; subsumes only the target *buck*). Tehan and Humphreys (1995, 1996) used word fragments, such as endings (e.g., *_uck*) and beginnings (e.g., *buc_*), as phonological retrieval

Table 3
Structure of Critical Two-Block Trials in Experiments 2A and 2B

		Control	Unrelated	Related
Block 1 (foil block)	Filler	x	x	crane
	Foil/filler	x	duck	duck
	Filler	x	x	stork
	Filler	x	x	swan
	Block separator	!	!	!
Block 2 (target block)	Filler	x	x	x
	Target	buck*/dud†	buck*/dud†	buck*/dud†
	Filler	x	x	x
	Filler	x	x	x
	Distractor task			
	Recall cue			

Note—x represents an unrelated filler word. The distractor task was a math verification problem. *For Experiment 2A, *buck* was the target. In the rhyme conditions, *rhymes with luck* was presented as the recall cue, which subsumed both the foil and the target. In the onset conditions, *sounds like the beginning of butt* was presented as the recall cue, which subsumed only the target. †For Experiment 2B, *dud* was the target. In the onset conditions, *sounds like the beginning of done* was presented as the recall cue, which subsumes both the foil and the target. In the rhyme conditions, *rhymes with thud* was presented as the recall cue, which subsumes only the target.

cues. However, we felt that there was a possibility that participants might, at times, be able to use orthography, rather than phonology, with such cues. Specifically, providing a whole word, rather than fragments, and directing participants to the relevant phonological portion of the word would maximize phonological processing.

We expected to replicate Tehan and Humphreys's (1995, 1996) findings in the semantically unrelated conditions: When a rhyme retrieval cue that subsumed both the foil and the target was presented, performance would be impaired; however, no impairment would occur when an onset retrieval cue that subsumed only the target was presented. In the novel related conditions, the extent to which the related category influenced the PI effect could be observed by examining the differences in the degree of PI, relative to the unrelated conditions.

Method

Participants. Forty introductory psychology students participated for course credit. None had participated in Experiment 1.

Design and Materials. Sixty monosyllabic foil–target pairs were created by selecting two semantically unrelated members from each of 60 unique rhyme categories (Nelson et al., 1998). The taxonomic fillers of 42 foils were obtained from Battig and Montague (1969) and McEvoy and Nelson (1982), with the rest generated by the authors. These fillers did not share rhyme and onset nucleus components with the foil–target pairs and the recall cues. These words are listed in the Appendix, along with the recall cues for the rhyme and onset conditions. As in Experiment 1, the words were randomly divided into six 120-word lists, with each list comprising 10 foils, 10 targets, 30 taxonomic fillers, and 70 unrelated fillers. As before, the lists were equated for average word frequency ($F < 1$), with the average log frequency for the six lists ranging from 1.98 to 2.06 (overall $M = 2.01$, $SD = 0.68$). Another 120 fillers were selected for the 30 one-block trials of 4 words each. Ten of these trials comprised fillers that were taxonomically related within list, and the rest included unrelated fillers. As before, this was to ensure that the participants could not predict one- and two-block trials on the basis of list organization.

The same design and counterbalancing procedures as those in Experiment 1 were used. The unrelated and related conditions in the present experiment were analogous to the nonrhyming and rhyming conditions, respectively, in the previous experiment. The rhyme and onset retrieval cues were analogous to the same-category and different-category retrieval cues, respectively, in Experiment 1.

Procedure. The same procedure as that in Experiment 1 was used. Several examples of what is meant by *sounds like the beginning of*, using words that were not part of the experimental trials, were presented during the practice session to ensure that the participants understood this retrieval cue.

Results

The average serial recall rate in the one-block trials was .69 ($SD = .20$). Four participants failed to exceed the criterion of minus two *SD*s from the mean, and the subsequent analyses included 36 participants. The proportion of accurate responses in the distractor task was very high ($M = .93$, $SD = .07$). Recall performance is summarized in the top half of Table 4.

Recall analyses. The ANOVA on recall rates yielded no reliable cue × filler interaction [$F(2,70) = 1.65$, $MS_e = 0.03$, n.s.] or main effect of cue ($F < 1$). The main effect of filler was significant [$F(2,70) = 11.81$, $MS_e = 0.02$, $p < .001$], with follow-up analyses showing that recall was best in the control condition, followed by the unrelated and then the related conditions [all ts$(35) > 2.22$, ps $< .05$]. We will defer discussion of these results until after the error analyses have been presented.

Error analyses. An error × cue × filler interaction was observed [$F(4,140) = 7.72$, $MS_e = 0.01$, $p < .001$]. As in Experiment 1, the error × filler simple interaction was significant for rhyme cue [$F(4,140) = 12.51$, $MS_e = 0.01$, $p < .001$], but not for onset cue ($F < 1$). Again, the latter result indicates that the proportion of errors did not depend on the nature of the fillers when the retrieval cue subsumed only the target and, thus, will not be considered further.

