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The ring of familiarity: False familiarity due to rhyming primes in item and associative recognition☆

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Abstract

The current study investigated false recognition within a paradigm (Whittlesea & Williams, 2001a) that manipulates fluency of test item processing by presenting test items at recognition in the context of a rhyming or nonrhyming nonword prime. Experiment 1 attempted to lower the salience of the role of primes at test by presenting items with primes at study. This produced a much greater bias to respond "old" to recognition test items preceded by rhyming primes, but only when those primes were old. Experiment 2 ruled out a cohort activation account of this large bias. Experiments 3 and 4 demonstrated that the bias to call rhyming test items "old" is partially mediated by attributions of fluent processing to past experience and partially mediated by the use of familiarity for the pair on an item recognition test. Taken together, these data illustrate how relations between elements in the test context can be mistaken for episodic familiarity.

Keywords: False recognition; Fluency; Rhyming; Associative recognition; Familiarity; Memory attributions

Jacoby and Dallas (1981) suggested that attributions about ease of perceptual processing (referred to as *perceptual fluency*) may form the basis for the feeling of familiarity in recognition, whereby fluent processing of a stimulus is attributed to past experience. A person makes the attribution unconsciously—the conscious experience of fluent processing is the feeling that something is familiar (see also Jacoby, Kelley, & Dywan, 1989; Kelley & Rhodes, 2002, for reviews). Support for this idea has come from studies showing that speed (Johnston, Dark, & Jacoby, 1985; Johnston, Hawley, & Elliot, 1991) and ease of perceptual identification (Goldinger, Kleider, & Shelley, 1999; Whittlesea, Jacoby, & Girard, 1990) are positively correlated with the probability that a target is called "old." Additional work has demonstrated that attributions about fluency of conceptual processing may also form a basis for memory (e.g., Lindsay & Kelley, 1996; Rajaram & Geraci, 2000; Whittlesea, 1993; Whittlesea & Williams, 2001b).

Tests of the processing fluency framework typically employ manipulations of processing fluency designed to create illusions of familiarity under conditions that either increase or decrease the salience of the real cause of fluent processing. For example, Jacoby and Whitehouse (1989) preceded recognition test items with a brief flash of the test item (referred to as a *match* trial) or an unrelated word (referred to as a *mismatch* trial). The logic was that matching trials should enhance fluency of test

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item processing relative to instances when the mask is unrelated to the test item in mismatch trials. As well, the effect of a matched prime should be most pronounced when its presentation is very brief and masked, such that participants would misinterpret fluent test item processing as familiarity rather than as being due to the flashed prime. Jacoby and Whitehouse showed that participants were more likely to call a test item "old" on match trials than on mismatch trials when the prime was flashed for a very short duration. However, when the prime was presented in full view, participants were less willing to call a test item "old" on match trials than on mismatch trials, presumably because participants overly attributed the effect of the prime on test item processing to the obvious presence of the prime.

Whittlesea and colleagues have also aimed to affect the attribution process by lowering the salience of the source of fluency. Leboe and Whittlesea (2002, Experiment 1a), for example, decreased the salience of the role played by related and unrelated context words on fluent test word processing by presenting context words at study. Specifically, participants studied items (e.g., STREET, TIGER, WINDOW, COFFEE) in the presence of either a semantically related context word (e.g., ROAD-STREET, LION-TIGER) or an unrelated word (e.g., APPLE-WINDOW, DOCTOR-COFFEE). At test, half of the test items were old, presented in the same context in which they had been studied, and half were new, paired with the remaining old context words from study. In addition, half of all new test items were preceded by a related context word and half were preceded by an unrelated context word. Naming latency data showed that test items presented following related contexts were processed more fluently than those presented following unrelated contexts. Most importantly, new related test items were more likely to be called "old" than new unrelated test items. Whittlesea and Leboe (2002) subsequently demonstrated that when items were studied without their accompanying context words, with context words first introduced at test, the effect of relatedness on recognition was abolished. Thus, presenting context words at study and at test made the context words a less salient source of fluent processing at test and, consequently, produced an illusion of familiarity.

In Experiment 1, we used items from Whittlesea and Williams' (2001a) rhyming illusion experiments to determine whether presenting rhyming and nonrhyming primes at study and test operates by affecting the attribution process or whether other factors are involved. Specifically, Whittlesea and Williams manipulated processing fluency by preceding recognition test words with a nonword prime that either rhymed with the test item (e.g., PINGLE-SINGLE) or did not rhyme with the test item (e.g., BARDEN-PELICAN). Participants were instructed to read the prime and test item aloud and make a recognition decision on the test item. Rhyming primes enhanced test item processing fluency, as reflected by naming latencies, and also led to a higher level of false alarms (0.26 for new test items preceded by rhyming primes compared to 0.20 for test items preceded by nonrhyming primes; Experiment 3a). We presented items in rhyming and nonrhyming pairs at study and at test in order to lessen the salience of the rhyming prime's role in enhancing processing of the test item. If the effect of the prime on test item processing during recognition can be made less salient by presenting items in pairs at study, then participants should be less likely to correctly attribute fluent processing of test items to the rhyming prime at test. Therefore, we expected a larger misattribution of fluent processing when primes were studied compared to when single items were studied and primes were first introduced during the recognition test.

To anticipate, presenting primes at study as well as at test did lead to a substantial illusion of familiarity for items preceded at test by rhyming primes. When single items were presented at study, we replicated Whittlesea and Williams' finding of greater false alarms to test items preceded by a rhyming prime than to test items preceded by a nonrhyming prime. However, when pairs of nonword primes and test items were presented at study, there was a substantial increase in false alarms to test items preceded by a rhyming prime compared to a nonrhyming prime. The effect occurred in the hits as well as false alarms, leading to a more liberal bias for rhyming compared to nonrhyming test items.

To test the attribution interpretation of the effect of including primes in the study list, we included an additional condition in Experiment 1 where items were studied in the context of rhyming or nonrhyming primes but, at test, only new primes were used. Results suggested that presenting primes at study and at test did not affect the attribution process per se. Instead, the presentation of primes in the study list had a number of different effects on later recognition. One possibility is that differential cohort activation (e.g., Wallace, Stewart, Sherman, & Mellor, 1995) for rhyming versus nonrhyming test items was induced. We tested that possibility in Experiment 2. We next tested the fluency account of the bias to respond "old" to test items preceded by rhyming primes by reversing the prime–test item presentation order in Experiment 3. If the rhyming prime effect depends on fluency of test item processing, then reversing the prime–test item test order should eliminate it. Finally, in Experiment 4, we assessed whether part of the effect of studying items in the context of primes stems from participants judging the familiarity of test pairs as a whole rather than the familiarity of the test item alone. Similarity between items in a rhyming pair might give rise to a feeling of familiarity for the pair.

Experiment 1

Experiment 1 investigated whether presenting items in rhyming and nonrhyming pairs at study would increase the chance that the most fluently named test items (i.e., rhyming test items) would be more likely to be judged "old" at test. Participants studied a list of 120 words (e.g., SINGLE, GARDEN). In the study single words condition, nonword primes appeared for the first time at test, preceding each test item, in a replication of Whittlesea and Williams (2001a, Experiment 3a). In the study pairs—old prime condition, we attempted to reduce the salience of the prime manipulation at test by presenting items at study in rhyming (e.g., PINGLE-SINGLE) and nonrhyming (e.g., BARDEN-TRACTOR) pairs. At test, all old test items were accompanied by their studied primes and all new items were also presented with primes that had been studied.