Within the rhyme cue conditions, the simple main effect of filler was significant for Block 1 intrusions [$F(2,70) = 22.74$, $MS_e = 0.01$, $p < .001$], but not for omissions

Table 4
Mean Correct Recall and Error Rates in Experiments 2A and 2B

			Type of Error					
	Recall		Block 1 Intrusions		Omissions		Item	
Condition	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Experiment 2A								
Rhyme retrieval cue								
Control (no interference)	.79	.16	.01	.02	.05	.07	.15	.13
Unrelated fillers	.69	.23	.11	.14	.04	.07	.16	.13
Related fillers	.68	.22	.17	.17	.03	.06	.11	.12
Onset retrieval cue								
Control (no interference)	.74	.19	.01	.03	.04	.08	.20	.15
Unrelated fillers	.73	.19	.02	.04	.05	.09	.21	.18
Related fillers	.64	.23	.03	.07	.08	.13	.23	.18
Experiment 2B								
Onset retrieval cue								
Control (no interference)	.66	.20	.00	.00	.11	.14	.23	.16
Unrelated fillers	.64	.24	.10	.10	.10	.16	.17	.15
Related fillers	.65	.21	.10	.11	.08	.14	.16	.12
Rhyme retrieval cue								
Control (no interference)	.81	.17	.00	.02	.07	.11	.12	.12
Unrelated fillers	.80	.16	.02	.04	.06	.10	.12	.10
Related fillers	.79	.16	.02	.05	.07	.11	.12	.11

[$F(2,70) = 1.35$, $MS_e = 0.003$, n.s.] and item errors [$F(2,70) = 1.79$, $MS_e = 0.01$, n.s.]. The latter two findings were consistent with Friedman tests [both $\chi^2(2, N = 46) < 1.97$, n.s.]. Specific comparisons for Block 1 intrusions revealed a trend identical to that in Experiment 1; the greatest number of intrusions occurred with related fillers, followed by unrelated fillers, and the control condition [all ts$(35) > 2.57$, ps $< .05$]. The Wilcoxon test ($Z = 2.33$, $p < .05$) confirmed these findings, with 19 participants showing more Block 1 intrusions in the related than in the unrelated conditions, 7 with the opposite pattern, and 10 ties. These findings showed that related fillers increased the number of foils incorrectly recalled.

Discussion

The error patterns were clearly identical to the patterns observed in Experiment 1; there was evidence that when the foil context was semantically similar, the probability of recalling the foil, instead of the target, increased, relative to when the foil context comprised unrelated words. This pattern was found only with the rhyme retrieval cues that subsumed both the foil and the target, and not with the onset cues that subsumed only the target. These findings strongly suggest that there were PI effects, despite the lack of supporting trends from the recall accuracy measures.

Inspection of the recall accuracy trend with rhyme retrieval cues in Table 4 suggests that the pattern is similar to the trend observed with the same-category cues in Table 2; that is, there was decreased performance in the conditions in which interference was expected, relative to the control condition. This apparent effect may have been obscured by the lower recall rates of the onset cue conditions (relative to the accuracy rates in the analogous different-category cue conditions). One possibility could be due to the "naturalness" of the retrieval cue that was used. A rhyme is a familiar component of a syllable (cf. Ladefoged, 1993, p. 248), whereas the onset nucleus component is not. Therefore, the latter may be a relatively weaker cue than the former. A weak retrieval cue may inherently not provide high cue–target diagnosticity in terms of matching the cue dimension with the target. As a result, performance is generally weaker using these cues, even though they subsume only the target.

To examine this possibility, Experiment 2B was conducted, in which the roles of the rhyme and the onset retrieval cues were reversed. The onset cues now subsumed both the foils and the targets, whereas the rhyme cue subsumed only the target. If the onset cues are weak, we would not expect to find a pattern in which PI is evident when the cue subsumes the foil and the target, which would be similar to Experiment 1 or what seems to be the case for the rhyme cues in Experiment 2A.

EXPERIMENT 2B

Table 3 depicts the structure of the critical two-block trials, which was identical to that for Experiment 2A, except that the target *dud* now shared the same onset nucleus portion of the foil *duck*. The retrieval cues were either *sounds like the beginning of done*, subsuming the foil and the target, or *rhymes with thud*, subsuming only the target.

Method

Participants. Forty-six introductory psychology students participated for course credit. None had participated in the previous experiments.

Design, Materials, and Procedure. A set of new targets and rhyme and onset cues were created. The same foils and related fillers as those in Experiment 2A were used, except in a few cases indicated

in the Appendix. The average log frequency for the six lists did not differ [$F(5,714) = 2.00$, $MS_e = 0.49$, n.s.] and ranged from 1.89 to 2.11 (overall $M = 1.97$, $SD = 0.71$). The same design, counterbalancing methods, and procedures as those in the previous experiments were used.

Results

The average serial recall rate in the one-block trials was .74 ($SD = .16$). Two participants did not meet criterion, and subsequent analyses included 44 participants. Performance in the distractor task was very high ($M = .94$, $SD = .04$). Recall performance is summarized in the bottom half of Table 4.

Recall analyses. The ANOVA on recall rate yielded no reliable cue × filler interaction or main effect of filler (both Fs < 1). The main effect of cue was significant [$F(1,43) = 47.39$, $MS_e = 0.03$, $p < .001$]; overall performance with rhyme cues ($M = .80$, $SD = .14$) was much better than that with onset cues ($M = .65$, $SD = .17$). This supports our earlier speculation that onset cues would yield generally poorer performance, because the participants might find the onset nucleus portion of a word less "natural" than the rhyme portion.

Error analyses. An error × cue × filler interaction was observed [$F(4,172) = 6.08$, $MS_e = 0.01$, $p < .001$]. As in the previous experiments, the error × filler simple interaction was significant for onset cue [$F(4,172) = 10.87$, $MS_e = 0.01$, $p < .001$], but not for rhyme cue ($F < 1$). Within the onset cue conditions, the simple main effect of filler was significant for Block 1 intrusions [$F(2,86) = 24.32$, $MS_e = 0.01$, $p < .001$] and item errors [$F(2,86) = 4.45$, $MS_e = 0.01$, $p < .05$], but not for omissions ($F < 1$). Specific comparisons showed that the effect was due entirely to the fact that very few Block 1 intrusions were observed in the control condition, in comparison with the unrelated and related filler conditions [both ts$(43) > 6.48$, ps $< .001$]. The critical finding is that the number of Block 1 intrusions did not differ between unrelated and related conditions ($t < 1$). The Wilcoxon test ($Z = 0.29$, n.s.) confirmed these findings, with 16 participants showing more Block 1 intrusions in the related than in the unrelated conditions, 14 with the opposite pattern and 14 ties. Hence, unlike in the two previous experiments, there was no evidence that related fillers increased the number of foils incorrectly recalled when onset cues subsuming the foil and the target were used. For item errors, there were more errors in the control condition than in the unrelated and related conditions [both ts$(43) > 2.42$, ps $< .05$], with no difference between the latter two ($t < 1$). However, the Friedman test was not significant for omissions or for item errors [both $\chi^2(2, N = 41) < 5.46$, n.s.].

Clearly, overall performance using onset cues was poor, in comparison with the rhyme cues. Even in the control condition, where interference from foils did not exist, performance was significantly below that in the rhyme cue conditions. There was some indication that interference occurred with onset cues in the unrelated and related conditions, given that Block 1 intrusions were observed. However, the critical finding that differed from those in the previous two experiments was that the probability of recalling a foil did not significantly increase in the related filler conditions—suggesting that even if semantic similarity in the foil context strengthened the foil, the potential increased interference with the target did not materialize, on account of the weak onset retrieval cue.

Combined Analyses of Experiments 2A and 2B

The reversal of the roles of the rhyme and onset cues in Experiments 2A and 2B afforded an opportunity to use rhyme cues to analyze the PI effects independently from the analysis of the effects when onset cues were used. For recall accuracy, it was not possible to do a straightforward three-way ANOVA with experiment as a between-subjects factor, because the interference and no-interference conditions used different types of cues in each experiment. Hence, separate two-way mixed design ANOVAs were performed independently for rhyme and onset cues, with cue subsuming the foil and the target (interference conditions) versus cue subsuming the target only (no-interference conditions) constituting the between-subjects factor and the three filler conditions constituting the within-subjects factor. The relevant mixed ANOVAs were also performed for the error analyses.

Rhyme cues. Figure 2 illustrates the pattern of results across the two experiments for rhyme cues. The ANOVA on recall rates yielded a significant interaction [$F(2,156) = 3.43$, $MS_e = 0.02$, $p < .05$]. The source of the interaction was a significant simple main effect of filler when the cue subsumed the foil and the target [Experiment 2A; $F(2,156) = 6.15$, $MS_e = 0.02$, $p < .01$], but not when the cue subsumed only the target (Experiment 2B; $F < 1$). When the cue subsumed the foil and the target, no recall differences were found between the unrelated and the related filler conditions ($F < 1$), but recall was worse for these two conditions than for the control condition [both Fs$(1,35) > 8.28$, MS_es < 0.03, ps $< .01$]. This finding is identical to the recall rate results in Experiment 1 and, essentially, provides statistical support for our earlier observation in Experiment 2A that the pattern for the rhyming cues followed the same trend as that for the semantic cues in Experiment 1 but was obscured by the lower performance levels for the onset cues. The error analyses revealed a significant error × filler × interference/no-interference interaction [$F(4,312) = 7.43$, $MS_e = 0.01$, $p < .001$]. Follow-up analyses were identical to those reported in Experiments 2A and 2B and will not be repeated here.

Onset cues. Figure 3 illustrates the pattern of results across the two experiments for onset cues. No reliable effects were found from the ANOVA on recall rates (all Fs < 2.91, MS_es < 0.09, n.s.). The error analyses revealed a significant error × filler × interference/no-interference interaction [$F(4,312) = 6.06$, $MS_e = 0.01$, $p < .001$]. Again, follow-up analyses were identical to those reported in Experiments 2A and 2B and will not be repeated here.

To summarize, the independent analyses of rhyme and onset cue effects revealed that using rhyme cues resulted in a pattern of results that was identical to that using semantic cues in Experiment 1. Hence, PI effects caused by using a cue that subsumed the foil and the target increased