In a third condition, we also presented primes at both study and test, but only new primes were used during the recognition test. This was done for two reasons. First, old primes may simply become another source of familiarity, close in time and space to the test item, which may be mistaken for familiarity of the test item. Second, in the study pairs—old prime condition, including primes on the study list meant that memory for the associative relation between the prime and test item could also support recognition of the test item, as all old test items appeared with the same prime with which they were studied. Thus, participants in the study pairs—old prime condition may partially rely on a strategy of making associative recognition judgments even though the task calls for item recognition. This could not be the case when new primes were presented at test.

If participants in the study pairs—old prime condition began to base item recognition judgments on memory for the pair as a whole, what pattern of data would result? Presumably, if participants could recall inter-item associative information linking an old prime and test item (Hockley & Consoli, 1999; Westerman, 2001; Yonelinas, 1997), they could reduce their production of false alarms in the study pairs—old prime condition via a recall-to-reject strategy (e.g., Rotello & Heit, 1999). However, it may be difficult for participants to encode associative information between a meaningless prime and a test word. A more likely possibility is that participants could assess the overall familiarity of the prime and test item and use that familiarity as a basis for judging whether the test item is old. There is some evidence that both item familiarity and familiarity of a pair treated holistically influences associative recognition judgments. Nairne (1983) found that sheer maintenance rehearsal of a pair of words increased both hits to intact pairs and false alarms to rearranged pairs on a later associative recognition test. Just as Nairne found that item familiarity affected associative recognition, familiarity of the pair might also affect item recognition in the current study (see also Hockley, 1992). In addition, recent work by Yonelinas and colleagues using analyses of ROC curves suggests that familiarity plays a role in associative recognition when separate items are treated holistically (Quamme & Yonelinas, 2001; Yonelinas, Kroll, Dobbins, & Soltani, 1999).

In the current study, the rhyming relationship between primes and test words may give rise to a feeling that the pair as a whole is familiar. That familiarity might be mediated by the far more fluent reading of a rhyming compared to nonrhyming pair. To the extent that participants in the study pairs—old prime condition are willing to use a feeling of familiarity for the pair to make item recognition judgments, we would expect a larger effect of rhyming primes on both hits and false alarms to test items, exhibited as a greater bias to rhyming test items.

Method

Participants. Sixty Florida State University psychology students participated for partial course credit. Participants were tested individually.

Design. A 3 (Study Presentation: study pairs—old primes at test, study pairs—new primes at test, study single words) × 2 (Test Item Status: old, new) × 2 (Rhyme Status: rhyming, nonrhyming) mixed-factor design was used with Study Presentation manipulated between-subjects and Test Item Status and Rhyme Status manipulated within-subjects.

Materials. Materials consisted of 120 words and corresponding rhyming nonwords taken from Whittlesea and Williams (2001a), which we will call Set A, and 120 new pairs (see Appendix A) created to the same specifications, which we will call Set B. All words were of moderate frequency in Kucera and Francis (1967) word norms (10–70 appearances in the Kucera and Francis corpus), 2–3 syllables in length, and all were nouns or adjectives. Nonwords were identical to the words with the exception of the first letter. Examples include PINGLE-SINGLE, BARDEN-GARDEN, FRATER-CRATER, and MELICAN-PELICAN.

The test list was equivalent for all study conditions. All test lists consisted of the 120 words from Set A, preceded equally often by rhyming and nonrhyming primes. Nonrhyming pairs were composed of words from Set A paired with nonword primes from Set B, whereas rhyming pairs were composed of words from Set A paired with their corresponding rhyming nonword from Set A. This manipulation of rhyming primes was crossed with old–new status of the test item to create four different types of pairs at test. All items served equally often in each of the test conditions. For the study pairs—old prime condition, the prime components of all pairs had appeared on the study list. For the study

pairs—new prime condition and the study single words condition, the prime at test was always new. The test list was uniquely randomized for each participant.

For the study single words condition, the study list consisted of 120 words (e.g., SINGLE, PELICAN, GARDEN). Sixty words were from Set A and re-appeared on the test list paired with either their rhyming primes from Set A or nonrhyming primes from Set B. The other half of the words on the study list were from Set B and were not included on the test list, but were included to allow us to present the corresponding primes for the study pairs—old prime condition. For the study pairs—old prime condition, the same 120 words were presented at study paired with nonwords. The study lists consisted of 30 Set A rhyming pairs and 30 nonrhyming pairs composed of words from Set A paired with primes from Set B. These would appear as rhyming and nonrhyming targets on the recognition test. The study list also included 30 nonrhyming pairs composed of primes from Set A paired with words from Set B; these primes would later be paired with the corresponding Set A words to create rhyming lure pairs on the recognition test. Finally, there were 30 rhyming pairs composed of primes and words from Set B; these primes would later be paired with Set A words to create nonrhyming lure pairs on the recognition test.

For the study pairs—new prime condition participants also studied 120 pairs of items, half of which rhymed and half of which did not rhyme. The key manipulation in this condition, however, was that all primes at test were new. To accomplish this, participants studied Set A and Set B words with primes from the set opposite that used for the study pairs—old prime condition described above. An additional set of 30 nonrhyming primes was created and substituted into the study list in the study pairs—new prime condition (see Appendix B). This was necessary to present a set of nonrhyming pairs at study different from the nonrhyming test lures that would appear with new primes.

Procedure. All study and test items were presented using Micro Experimental Laboratory (MEL) software (Schneider, 1990). Participants studied a list of 120 words or nonword–word pairs shown in a uniquely randomized order for each participant. For words presented in pairs, half of the time the prime rhymed with the word while half of the time the prime did not rhyme with the accompanying word. Pairs were presented simultaneously, with the nonword prime presented to the left of the word. Items in all conditions were presented in the center of the screen in a large font and study time was 2-s per pair. Participants in the study single words condition were instructed to read each word aloud in preparation for a memory test. Participants in the conditions where primes and words were paired at study were instructed to read both the nonword and word aloud. In addition, participants in the study pairs conditions were told to pay particular attention to the second item of each pair (the word) in preparation for a memory test. Following the study list, participants completed an unrelated filler task for 4 min.

Table 1
Experiment 1: Mean target naming latencies for rhyming and nonrhyming test items; naming latency (ms)

Condition	Old	New
Study pairs—old prime		
Rhyme	613 (140)	642 (149)
Nonrhyme	687 (182)	703 (181)
Study pairs—new prime		
Rhyme	637 (97)	645 (97)
Nonrhyme	703 (102)	724 (119)
Study words alone		
Rhyme	616 (150)	625 (143)
Nonrhyme	690 (77)	719 (95)

Note. Standard deviations are in parentheses.