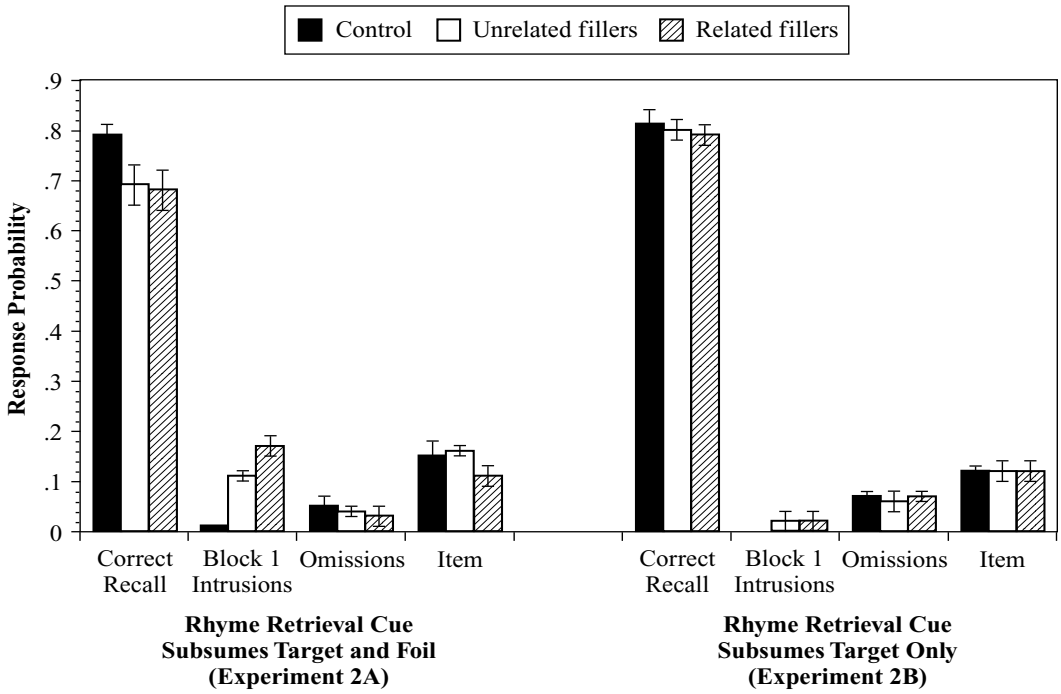

Figure 2. Average response probability (+*SE*s) of recall and error measures across filler conditions, using rhyme retrieval cues.

when the foil block comprised words with a contextual organization. This finding can be generalized across semantic and rhyme cues and contextual similarity on the basis of these factors. No evidence of this effect was found for onset cues, which may be attributed to the potentially weak diagnosticity and familiarity with onset cues.

Discussion

The results of the previous experiments are consistent with the prediction that contextual organization strengthens the foil, rather than weakens it. This resulted in increased foil intrusions when the cue subsumed both the foil and the target, but not when the cue subsumed only the target. Despite a strengthened foil in the rhyming and related filler conditions, there was no effect when the cue uniquely pointed to the target, as evidenced by the lack of differential performance levels among the filler conditions when the cue subsumed only the target. This strongly suggests that PI is driven first and foremost by the nature of the retrieval cue, regardless of the surrounding context. The context may strengthen foil activation under certain conditions, but the effects of this strengthening can be manifested only when a retrieval cue points to both the foil and the target. This empirical finding is consistent with the view that STM recall is a cue-driven process.

Of course, one could argue that the recall accuracy findings are not consistent with the conclusion that contextual organization strengthens the foil. There was no differential performance in recall accuracy between the interference conditions with or without contextual organization, although the pattern of Block 1 intrusions critically suggests that differential PI effects were evident. Nevertheless, some independent index that the participants encoded the contextual organization would lend greater weight to the conclusion.

For this, we compared the average serial recall performance between the 10 trials in the one-block conditions that either rhymed (Experiment 1) or were semantically related (Experiments 2A and 2B) with the corresponding 20 trials that did not rhyme or were unrelated. For Experiment 1, no differences were found between the rhyme ($M = .69$, $SD = .17$) and the nonrhyme ($M = .70$, $SD = .16$) trials ($t < 1$). For Experiments 2A [$t(35) = 2.11$, $p < .05$] and 2B [$t(44) = 7.84$, $p < .001$], the participants reliably recalled more words in the semantically related trials (Ms = .78 and .83, SDs = .12 and .14, for Experiments 2A and 2B, respectively) than in the unrelated trials (Ms = .73 and .71, SDs = .15 and .15).

These results suggest that for the latter two experiments, there is unequivocal evidence that the participants encoded the semantic similarity in the contextually organized foil blocks, and the findings are similar to those in previous work showing a semantic similarity advantage in serial recall (e.g., Poirier & Saint-Aubin, 1995). The findings for Experiment 1 were surprising, since evidence of a phonological similarity effect was expected. Although this may suggest that the participants did not encode the rhyme organization, this view would be problematic in explaining how rhyme organization would result in increased Block 1 intrusion errors if the participants did not encode the rhyme.

We attempted to resolve this indirectly by replicating Experiment 1 in the next experiment, but this time, the rhyming fillers were placed in the target block, instead of

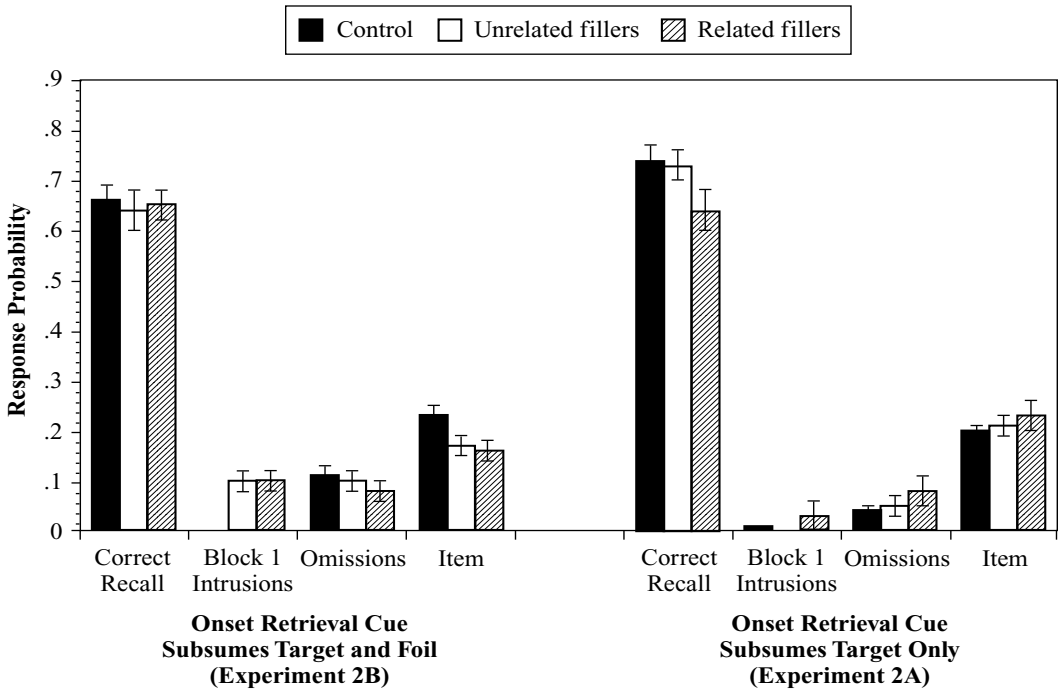

Figure 3. Average response probability (+*SE*s) of recall and error measures across filler conditions, using onset nucleus retrieval cues.

the foil block. This is essentially the manipulation used in Tehan and Humphreys (1998), although they used only one rhyming filler for their rhyme experiment. By having the rhymes in the second block, there would be no contextual organization in the first block, including the single-block filler trials (this was to ensure that the participants could not predict one- and two-block trials in advance). Although this made it impossible to have a similar independent index of whether the participants encoded contextual organization, the rationale was that if the results implicating foil strengthening were replicated in this experiment, it would strongly suggest that contextual organization influences PI, because there would now be converging evidence that context effects occur across two different contextual block manipulations.

Another motivation for the next experiment was that Tehan and Humphreys (1998) did not include conditions in which the retrieval cue was from a different semantic category than was the foil. As was noted above, if foils strengthened by a rhyme context have no effect when the retrieval cue subsumes only the target, there would be very strong evidence that the retrieval cue was driving PI.

EXPERIMENT 3

Method

Participants. Thirty-seven introductory psychology students participated for course credit. None had participated in the previous experiments.

Design, Materials, and Procedure. The design, materials, and procedure were identical to those in Experiment 1, except that the three rhyming fillers in the foil block were now switched to the target block and the unrelated fillers in the corresponding target block were switched to the foil block. Using the example presented in Table 1 for Experiment 1, the rhyming condition in Experiment 3 comprised "*x*, *shoe*, *x*, *x*" in Block 1 and "*loo*, *boot*, *flu*, *zoo*" in Block 2. All the one-block trials comprised unrelated words.

Results and Discussion

The average serial recall rate in the one-block trials was .68 ($SD = .20$). Two participants did not meet criterion, and subsequent analyses included the scores from 35 participants. Distractor task performance was very high ($M = .95$, $SD = .03$). Recall performance is summarized in Table 5.

Recall analyses. A significant interaction was obtained for recall rate [$F(2,68) = 7.11$, $MS_e = 0.01$, $p < .01$]. The simple main effect of filler was significant for same-category cues [$F(2,68) = 7.14$, $MS_e = 0.01$, $p < .01$], but not for different-category cues [$F(2,68) = 1.21$, $MS_e = 0.01$, n.s.]. With same-category cues, no reliable difference was observed between the rhyming and the nonrhyming filler conditions [$F(1,34) = 2.03$, $MS_e = 0.02$, n.s.], but recall was worse for these two conditions than for the control condition [both Fs$(1,34) > 6.26$, MS_es < 0.02, ps $< .05$]. This finding is identical to the recall accuracy results in Experiment 1; recall accuracy decreased only when the semantic retrieval cue subsumed the foil and the target, and there was no reliable difference in accuracy between target blocks that had fillers rhyming with the foil and those with nonrhyming fillers.

Error analyses. An error × cue × filler interaction was observed [$F(4,136) = 10.67$, $MS_e = 0.01$, $p < .001$].

Table 5
Mean Correct Recall and Error Rates in Experiment 3

			Type of Error					
	Recall		Block 1 Intrusions		Omissions		Item	
Condition	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Same-category retrieval cue								
Control (no interference)	.80	.17	.00	.02	.08	.10	.12	.14
Nonrhyming fillers	.74	.21	.07	.10	.07	.11	.11	.12
Rhyming fillers	.69	.20	.20	.16	.04	.07	.07	.08
Different-category retrieval cue								
Control (no interference)	.82	.17	.00	.00	.09	.11	.09	.09
Nonrhyming fillers	.85	.14	.00	.02	.05	.07	.10	.10
Rhyming fillers	.85	.16	.01	.04	.05	.08	.08	.10

The error × filler simple interaction was significant for same-category cues [$F(4,136) = 15.67$, $MS_e = 0.01$, $p < .001$]. The simple main effect of filler was significant for Block 1 intrusions [$F(2,68) = 32.51$, $MS_e = 0.01$, $p < .001$], but not for omissions [$F(2,68) = 2.69$, $MS_e = 0.01$, n.s.] and item errors [$F(2,68) = 2.59$, $MS_e = 0.01$, n.s.]. The latter two findings were consistent with Friedman tests [both $\chi^2(2, N = 35) < 3.78$, n.s.]. Specific comparisons for Block 1 intrusions revealed a trend identical to that in Experiment 1; the greatest number of intrusions occurred with related fillers, followed by unrelated fillers and the control condition [all ts$(34) > 4.27$, ps $< .001$]. The Wilcoxon test ($Z = 3.66$, $p < .001$) confirmed these findings, with 22 participants showing more Block 1 intrusions in the rhyming than in the nonrhyming conditions, 4 with the opposite pattern, and 9 ties. These findings showed that rhyming fillers increased the number of foils incorrectly recalled when the cue subsumed both the foil and the target.