At test, the prime appeared on the screen first. Participants were required to name the prime aloud, and a voice-activated key triggered the presentation of the test item below the prime after a 500-ms delay. Participants then read the test word aloud and made a recognition decision. Both the prime and test item remained on the screen until a recognition decision was made. Test item naming latencies were recorded automatically. Participants were instructed that half of the test items presented were old and half were new. Participants who had studied prime–word pairs were correctly informed that the prime was always old (study pairs—old prime condition) or always new (study pairs—new prime condition).

Results and discussion

Unless otherwise noted, the α level for all statistical analyses reported was set to .05. Data for RTs greater than 2.5 *SD*s above and below the mean were dropped from the analysis, resulting in 6.4% of the observations being excluded.[1]

Test item naming latencies. Test item naming latencies are presented in Table 1. A 3 (Study Presentation: study pairs—old primes, study pairs-new primes, study single words) × 2 (Test Item Status: old, new) × 2 (Rhyme Status: rhyme, nonrhyme) mixed analysis of variance (ANOVA) conducted on test item naming latency data revealed a marginal main effect of test item status [$F(1, 57) = 3.45$, $MSE = 20511.3$, $p = .07$]. This reflects the fact that old test items were named approximately 18 ms faster than new test items, with mean latencies of

[1] Analyses of recognition data for Experiment 1 and subsequent experiments that included all observations indicated no significant departures from the data reported.

658 ms and 676 ms for old and new test items, respectively. In addition, a main effect of rhyme status was also evident [$F(1,57) = 55.82$, $MSE = 335110.3$] as rhyming test items ($M = 630$ ms) were named approximately 74 ms faster than nonrhyming test items ($M = 704$ ms). No other main effects or interactions were significant. Thus, participants named old items and rhyming items most quickly.

Discriminability and response bias data. Recognition data for Experiment 1 are presented in Table 2. Following Whittlesea and Williams (2001a), we expected rhyming primes to produce a bias to call test items "old." A signal detection analysis was performed using A' as the estimate of discriminability and B''_D as the estimate of bias (Donaldson, 1992; Snodgrass & Corwin, 1988). Values of A' can vary between 0 and 1 with higher values indicating greater discriminability and a value of 0.5 indicating chance performance. Values of B''_D can vary from 1 to −1 with negative values corresponding to a more liberal basis for responding. Following Snodgrass and Corwin, all hit rates and false alarm rates for the discriminability and bias data reported here and in subsequent experiments were corrected by adding 0.5 to each frequency and dividing by $N + 1$, where N is the number of trials for a particular item type.

A 3 (Study Presentation: study pairs—old prime, study pairs—new prime, study single words) × 2 (Rhyme status: rhyme, nonrhyme) mixed ANOVA on estimates of discriminability (A') revealed that participants showed slightly greater discriminability for nonrhyming test items ($A' = .77$) than for rhyming test items ($A' = .74$), [$F(1,57) = 7.21$, $MSE = 0.04$]. In addition, a main effect of study presentation was evident [$F(1,57) = 14.91$, $MSE = 0.17$], reflecting the fact that participants in the study single words condition showed greater discriminability ($A' = .83$) than participants in the study pairs—new prime condition ($A' = .72$) and in the study pairs—old prime condition ($A' = .71$). The interaction of study presentation with rhyme status was not significant, ($F < 1$).

Response bias (B''_D) data were analyzed based on the same factors as the A' data. As predicted, rhyming test items ($B''_D = -.16$) were associated with a significantly more liberal response bias than nonrhyming test items ($B''_D = .23$), [$F(1,57) = 41.61$, $MSE = 4.53$]. Furthermore, the extent of the rhyme bias depended on the study presentation condition [$F(2,57) = 13.59$, $MSE = 1.48$]. Participants in the study pairs—old prime condition showed the most liberal response bias for rhyming test items ($B''_D = -.39$) in comparison to nonrhyming test items ($B''_D = .44$) [$t(19) = -7.25$]. Participants in the study single words condition also showed a significantly more liberal response bias for rhyming test items ($B''_D = .00$) than for nonrhyming test items ($B''_D = .22$) [$t(19) = -2.84$]. In contrast, participants in the study pairs—new prime condition did not differ in their bias to respond "old" to rhyming test items ($B''_D = -.07$) compared to nonrhyming test items ($B''_D = .04$) [$t(19) = -0.96$, $p = .35$].

Follow-up analyses confirmed that the study pairs—old prime condition produced a different pattern of response bias data than the study single words condition. Specifically, a 2 (Study Presentation: study pairs—old prime, study single words) × 2 (Rhyme Status: rhyme, nonrhyme) mixed on ANOVA on response bias data revealed a significant study presentation × rhyme status interaction [$F(1,38) = 18.41$, $MSE = 1.80$]. The difference in response bias for rhyming versus nonrhyming test items was significantly greater in the study pairs—old prime condition than in the study single words condition. As would be expected, a main effect of rhyme status was present [$F(1,38) = 57.16$, $MSE = 5.58$], with rhyming test items associated with a more liberal response bias ($B''_D = -.20$) than nonrhyming test items ($B''_D = .33$). There was no main effect of study presentation ($F < 1$).

Discussion. Overall, Experiment 1 demonstrated that introducing pairs at study did not seem to affect the size of the rhyming bias by reducing the salience of the prime manipulation at test. That is, manipulating study

Table 2
Experiment 1: Mean proportion of rhyming and nonrhyming test items called "old"

Condition	Old	New	A'	B''_D
Study pairs—old prime				
Rhyme	.73 (.12)	.49 (.15)	.69 (.11)	−.39 (.34)
Nonrhyme	.55 (.11)	.23 (.12)	.74 (.08)	.44 (.25)
Study pairs—new prime				
Rhyme	.65 (.13)	.39 (.14)	.70 (.10)	−.07 (.40)
Nonrhyme	.66 (.15)	.31 (.12)	.74 (.10)	.04 (.40)
Study words alone				
Rhyme	.76 (.12)	.27 (.20)	.82 (.07)	.00 (.51)
Nonrhyme	.73 (.11)	.20 (.15)	.84 (.07)	.22 (.49)

Note. A' and B''_D are indices of discrimination and bias, like d' and β (Snodgrass & Corwin, 1988). A' values of .50 indicate chance discrimination performance while negative values of B''_D indicate a liberal basis for responding. Standard deviations are in parentheses.

presentation did not have equivalent effects across conditions. Rather, the large bias to endorse test items preceded by rhyming primes only emerged when old primes were used at test. In fact, for the study pairs—new prime condition, the response bias for rhyming test items was comparable to that present for nonrhyming test items.

One possibility is that the provision of an old prime at test led participants in the study pairs—old prime condition to recognize the prime–test item pair as a whole; that is, to base their item recognition judgment on familiarity for the pair. This is a reasonable strategy, as all old test items are presented with their corresponding studied prime. However, the rhyming relation between prime and test item could produce an illusory feeling of familiarity in associative recognition as well as in item recognition, leading to false alarms to rhyming lures, a possibility which we will explore in Experiment 4. For the moment, Experiment 2 will consider an alternative explanation for the substantial liberal bias evident for rhyming test items in the study pairs—old prime condition.