Unlike in Experiment 1, the error × filler simple interaction was significant for different-category cues [$F(4,136) = 3.98$, $MS_e = 0.003$, $p < .01$]. This was due to a significant simple main effect of filler for omissions [$F(2,68) = 6.68$, $MS_e = 0.004$, $p < .01$], but not for Block 1 intrusions [$F(2,68) = 1.91$, $MS_e = 0.001$, n.s.] or for item errors ($F < 1$). Friedman tests confirmed the findings for omissions [$\chi^2(2, N = 35) = 9.11$, $p < .05$] and item errors [$\chi^2(2, N = 35) = 0.61$, n.s.]. Additional tests for omissions showed that there were more errors in the control condition [both ts$(34) > 2.84$, ps $< .01$] than in the other two filler conditions, which did not differ ($t < 1$). We have no explanation for this finding, but the important thing to note is that there is no evidence of any differences between the critical nonrhyming and rhyming filler conditions. This implies that whatever the cause of the increased level of omissions in the control condition, having rhyming fillers did not result in differential error rates when the retrieval cue subsumed only the target.

GENERAL DISCUSSION

The present study explored the extent to which susceptibility to PI in the cued recall task of Tehan and Humphreys (1995, 1996) can be influenced by contextual or organizational information in the foil block. We introduced a novel manipulation in which the words in the to-be-forgotten block shared similar phonological attributes in Experiment 1 and similar semantic attributes in Experiments 2A and 2B. We considered two opposing predictions. First, item similarity along one dimension would reduce the level of PI when a retrieval cue subsuming both the foil and the target, but emphasizing a different dimension, was used. A foil studied in a particular contextual organization may inhibit links to attributes of the word that are irrelevant to the context. As such, when a retrieval cue incompatible with the context is used, the probability that the foil would be recalled, instead of the target, is attenuated. Second, studying a foil in context would strengthen, rather than weaken, the foil's activation. The contextual information would increase the activation of the foil on the basis of the shared features. As such, even when a retrieval cue that subsumed the foil on other dimensions was used, the highly activated foil would increase the probability that it would be recalled, instead of the target.

In all the experiments, the evidence strongly supports the second hypothesis. PI was evident when the cue subsumed both the foil and the target. Although there were no differences in recall accuracy between conditions in which contextual organization was present or absent, reliable increases in foil intrusions were observed when contextual organization was present. This finding was generalized across rhyme contexts with semantic cues and semantic contexts with rhyme cues. It was further generalized to rhyme contexts in the target block, a result that replicated the basic findings from Tehan and Humphreys (1998). The pattern of results is consistent with the interpretation that contextual information matching the foil would strengthen, rather than weaken, its ability to cause PI.

In terms of the roles of encoding and retrieval processes in PI, the failure to find that PI does not vary with contextual organization does not allow us to conclude unequivocally that PI is due to retrieval processes alone. However, although encoding appears to play a role, the pattern of results still favors a retrieval locus, for the following reasons. The fact that Block 1 intrusions varied with context suggests that the encoding context is also important in influencing the degree of PI observed. If the strength of the foil is boosted by the contextual information, its efficacy

in interfering with recall of the target will increase. However, the effect of encoding context was manifested if and only if the retrieval cue subsumed the foil, as well as the target. When the cue subsumed a dimension that encompassed only the target, but not the foil, it did not matter whether the foil was strengthened by the context or not; no PI was evident. Hence, the precise locus of encoding processes is, perhaps, limited to influencing the potential for interference, whereas the actual manifestation of PI depends on the nature of the retrieval cue. This strongly suggests that retrieval in STM is a cue-driven process. This account is consistent with previous interpretations regarding the retrieval locus of PI effects in STM cued recall (Tehan & Humphreys, 1996) and release from PI paradigms (Gardiner et al., 1972).

One potential qualification to the conclusions of this study is the inconclusive findings with regard to the use of onset nucleus cues that complicated the interpretation of Experiments 2A and 2B. The results suggest that these cues were relatively weak and unfamiliar to the participants, since recall was relatively poor even in conditions in which no interference was expected. However, there did seem to be some Block 1 intrusions when the onset cue subsumed the foil and the target, although there was no increase in these intrusions when the foil was studied in the context of semantically similar fillers, unlike in the case with rhyme cues and the analogous conditions with semantic cues.

Because similar effects were observed across manipulations involving rhyme and semantic attributes, the results suggest that these word features are simultaneously active during retrieval (cf. Tehan & Humphreys, 1998). In addition to the research cited in the introduction regarding the contribution of LTM factors to STM performance, researchers have found that using articulatory suppression to disrupt articulatory or phonological coding, which generally forms the basis of rehearsal mechanisms in the standard models of STM, tends to enhance the effects of other word attributes in recall. For example, Saint-Aubin and Poirier (1999) and Poirier and Saint-Aubin (1995) demonstrated that the magnitude of the semantic similarity advantage in serial recall tends to be greater when articulatory rehearsal is suppressed. This suggests that disruption or impairment of one form of coding tends to enhance the use of other codes. This argument has received support from studies showing double dissociations among patients with selective impairment to semantic or phonological memory, in which they performed normally for memory tasks that emphasized the dimension that was unimpaired, but poorly for those involving the impaired dimension (e.g., Martin & Romani, 1994; Martin, Shelton, & Yaffee, 1994), or in which patients showed increased phonological errors when semantics was impaired (e.g., Caza, Belleville, & Gilbert, 2002). Indeed, the redintegration model of STM recall (Schweickert, 1993) suggests that when memory traces are degraded, word attributes derived from LTM, such as semantics and phonotactic structure (Gathercole et al., 1999), can be brought to bear in recovering the memory traces for successful recall. Taken together, these findings are consistent with the view that separate levels of representations of word features, such as phonology and semantics, are simultaneously available during STM recall.