Experiment 2

A portion of the bias to call fluently processed rhyming test items "old" more often than nonrhyming test items in the study pairs—old prime condition may have been due to the nature of the study and test lists used in that condition. Specifically, lures at test differed not only in whether they rhymed or not, but also in whether their component prime was presented at study. An example can serve to clarify this point. A participant who had studied WOWDER-POWDER might be given the nonrhyming pair WOWDER-CARPET as a lure at test. Likewise, that participant might also study the pair MELICAN-SIGNAL and be given the rhyming pair MELICAN-PELICAN as a lure at test. The test lures in each case differ both in terms of rhyming status and in whether its corresponding rhyming nonword had been studied. That is, for the lure PELICAN, its corresponding rhyming nonword, MELICAN, had already been studied. In contrast, the test lure CARPET never had its corresponding rhyming nonword, HARPET, presented. Thus, for rhyming test pairs (e.g., MELICAN-PELICAN) the corresponding rhyming nonword had already been presented at study whereas this was not the case for nonrhyming test pairs (e.g., WOWDER-CARPET).

This is particularly relevant in a light of work by Wallace et al. (1995) and Dewhurst and Hitch (1997). They presented participants with several types of items for an auditory lexical decision task, including nonwords derived from words that had one phoneme altered. Nonwords were created by changing a phoneme at the beginning of a word (e.g., FARADISE was created from PARADISE) or at the end of a word (e.g., PARADIFE was created from PARADISE). The main concern in each study was whether activation of the cohort of a nonword (e.g., FARADISE) presented for lexical decision might later lead to false recognition of its base word (e.g., PARADISE). Results showed that presenting nonwords that were altered forms of the base word led to more false alarms to the base word than a comparable control condition consisting of words never presented in any form. For example, Dewhurst and Hitch found that an early phoneme change in the base word produced 7% more false alarms than a control condition.

In the current study, a phoneme change occurs early in the prime used at study and test (e.g., PINGLE is created from SINGLE). Thus, it may be the case that cohort activation is the source of the larger difference in bias to rhyming and nonrhyming test items in the study pairs—old prime condition than in the study single words condition. Experiment 2 assessed this possibility. In one condition (study pairs—old prime standard), study presentation replicated that used in Experiment 1 for the study pairs—old prime condition and thus did not control for differential cohort activation of the lures. Another condition (study pairs—old prime cohort) controlled for cohort activation by presenting the corresponding rhyming nonwords of both nonrhyming and rhyming test items at study. An additional condition presented study items without an accompanying prime, replicating the study single words condition of Experiment 1.

If differential cohort activation is the basis for the rhyming prime bias present in the study pairs—old prime condition of Experiment 1, then controlling cohort activation should minimize this bias. However, if the rhyming prime bias is unaffected by controlling for cohort activation, it would seem that a different source of familiarity is operating.

Method

Subjects. Seventy-two Florida State University psychology students participated for partial course credit. Participants were tested individually.

Design. A 3 (Study Presentation: study pairs—old prime standard, study pairs—old prime cohort, study single words) × 2 (Test Item Status: old, new) × 2 (Rhyme Status: rhyming, nonrhyming) mixed-factor design was used with Study Presentation manipulated between-subjects and Test Item Status and Rhyme Status manipulated within-subjects.

Materials. The study and test lists for Experiment 2 were constructed in the same way as Experiment 1 with the following exceptions. First, to create the study pairs—old prime cohort condition, we needed to present the cohort nonword in the study list for items that would

later appear as nonrhyming lures. We did so by adding in a set of 20 rhyming and 20 nonrhyming pairs to the study list. The primes for the 20 nonrhyming study items in this set (e.g., SLATTER-BRANDY) were the cohorts for items that would later be presented at test in the nonrhyming lure condition (SARROW-PLATTER). The rhyming items in this new study cell were included simply to keep the balance of half rhyming and half nonrhyming items at study in the two conditions where pairs were presented at study. For the study pairs—old prime standard condition, these cohort nonwords were not presented in the study list and 20 unrelated nonrhyming primes were substituted. The second change from Experiment 1 was that the other study and test cells were reduced from 30 items to 20 items to allow us to keep the study list length at 120 nonword-word pairs or 120 words.

The test list was identical for all conditions and paralleled that used in Experiment 1. As items in the cohort set and the additional set in the study pairs—old prime standard conditions were not tested, the test list was shortened from 120 items to 80 items.

Procedure. The test and study procedure was identical to that used in Experiment 1 for the study pairs—old prime condition and the study single words conditions, respectively.

Results and discussion

As in Experiment 1, data for RTs greater than 2.5 *SD*s above the mean were dropped from the analysis, resulting in 8.6% of the observations being excluded.

Test item naming latencies. Test item naming latencies are presented in Table 3. A 3 (Study Presentation: study pairs—old prime standard, study pairs—old prime cohort, study single words) × 2 (Test Item Status: old, new) × 2 (Rhyme Status: rhyme, nonrhyme) mixed ANOVA conducted on test item naming latency data confirmed that rhyming test items and old test items were named most rapidly. Across conditions, rhyming test items were named approximately 62 ms faster than nonrhyming test items [$F(1,69) = 127.68$, $MSE = 270133.9$] and old test items were named approximately 24 ms faster than new test items [$F(1,69) = 31.73$, $MSE = 41658.7$]. As well, a significant rhyme status × test item status interaction was present [$F(1,69) = 7.47$, $MSE = 7880.5$], reflecting the fact that old rhyming test items were named approximately 35 ms faster than new, rhyming test items while old nonrhyming test items were named only 14 ms faster than new, nonrhyming test items.

Table 3
Experiment 2: Mean target naming latencies for rhyming and nonrhyming test items; naming latency (ms)

Condition	Old	New
Study pairs—old prime-standard		
Rhyme	617 (104)	643 (87)
Nonrhyme	678 (97)	705 (109)
Study pairs—old prime-cohort		
Rhyme	637 (130)	679 (143)
Nonrhyme	720 (157)	723 (139)
Study words alone		
Rhyme	620 (79)	656 (109)
Nonrhyme	691 (105)	701 (102)

Note. Standard deviations are in parentheses.

Discriminability and response bias data. Recognition data are presented in Table 4. A 3 (Study Presentation: study pairs—old prime standard, study pairs—old prime cohort, study single words) × 2 (Rhyme status: rhyme, nonrhyme) mixed ANOVA on A' showed that study presentation did not interact with rhyme status [$F(2,69) = 2.43$, $p > .05$]. As well, discriminability did not differ between rhyming and nonrhyming items ($F < 1$) but did differ between study presentation conditions [$F(2,69) = 11.47$, $MSE = 0.17$]. This reflects the fact that participants showed higher discriminability in the study single words condition than in the study pairs—old prime standard and the study pairs—old prime cohort condition.

Response bias (B''_D) data were analyzed based on the same factors as the A' data. Replicating Experiment 1, rhyming items ($B''_D = -.28$) elicited a more liberal response bias than nonrhyming items ($B''_D = .18$) [$F(1,69) = 49.17$, $MSE = 7.39$]. In addition, study presentation interacted with rhyme status [$F(1,69) = 10.06$, $MSE = 1.51$], as the difference in response bias to rhyming and nonrhyming items was considerably smaller in the study single words condition than in the study pairs—old prime standard and the study pairs—old prime cohort conditions.

Follow-up analyses were conducted to further explore this interaction. A 2 (Study Presentation: study pairs—old prime standard, study pairs—old prime cohort) × 2 (Rhyme status: rhyming, nonrhyming) mixed ANOVA on B''_D data for the study pairs—old prime standard and study pairs—old prime cohort conditions indicated that the extent of the rhyme bias did not interact with study condition ($F < 1$) when only these conditions were analyzed. Thus, these two conditions in fact produced comparable levels of response bias to rhyming pairs.

Discussion. Experiment 2 attempted to account for any possible effects of cohort activation by ensuring that the corresponding rhyming nonword of both rhyming and nonrhyming test lures were presented at study. Results indicated that the bias to call rhyming test items "old" was unaffected by controlling for cohort activation, as response bias was largely equivalent in the study pairs—old prime cohort condition ($B''_D = -.35$) and the study pairs—old prime standard condition ($B''_D = -.41$).

Table 4
Experiment 2: Mean proportion of rhyming and nonrhyming test items called "old"

Condition	Old	New	A'	B''_D
Study pairs—old prime-standard				
Rhyme	.74 (.12)	.49 (.15)	.68 (.15)	−.41 (.35)
Nonrhyme	.58 (.14)	.28 (.16)	.72 (.12)	.29 (.42)
Study pairs—old prime-cohort				
Rhyme	.76 (.13)	.43 (.14)	.74 (.08)	−.35 (.41)
Nonrhyme	.57 (.13)	.29 (.13)	.70 (.11)	.26 (.37)
Study words alone				
Rhyme	.76 (.13)	.29 (.16)	.79 (.12)	−.07 (.41)
Nonrhyme	.77 (.12)	.23 (.12)	.83 (.07)	−.03 (.43)

Note. Standard deviations are in parentheses.

It is also clear that differential cohort activation was not responsible for the substantial liberal response bias to rhyming test items evident in Experiment 1 when primes were old and items studied in pairs. For example, the effect size for the bias data in Experiment 2 in the study pairs—old prime cohort condition is considerably larger ($d = 1.11$) than that present in Experiment 1 for the study pairs—new prime condition ($d = 0.19$). Therefore, it is apparent that another source of familiarity is operating in the study pairs—old prime condition.

Experiment 3

Experiment 3 was conducted to assess the degree to which test item processing fluency accounted for the large bias to endorse test items preceded by old rhyming primes as old. For half of the participants, we removed the variation in naming latencies by reversing test presentation format, with test items now presented before their accompanying prime (e.g., a participant might be presented with SINGLE followed by PINGLE). By reversing test format, fluency of test item naming could no longer be a possible source of familiarity, as all test items presented first should elicit roughly the same naming latencies. If fluency is mediating item recognition judgments in the study pairs—old prime condition, then reversing test format should have the effect of diminishing the bias to respond "old" to rhyming test items.

Whittlesea and Leboe (2002) employed the same strategy in their investigation of the effects of semantically related and unrelated contexts on false recognition, extending the work of Leboe and Whittlesea (2002). Whittlesea and Leboe found that reversing test format by presenting a test item before its accompanying context item (e.g., TIGER-LION compared to LION-TIGER) abolished the effect of elevated false alarms to related items. Thus, reversing test format may produce a similar pattern of data in Experiment 3 and eliminate the more liberal response bias elicited by rhyming test items compared to nonrhyming test items.

Method

Participants. Fifty-six Florida State University psychology students participated for partial course credit and were tested individually.

Design. A 2 (Test Format: prime first, test item first) × 2 (Test Item Status: old, new) × 2 (Rhyme Status: rhyming, nonrhyming) mixed-factor design was used with Test Format manipulated between-subjects and test item status and rhyme status manipulated within-subjects.

Materials. The study list was identical to that used for the study pairs—old prime cohort condition of Experiment 2. The test list was identical to the test list used in Experiment 2.

Procedure. The study and test procedure was identical to that of Experiment 1 for the study pairs—old prime condition with one exception. For half of the participants, the order of presentation of the test item and prime at test was reversed from the order used in Experiment 1. For example, a participant in the test item first condition might be tested on the rhyming pair GARDEN-BARDEN, with the test item presented first and the accompanying prime presented second.

Results and discussion

Data for RTs greater than 2.5 *SD*s were removed from the analysis, resulting in 6.0% of the observations being excluded.

Test item naming latencies. Table 5 displays test item naming latencies for Experiment 3. All latency data were subjected to a 2 (Test Format: prime first, test item first) × 2 (Test Item Status: old, new) × 2 (Rhyme Status: rhyme, nonrhyme) mixed ANOVA. Most importantly for the current experiment, a significant rhyme status× test format interaction was present [$F(1, 54) = 59.76$,

Table 5
Experiment 3: Mean target naming latencies for rhyming and nonrhyming test items

Condition	Old	New
Prime first		
Rhyme	599 (125)	618 (115)
Nonrhyme	683 (134)	683 (120)
Test item first		
Rhyme	699 (114)	710 (116)
Nonrhyme	706 (120)	710 (139)

Note. Standard deviations are in parentheses.

$MSE = 70453.4$]. This interaction reflects the fact that while rhyming test items were named 74 ms faster than nonrhyming test items when the prime appeared first at test, little difference (3 ms) existed between rhyming and nonrhyming test items when the test item appeared first. Thus, the manipulation of test format had its intended effect of removing variation in test item naming fluency due to the rhyming versus nonrhyming prime.

Discriminability and response bias data. Recognition data are presented in Table 6. Discriminability estimates (A') were analyzed in a 2 (Test Format : prime first, test item first) × 2 (Rhyme status: rhyming, nonrhyme) mixed ANOVA. In contrast to the previous experiments, participants demonstrated lower discriminability for nonrhyming items ($A' = .67$) than for rhyming items ($A' = .71$), [$F(1, 54) = 4.27$, $MSE = 0.05$]. Discriminability did not differ between test formats [$F(1, 54) = 1.92$, $MSE = 0.03$] nor did test format interact with rhyme status ($F < 1$).

Response bias data (B''_D) were analyzed based on the same factors as the A' data. Results indicated that a significant rhyme status × test format interaction was evident [$F(1, 54) = 4.51$, $MSE = 0.60$]. The difference in response bias between rhyming and nonrhyming items was a great deal larger when the prime was presented first ($B''_D = -.35$ and $B''_D = .35$ for rhyming and nonrhyming items, respectively) than when the test item was presented first ($B''_D = -.29$ and $B''_D = .13$ for rhyming and nonrhyming items, respectively).

Table 6
Experiment 3: Mean proportion of rhyming and nonrhyming test items called "old"

Condition	Old	New	A'	B''_D
Prime first				
Rhyme	.75 (.14)	.44 (.17)	.72 (.12)	−.35 (.39)
Nonrhyme	.54 (.14)	.27 (.12)	.69 (.12)	.35 (.34)
Test item first				
Rhyme	.72 (.11)	.44 (.16)	.70 (.13)	−.28 (.33)
Nonrhyme	.56 (.15)	.37 (.14)	.65 (.11)	.13 (.43)

Note. Standard deviations are in parentheses.