In summary, the present results extend Tehan and Humphreys's (1995, 1996, 1998) work, using their STM cued recall paradigm. We have demonstrated that their earlier results showing cue-driven recall were replicated when we introduced a novel manipulation involving the foil context, and the results were generalized across both rhyming and semantic cues and contexts. Encoding contextual organization strengthens the foil, rather than weakens it—presumably, by an increased activation in the foil, due to activation of shared features among the contextual fillers. This increased activation increases the potential for interfering with the target during recall, but the increased PI will be manifested only if the retrieval cue's attributes subsume both the foil and the target. The increased interference potential is not realized if the cue subsumes only the target.

Taken together, these findings support the assertion that recall in STM is a cue-driven process (Nairne, 2002b). The present experimental design certainly does not rule out, nor is it intended to test, the "standard model" of STM that emphasizes rehearsal and time-based processes (e.g., Baddeley, 2000; Baddeley & Hitch, 1974). Rather, it adds to the growing evidence that the nature of retrieval cues and the conditions that affect cue–target diagnosticity are important factors to consider in explaining recall in STM.

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APPENDIX
Critical Words and Retrieval Cues Across Word Lists

Table A1
Experiments 1 and 3

Target	Foil	Rhyming Fillers			Same Category Cue	Different Category Cue
			List 1			
brush	clay	bay	hay	tray	material for art and craft	type of comb
cloves	salt	halt	fault	malt	a substance for flavoring food	type of herb
cream	blush	crush	flush	plush	type of cosmetic	a dairy product
lamp	couch	douch	grouch	pouch	piece of living room furniture	a light source
mint	gum	bum	rum	thumb	type of candy	type of flavor
nail	head	sled	bed	red	part of the human body	a metallic object
pipe	flute	chute	root	suit	musical wind instrument	smoking contraption
prune	pear	bear	chair	mare	a fruit	type of gardening activity
swing	slide	hide	pride	tide	part of a playground	type of dance
yen	coin	groin	join	loin	type of money	type of national currency
			List 2			
boot	shoe	loo	flu	zoo	type of footwear	part of a car
bra	dress	chess	press	stress	an article of female wear	an article of underwear
cave	hill	gill	pill	mill	a natural earth formation	type of human dwelling
cube	square	hair	rare	stair	a geometric shape	a 3-D object
heart	lung	dung	tongue	bung	type of organ	type of shape
oar	stern	burn	churn	fern	part of a boat	a rowing equipment
play	book	crook	hook	brook	type of reading material	performing art
sap	trunk	skunk	bunk	monk	part of tree	a liquid
urn	grave	slave	wave	shave	a burial place	type of container
wind	sun	ton	nun	pun	source of energy	type of air movement
			List 3			
art	speech	beach	leech	peach	means of communication	a teaching subject
boat	car	jar	bar	tar	type of vehicle	type of ship
brown	blond	wand	fond	pond	type of hair color	type of skin color
cold	mumps	bumps	dumps	pumps	type of disease	description of climate
crane	duck	buck	truck	luck	type of water bird	a building equipment
drill	saw	jaw	maw	paw	a carpenter's tool	a military exercise
hot	dry	pie	tie	fry	type of climate	type of taste
net	rod	cod	pod	sod	type of fishing equipment	part of ball game
pop	folk	cloak	stroke	yolk	type of music	a sharp sound
roast	beef	leaf	reef	thief	major type of meat	type of cooking method
			List 4			
black	blue	sue	brew	screw	type of color	a racial identity
calf	pup	tup	sup	cup	young of animals	part of leg
coke	coal	foal	sole	bowl	type of fuel	a carbonated drink
earth	mars	grass	jars	scars	a planet	material for plant growth
felt	silk	milk	bilk	pilk	type of cloth	a synthetic material
glass	fork	cork	pork	stork	a kitchen utensil	a drinking vessel
glue	snap	lap	cap	tap	type of fastener	type of stationery
owl	hawk	wok	talk	gawk	bird of prey	a nocturnal creature
stool	bench	stench	trench	wrench	type of seat	type of bodily discharge
tile	sink	pink	mink	rink	a bathroom fixture	part of roof
			List 5			
ale	gin	pink	fin	skin	an alcoholic beverage	a beer
bun	plait	flat	bat	cat	type of hair style	type of food
corn	wheat	peat	beet	feet	type of bread	type of vegetable
harp	drum	slum	crumb	glum	a musical instrument	a string instrument
hat	pants	rents	cents	gents	an article of clothing	type of headwear
pool	squash	gosh	wash	posh	a sport	a place to swim
stove	tent	dent	lent	bent	item of camping equipment	major appliance
train	ball	gall	wall	mall	type of toy	type of transport
weed	tree	free	bee	sea	type of plant	type of drug
yard	mile	aisle	file	bile	unit of measurement	part of a house

APPENDIX (Continued)

Table A1 (Continued)

Target	Foil	Rhyming Fillers			Same Category Cue	Different Category Cue
				List 6		
axe	gun	fun	stun	run	a weapon	type of fire-fighting equipment
bank	house	spouse	mouse	louse	type of building	part of a river
brass	steel	heel	wheel	seal	type of metal	type of band
chalk	pen	fan	den	hen	writing implement	a powdery substance
mole	rat	jet	bet	mat	a rodent	a facial marking
palm	pine	spine	wine	vine	type of tree	part of hand
punch	tea	ski	bee	pea	a nonalcoholic beverage	an act of violence
sand	wood	mood	hood	good	building material	part of a beach
vault	sprint	flint	glint	hint	a track and field event	type of room
watch	ring	king	string	wing	type of accessory	type of timepiece