Discussion. If recognition decisions were being driven by familiarity arising from fluent test item processing, then reversing test format was expected to substantially diminish the bias to call rhyming test items "old." Although there was a reduction in the size of the bias difference to rhyming as opposed to nonrhyming primes in the test item first condition, it was largely due to an increase in false alarms to nonrhyming test items rather than a reduction in hits and false alarms to rhyming test items, as would be expected by fluency of processing test items.

The remaining liberal bias to rhyming pairs in the test item first condition may point to participants' use of familiarity of the pair derived from phonologically and orthographically similar rhyming prime–test item pairs. People evaluate their processing at a number of levels of analysis. For example, Whittlesea and Williams (2000) found high false alarm rates and hit rates to regular nonwords (e.g., HENSION) when those words were presented in isolation, presumably because people mistakenly attributed their fluent processing of such nonwords to having studied them. However, when those same nonwords were presented on a recognition test following a sentence stem (e.g., "The priest gave the nuns his...HENSION"), people evaluated their processing on the level of the fit of the final term with the rest of the sentence, and no longer produced as many false alarms to nonwords such as HENSION. Similarly, when primes are old in the current paradigm, people may move to evaluate their ease of processing at the level of the prime–word pair and thus may be unaffected by the order of presentation of the prime and the word. We address this possibility indirectly in Experiment 4 by testing whether rhyming pairs produce high levels of false alarms in associative recognition.

Experiment 4

One possible source of the liberal response bias to test items preceded by a rhyming prime may be found in familiarity emanating from the prime–test item pair. In this sense, familiarity for the pair as a *whole* may have been the basis for recognition decisions, even though the test called for item recognition. This would be a reasonable strategy in the study pairs—old prime conditions of the preceding experiments, as all old test items on the item recognition tests were presented with their corresponding old primes. Thus, participants could engage in a strategy of judging a test item "old" based on their sense that the pair was familiar. As outlined in Experiment 1, we think it plausible that rhyming prime–word pairs form a unitized whole. Oldness of the prime in a unitized whole might contribute to a sense that the whole is familiar (Nairne, 1983), leading to false

associative recognition for rhyming pairs. The rhyming relationship between the prime and word could thus create a false feeling that the pair is familiar because the pair is read more fluently.

Greene and Tussing (2001) have examined the role of similarity between words in associative recognition. They had participants study related pairs of items that were either synonyms, antonyms, or part of the same taxonomic category, as well as unrelated items. Across several experiments, participants exhibited a marked bias to endorse related pairs of items as having been studied in intact pairs, with higher levels of both hits and false alarms to related pairs of items in comparison to unrelated pairs of items. Orthographic and acoustic similarity between the rhyming prime and word may be yet another source of false associative recognition.

In Experiment 4, we examined whether familiarity due to the rhyming relation between nonwords and words could be elicited when participants were explicitly instructed to make recognition judgments for the nonword–word pair rather than for a particular test word. Specifically, participants were instructed to engage in associative recognition at test, with half of the test pairs presented as intact pairs and half rearranged into new pairs between study and test. Nonword–word presentation order within the pair was also varied at test, as in Experiment 3. (We use the associative recognition terms "intact" and "rearranged" to refer to whether the elements of the pair are the same or different as at study, although an "intact" pair could be presented in a reversed order at test compared to study.) Our intuition is that if judgments are made based on the familiarity of the pair, then the familiarity of a unitized rhyming pair such as PINGLE-SINGLE should be just as high if the pair is presented in reversed format SINGLE-PINGLE at test. Thus, familiarity for the pair should be unaffected by presentation order.

Method

Subjects. Forty-eight Florida State University psychology students participated for course credit. Participants were tested individually.

Design. A 2 (Test Format: nonword first, word first) × 2 (Pair Status: intact, rearranged) × 2 (Rhyme Status: rhyming, nonrhyming) mixed-factor design was used with Test Format manipulated between-subjects and Pair Status and Rhyme Status manipulated within-subjects.

Materials. The materials and the test list were the same as in the study pairs—old prime cohort condition of Experiment 2. The study list consisted of 120 pairs, half of which rhymed and half of which did not rhyme. One possible difference between rhyming versus nonrhyming rearranged pairs is that pairs studied as rhymes (e.g., SLATTER-PLATTER) may be more memorable than pairs studied as nonrhymes (e.g., PINGLE-TRACTOR). Consequently, correctly identifying a pair as rearranged at test may be easier if it were originally studied as a rhyme (e.g., test item SLATTER-TRACTOR) than as a nonrhyme (e.g., test item PINGLE-SINGLE). To control for this possibility, all rearranged pairs presented at test were studied as nonrhymes. For example, a participant might study the nonrhyming pair CORTAL-FLOWER and FALENT-MORTAL. At test, these nonrhyming pairs were rearranged to create the rhyming pair CORTAL-MORTAL and the nonrhyming pair FALENT-FLOWER. Given that all rearranged pairs were studied as nonrhymes, an additional set of 40 rhyming pairs was presented to ensure that an equal number of rhyming and nonrhyming pairs were in the study list. Items in this additional set were not tested.

The test list consisted of 80 pairs, half of which were re-presented at test as intact pairs and half of which were rearranged to form new pairs. Pair status (intact, rearranged) was crossed with rhyming status at test (rhyming, nonrhyming) to create four types of test items. In addition, half of the participants took the associative recognition test with the nonword presented before the word and with other half given the reverse format.

Procedure. The study procedure was nearly identical to that used in the previous experiments with one exception. Participants were instructed to pay attention to the nonword–word pair in preparation for a memory test whereas in previous experiments participants were instructed to pay particular attention to only the word. At test, half of the participants were presented with the nonword first and half were presented with the word first. Participants were informed that all words and nonwords presented at test had been studied previously. They were instructed to judge whether members in a pair had been presented together (in which case they would say "yes") or had been presented in different pairs (in which case they would say "no"). In addition, participants were informed that half of the test pairs were intact and half were rearranged. Participants read each pair at test aloud and indicated to the experimenter whether the pair was intact or rearranged. Latency to name the word and the prime was recorded along with the recognition decision.

Results and discussion

Word naming latencies. Results from Experiment 3 established the fact that presenting the nonword first speeds word naming when the nonword rhymes with the word whereas presentation of the word first renders word naming latencies equal. We assume that holds in Experiment 4. Therefore, to eliminate redundancy, the analysis of the latency data will not be presented.

Table 7
Experiment 4: Mean proportion of intact and rearranged pairs called "intact"

Condition	Intact	Rearranged	A'	B''_D
Prime first				
Rhyme	.78 (.12)	.62 (.17)	.68 (.09)	−.62 (.30)
Nonrhyme	.45 (.17)	.36 (.14)	.62 (.08)	.32 (.44)
Test item first				
Rhyme	.71 (.15)	.66 (.13)	.60 (.09)	−.57 (.34)
Nonrhyme	.37 (.14)	.34 (.14)	.59 (.07)	.46 (.37)

Note. Standard deviations are in parentheses.

Associative recognition. Associative recognition means for Experiment 4 are presented in Table 7. A 2 (Test Format : nonword first, word first) × 2 (Rhyme status : rhyme, nonrhyme) mixed ANOVA on discriminability estimates showed that presenting the nonword first resulted in greater discriminability ($A' = .65$) than presenting the word first ($A' = .60$), [$F(1,46) = 11.62$, $MSE = 0.07$], a finding which is reasonable given that pairs were studied in the nonword first format. There was no main effect of rhyme status on A', [$F(1,46) = 2.96$, $MSE = 0.02$, $p = .09$], and no interaction of rhyme status with test format [$F(1,46) = 1.98$, $MSE = 0.01$].

Response bias (B''_D) data were analyzed based on the same factors as the A' data. As predicted, rhyming pairs ($B''_D = -.60$) elicited a considerably more liberal response bias than nonrhyming pairs ($B''_D = .39$), [$F(1,46) = 129.24$, $MSE = 23.47$]. Also as predicted, test presentation order did not affect response bias [$F(1,46) = 2.54$, $MSE = 0.22$], nor did it interact with rhyme status ($F < 1$).

Discussion. Experiment 4 clearly demonstrated that participants were biased to respond "intact" when the word and nonword formed a rhyming pair at test. Further, the effect was unrelated to nonword–word presentation order at test. From our perspective, such results are quite plausible if the familiarity of the pair was used as a basis for recognition judgments. Obviously, a rhyming relationship between items in the pair may lead to a powerful illusion of familiarity as, across test formats, participants were 29 percentage points more likely to falsely call rhyming pairs "intact" than nonrhyming pairs.

One factor which likely contributed is that the opportunity for elaboration at study was minimal with a 2 s presentation duration, presumably allowing little opportunity to encode associative relations between nonwords and words in a pair (cf., Hockley & Consoli, 1999). Greene and Tussing (2001), for example, found that short compared to long study time increased the relatedness bias on associative recognition. In addition, the fact that one element of the pair is meaningless would also hinder encoding of associative relations. This may have contributed to a situation where participants' primary basis for associative recognition was their experience of familiarity of the pair. The orthographic and acoustic similarity of a rhyming test pair, even in a rearranged pair, may have contributed to the feeling that the pair was familiar.

Participants may have had a bias to judge rhyming pairs as intact because of fluent processing of the second component of the pair. Just as rhyming primes enhanced the speed of naming the following word, rhyming words enhanced the speed of naming the following nonword when items were presented in the word-nonword order at test.[2] Fluent processing of the prime following a rhyming word may give rise to a feeling that the prime is familiar, a point which is particularly relevant given that item familiarity in associative recognition produces a bias to say "intact" (Nairne, 1983). Whether familiarity for a rhyming pair occurs based on an evaluation of enhanced processing fluency for the second component of the pair or based on an evaluation of the overall ease of processing the pair as a whole is an important question for future research.

General discussion

We investigated the effects of nonword rhyming primes on recognition memory in both item and associative recognition. One account of the effect of rhyming primes on item recognition is that processing of the corresponding test item is more fluent, and such fluent processing is experienced as familiarity (Whittlesea & Williams, 2001a). Experiment 1 tested whether making the role of the primes at test less salient by also presenting primes at study affects the attribution process and leads a bias to respond "old" to test items preceded by rhyming primes. Results showed that rhyming primes elicited a strong bias to endorse test items when the primes were also old, but the effect does not seem to be mediated by the salience of the primes at test. That is, presenting primes at study did not produce a bias to endorse rhyming items as old when new primes were substituted at test.

Experiment 2 ruled out differential cohort activation of new test items in the rhyming versus nonrhyming condition as a source of the large bias in the study pairs—old prime condition. Experiment 3 tested the fluency account by attempting to abolish fluent processing of the test item, as half of the participants viewed the test item before the prime. Presenting the test item first greatly diminished the difference in bias to rhyming

[2] Latency data for naming a prime presented after a test item indicated that primes which rhymed with test items were named faster than primes preceded by a nonrhyming word, [$F(1,23) = 52.96$, $p = .000$]. The same pattern was also evident in the test-item first condition of Experiment 3 [$F(1,27) = 130.44$, $p = .000$].

versus nonrhyming test items. However, participants still showed a strong bias to call test items followed by rhyming nonwords "old" compared to those test items followed by nonrhyming nonwords.

A possible explanation for this bias may be found in familiarity arising from the prime–test item unit as a whole rather than from the test item alone. When primes were presented at study and at test (e.g., the study pairs—old prime condition of Experiment 1), all old test items were presented with their corresponding studied prime. Therefore, familiarity of the prime–test item pair should be a good basis for item recognition decisions on the test item. However, the similarity of a rhyming prime to its test item could give rise to an illusory feeling of familiarity for the pair as a whole, even when the prime and test items have been rearranged. The subjective experience that the pair is familiar could either be due to fluency of processing the second component or an undifferentiated sense of fluent processing of the pair. Importantly, we predicted that familiarity of the rhyming nonword–word test pairs would be unaffected by test presentation order, as the similarity of the nonword to the word would be unchanged. Experiment 4 found that participants were biased to claim that pairs rearranged to form rhyming pairs were intact relative to pairs rearranged to form nonrhyming pairs on an associative recognition test, regardless of presentation order. This rhyming bias also appeared for intact pairs.

The results of Experiment 4 may also have implications for the interpretation of Experiment 3. To the extent that participants in that experiment used familiarity of the prime–test item pair when making item recognition judgments, they would have experienced as much familiarity at the level of the pair when the test item was followed by the rhyming prime as when the test item was preceded by the rhyming prime. The feeling that the pair was familiar could have its origin in the study episode or be illusory familiarity emanating from the rhyming relationship between the word and nonword. In contrast, in the conditions where words alone were studied in Experiments 1 and 2, and in the study pairs—new prime condition of Experiment 1, no prime–test item pairs were old at test, making it less likely that familiarity of the pair could be used as a basis for item recognition judgments. In addition, new primes might be more easily segregated from the test item such that a participant could treat the pair as two separate components rather than as an integrated whole.

To explain their finding that a variety of similarity relationships between word pairs increase the probability of false alarms in associative recognition, Greene and Tussing (2001) speculated that extraexperimental memories of the related pairs are falsely taken as memories of the study episode. For example, given that an antonym pair such as HOT-COLD has a far higher frequency of occurrence than an unrelated pair, it may be more difficult for a participant to discriminate between the study episode and extraexperimental instances of the pair. However, such an explanation would not seem to fit the data from Experiment 4. In that experiment, related pairs with little or no extraexperimental familiarity (e.g., PINGLE-SINGLE) were far more likely to be called "intact" than unrelated pairs. Thus, an alternative to extraexperimental familiarity is needed to account for the data from the associative recognition test in Experiment 4. Fluent processing of the pair due to similarity between the items could give rise to a feeling that the pair is familiar.

In contrast to the current results, Greene and Tussing (2001) found no similarity effects when the test was one of item recognition rather than associative recognition. In fact, they found a substantial reversal in item recognition, with more positive responses when items in a test pair were unrelated than when they were related. Their item recognition test required participants to attempt to recognize each item in the pair and respond "yes" only if both items were old. One possibility is that the specific details of the test situation made it more likely that participants segregated the items in a test pair rather than treating the two components as a whole. Therefore, the discrepancy between the current data and that reported by Greene and Tussing may hinge on the fact that the item recognition test in Experiments 1, 2, and 3 was more likely to lead participants to treat the prime and test items as a whole.