Table A2
Experiments 2A and 2B

Target		Rhyme Cue (Rhymes With ___)		Onset Nucleus Cue (Sounds Like the Beginning of ___)		Both 2A and 2B			
2A	2B	2A	2B	2A	2B	Foil	Semantically Related Fillers		
				List 1					
bed	hen	dead	ten	bet	hell	head	leg	nose	toe
bumps	mug	humps	tug	bust	much	mumps	cold	flu	stroke
lap	snatch	cap	batch	land	snack	snap	glue	hook	pin
maze	hale	gaze	pale	maim	hate	haze	dust	smog	smoke
scars	mart	jars	cart	scarf	march	mars	earth	star	sun
skin	gym	win	him	skip	jig	gin	beer	scotch	wine
thumb	gush	rum	hush	thug	gut	gum	fudge	mint	sweet
tight	sign	bright	line	type	side	sight	smell	taste	touch
vine	pipe	spine	type	vibe	pike	pine	birch	oak	palm
wheel	steep	heel	sleep	wheeze	steam	steel	bronze	tin	zinc
				List 2					
bee	tease	pea	please	bean	teeth	tea	juice	punch	shake
brain	rail	pain	fail	brake	rate	rain	hot	snow	storm
cork	fawn	stork	gone	corpse	form	fork	pan	pot	spoon
cup	pun	sup	fun	cult	putt	pup	calf	chick	foal
fawn	shed	dawn	fed	false	chef	prawn*	clam	crab	squid
feet	weave	beat	leave	fee	week	wheat	corn	loaf	rye
monk	truss	skunk	fuss	month	trudge	trunk	branch	root	sap
park	bard	dark	hard	parch	barn	bark	chirp	purr	roar
pond	blotch	fond	notch	pomp	block	blond	black	brown	red
tar	carve	bar	starve	tart	calm	car	boat	bus	truck
				List 3					
bat	plaid	cat	maid	back	plan	plait	bun	fringe	perm
brook	bull	crook	pull	brood	butch	book	play	poem	text
buck	dud	luck	thud	butt	done	duck	crane	stork	swan
burn	marsh	fern	harsh	burp	mark	stern*	bow	oar	sail
dent	tech	bent	peck	deaf	tell	tent	camp	match	stove
fault	sawn	halt	lawn	fog	sort	salt	cloves	sauce†	thyme
lark	shard	mark	lard	lard	sharp	shark	bass	eel	trout
leaf	beep	reef	leap	leash	beach	beef	ham	pork	roast
rare	cute	stair	mute	rent	cue	square*	cube†	round	sphere
trench	bell	wrench	fell	trek	bet	bench	chair	couch	stool

APPENDIX (Continued)

Table A2 (Continued)

Target		Rhyme Cue (Rhymes With ___)		Onset Nucleus Cue (Sounds Like the Beginning of ___)		Both 2A and 2B			
2A	2B	2A	2B	2A	2B	Foil	Semantically Related Fillers		
List 4									
foal	cove	goal	grove	foam	coat	coal	gas	oil	wind
joke	foam	yolk	home	jolt	phone	folk	blues	jazz	pop
pail	tame	rail	same	paint	take	tail	fin	gill	scale
paw	source	law	horse	pause	sought	saw	drill	file	nail
pill	hiss	bill	miss	pit	hit	hill	cliff	lake	rock
pink	sip	rink	lip	pig	sin	sink	tap	tile	tub
pod	rot	nod	lot	pox	wrong	rod	bait	fish	net
run	gust	stun	lust	rush	gulf	gun	axe	knife	sword
spouse	howl	louse	fowl	spout	hound	house	bank	court	school
wok	horde	talk	ford	ward	hall	hawk	dove	gull	jay
List 5									
bet	vest	pet	best	bell	vent	vet	clerk	judge	nurse
bile	mine	style	dine	bike	might	mile	foot	inch	yard
chess	drench	stress	wrench	check	dread	dress	blouse	pants	shirt
fat	rash	mat	hash	fan	ran	rat	mole	mouse	shrew
flush	bluff	plush	puff	flux	blood	blush	base	cream	rouge
glint	sprig	flint	fig	glib	spring	sprint	jump	throw	vault
loo	booze	flu	lose	loom	boom	shoe*	boot†	clog	heels
mall	balk	fall	talk	moss	board	ball	doll	kite	top
plea	fleece	glee	lease	pleat	fleet	flea	ant	fly	wasp
slave	graze	wave	maze	slay	great	grave	crypt	tomb	urn
List 6									
good	brim	food	slim	goose	bridge	wood*	brick†	mud	stone
hair	grate	bear	late	hem	grace	pear*	grape†	lime	plum
hen	peg	ten	beg	hell	pet	pen	brush	chalk	quill
join	coil	groin	boil	joint	coif	coin	franc	pound	yen
king	rim	sing	limb	kiss	rich	ring	scarf	tie	watch
milk	sill	bilk	pill	mill	sit	silk	felt	fur	wool
pest	neck	best	wreck	pence	knelt	nest	cage	den	sty
posh	squat	quash	swat	pomp	squad	squash	golf	pool	ski
sea	heck	free	deck	seek	helm	tree*	bush	hedge†	weed
slum	drug	crumb	bug	slug	drunk	drum	flute	harp	horn

**Prawn*, *stern*, *square*, *shoe*, *wood*, *pear*, and *tree* were replaced with *shell*, *mast*, *cube*, *boot*, *brick*, *grape*, and *hedge* in Experiment 2B. †*Sauce*, *cube*, *boot*, *brick*, *grape*, and *hedge* were replaced with *spice*, *square*, *shoe*, *wood*, *pear*, and *tree* in Experiment 2B.

(Manuscript received August 4, 2004;
revision accepted for publication June 1, 2005.)