Within a larger framework, one interpretation of findings from the current study is that the fluency with which an item is processed is used to make attributions about prior experience. The general thrust of this viewpoint (e.g., Jacoby & Dallas, 1981; Jacoby et al., 1989) is that fluent processing of a stimulus gives rise to the feeling that the stimulus is familiar, with more recent versions of the fluency perspective stressing that evaluations of what is or is not considered fluent processing varies as a function of context and prior expectation (Whittlesea & Williams, 1998). In the current study, the most fluently named test items (rhyming test items) were also the most likely to be endorsed as having been studied in comparison to less fluently named, nonrhyming test items.

An alternative approach to the current results and other demonstrations from the fluency attribution framework is in terms of a general tendency to mistake similarity between test items and primes for episodic familiarity. Global activation models of memory (e.g., Gillund & Shiffrin, 1984; Hintzman, 1988; Murdock, 1993; see Clark & Gronlund, 1996, for a review) might be modified to allow for resonance between elements in the test context to contribute to the familiarity of a test item. These models essentially hold that a memory probe serves to simultaneously access multiple traces or events in memory, producing a specific level of activation in

memory for that cue. This level of activation or familiarity may then be compared to some criterion to determine whether the test cue is called "old" or "new." The effects of rhyming primes on recognition responses to test items suggest that people are also deriving familiarity from the similarity of the test probe to the prime. This is particularly the case for the study words alone conditions of Experiments 1 and 2, and the original study by Whittlesea and Williams (2001a, Experiment 3a). In those experiments, the presence of a new prime, which putatively should have little influence on recognition, had a clear impact on recognition judgments. Thus, it seems that some allowance should be made in global activation models for familiarity derived from elements in the test context that are similar to the probe. Acoustic and orthographic similarity between test items and other elements in the memory probe may be a general source of familiarity that can be mistakenly attributed to the test item in item recognition or the pair as a whole in associative recognition. Thus, the ring of familiarity may emanate from elements within the test context as well as from a trace in memory.

Overall, the effects of old rhyming primes on item recognition and associative recognition reported here were bias effects, present in both hits and false alarms (see also Whittlesea & Williams, 2001a, for other bias effects due to memory attributions). The fact that an effect occurs as a bias as opposed to a change in discriminability does not specify the mechanism of the effect (Whittlesea, 2002; Wixted & Stretch, 2000). Bias effects in memory have been interpreted in a variety of ways, as changes in response criteria, as evidence for a separate source of memory responses (Hay & Jacoby, 1996), and as changes in the subjective familiarity of both the lures and targets (Wixted & Stretch, 2000).

It is unlikely that participants changed their criterion repeatedly throughout the memory test for rhyming compared to nonrhyming test pairs (Stretch & Wixted, 1998). However, one could treat the current data as evidence for two separate sources of familiarity, episodic familiarity and familiarity arising from orthographic similarity between prime and target. Dosher, McElree, Hood, and Rosedale (1989) did so to model their finding of a constant increment (bias) priming effect that arose from placing semantically related primes in front of recognition test words. Hay and Jacoby (1996) also treated experimentally established "habits" as an accessibility bias for later memory responses that was independent of memory for the study list. In the current experiments, we think that what would normally be a source of memory discriminability (fluent test item or fluent prime–test item pair processing arising from prior study) becomes a source of bias because of the way we artificially manipulated processing fluency for both targets and lures. The fluency attribution framework emphasizes why a particular manipulation might be used as a separate source of memory responses: The orthographic or semantic relatedness of prime and target creates fluent processing, which is interpreted as familiarity.

Appendix A. Primes and test items used at study and test

Rainter-painter	Fention-mention	Fiberty-liberty	Mictim-victim
Bamera-camera	Wutter-butter	Fitual-ritual	Ramper-hamper
Hibrary-library	Bassage-passage	Minger-finger	Sundle-bundle
Redicine-medicine	Lavalry-cavalry	Darmer-farmer	Craffic-traffic
Hantle-mantle	Monest-honest	Cormation-formation	Drazy-crazy
Birror-mirror	Mellar-cellar	Bungry-hungry	Fandle-candle
Pilent-silent	Mirty-dirty	Wumber-lumber	Turnish-furnish
Megend-legend	Rapitol-capitol	Wudget-budget	Melative-relative
Tuppet-puppet	Pelish-relish	Sartner-partner	Flarity-clarity
Cample-sample	Mestiny-destiny	Pontact-contact	Flory-glory
Bayor-mayor	Bactory-factory	Dreight-freight	Farnival-carnival
Lavage-savage	Gulture-culture	Milence-silence	Biction-fiction
Weldom-seldom	Breaty-treaty	Farbon-carbon	Tervous-nervous
Wickel-nickel	Basual-casual	Crison-prison	Histant-distant
Lesture-gesture	Wilver-silver	Fenny-penny	Fesert-desert
Mignal-signal	Tural-rural	Narget-target	Fidnight-midnight
Rixture-mixture	Fedroom-bedroom	Mestival-festival	Mivid-vivid
Carlor-parlor	Tavish-lavish	Rissue-tissue	Bounter-counter
Mitness-witness	Mabinet-cabinet	Bategory-category	Bredit-credit
Sayment-payment	Flayer-player	Sinish-finish	Morrid-torrid
Fuspect-suspect	Friumph-triumph	Movel-novel	Tarvest-harvest
Henalty-penalty	Wencil-pencil	Subber-rubber	Rustomer-customer
Bontest-contest	Mallen-fallen	Sarrow-narrow	Regative-negative
Menefit-benefit	Falent-talent	Cassive-massive	Wowder-powder

Appendix A (*continued*)

Wingdom-kingdom	Crotest-protest	Berfect-perfect	Burniture-furniture
Tarbor-harbor	Pensity-density	Nodest-modest	Briminal-criminal
Sarble-marble	Broperty-property	Melfare-welfare	Wafety-safety
Fighway-highway	Lacket-jacket	Nicket-ticket	Mictor-victor
Terger-merger	Gortion-portion	Ridow-widow	Grimitive-primitive
Rancy-fancy	Fector-sector	Fantern-lantern	Lorder-border

Appendix B. Buffer list of nonrhyming pairs used at study in the study pairs—new prime condition

Fedley-membrane	Ricense-morale	Tefund-circuit	Freedy-militia
Melevant-circle	Turity-recall	Sadical-receipt	Trease-poison
Fenior-cottage	Rentist-autumn	Tombat-empire	Hispute-circus
Mobby-shadow	Sarren-excuse	Dallot-ragged	Bagoon-reform
Mepeat-device	Tinen-scholar	Cotion-lively	Mardon-decline
Fanding-leisure	Ferious-funny	Crofound-pursuit	Maradox-lemon
Conster-cushion	Cappen-reform	Sarallel-garbage	Wollar-poverty
Tuffle-nephew	Slunder-network		

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