MEMORY, 2005, 13 (8), 815–828

Psychology Press
Taylor & Francis Group

The incidence of false memories in native and non-native speakers

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The current study consisted of four experiments that utilised a novel approach to investigating false memories. Each of the experiments in the current study investigated individuals with varying experience with different languages. Experiment 1 tested participants in both their native and secondary languages as well as monolingual English speakers, while Experiment 2 assessed native Spanish speakers using both English and Spanish associative lists. Experiment 3 examined the illusory memories in monolingual Spanish speakers in both English and Spanish, while Experiment 4 investigated false memories in monolingual English speakers in both English and Spanish. Results indicated that memory for list items and critical lures was greatest when the lists were presented in the participants' primary language. Results can be explained by either activation-based or fuzzy-trace theories.

The Deese, Roediger and McDermott or DRM paradigm (Deese, 1959; Roediger & McDermott, 1995) has demonstrated that individuals can have compelling but false memories for words that have not actually been presented. The typical procedure involves presenting participants with lists of words that are semantically related to a common theme word (referred to as the *critical lure*). At test, participants frequently remember the critical lure despite the fact that it was never presented. For example, participants may be presented with a list of words related to the critical lure *sleep*, such as *bed*, *rest*, *awake*, *dream*, and *pillow*. When tested, participants will often remember the critical lure *sleep*, despite the fact that *sleep* was never presented. This general finding has been replicated in a number of studies (e.g., Anastasi, Rhodes, & Burns, 2000; Gallo, Roberts, & Seamon, 1997; Gallo & Roediger, 2001; Norman & Schacter, 1997; Payne, Elie, Blackwell, & Neuschatz, 1996; Rhodes & Anastasi, 2000; Seamon, Luo, & Gallo, 1998). At present, there are two major theories of false memories that differ considerably in their details but, with few exceptions,

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The authors would like to thank Alicia DeLeon for her assistance with the Spanish translations and for her help in testing participants. We would also like to thank Roddy Roediger, Charles Brainerd, and Jason Watson for their helpful comments on an earlier draft of this manuscript. This work was partially supported by a Scholarship, Research, and Creative Activities (SRCA) grant from Arizona State University West.

http://www.tandf.co.uk/journals/pp/09658211.html DOI:10.1080/09658210444000421

make similar predictions. These theories include activation-based theories (e.g., Ayers & Reder, 1998; McDermott & Watson, 2001; Roediger & McDermott, 1995; Roediger, Watson, McDermott, & Gallo, 2001; Underwood, 1965) and fuzzy-trace theory (e.g., Brainerd & Reyna, 1998; Reyna & Brainerd, 1995; Reyna & Lloyd, 1997).

Perhaps the most widely cited account of false memories in the DRM paradigm is Underwood's (1965) implicit associative response (IAR) theory. IAR theory is a generic activation-based theory that assumes a memory network of semantically connected items (cf. Collins & Loftus, 1975). Accordinhlisthey,nhl u9pr5A6qB0inhlPGBLtpmsoordinhlof

1815)e N9is0G5ALq[0activatiopr5Aorinh0G078q79theory5G7B8qproposes's dependence on the more durable gist representation. As a result, memory for list items decreases substantially over time, while false memories, reliant on the independent gist representation, may persist or even increase. Dissociations of this sort provide support for the idea that list items and critical lures are represented independently.

Manipulations of presentation duration (McDermott & Watson, 2001; Seamon et al., 1998, 2000, 2002b) and list repetition (Seamon et al., 2002a; Tussing & Greene, 1999) have provided mixed results with regard to the theoretical explanations of false memories. Seamon et al. (2002a), for example, showed that repetition of list items at encoding increased veridical memory, whereas memory illusions initially increased with 5 repetitions and then decreased with 10 repetitions.

In addition to the effects of repetition, Seamon et al. (2000) demonstrated that manipulations of study duration may also lead to dissociations in memory for list items and critical lures. Specifically, they found that memory for list items decreased when presentation duration was decreased from 2 seconds to 20 ms. Conversely, false memories for critical lures increased when presentation duration was changed from 2 seconds to 20 ms. McDermott and Watson (2001) showed a similar increase in false recall with shorter durations (i.e., more false memories with 250 ms compared to 20 ms presentation rates) but then showed a decline in false recall with longer presentation durations (i.e., fewer false memories with 5000 ms than with 3000 ms or 1000 ms). These results further demonstrate the independence of the memory traces responsible for true and false memories. Activation-monitoring theory can account for these findings if one assumes that at shorter presentation rates, activation is the primary encoding process, and memory for list items and critical lures increases as presentation times get longer. However, as presentation times get longer, participants are able to utilise memory-monitoring processes that help to oppose the effects of activation (McDermott & Watson, 2001). Fuzzy-trace theory would also contend that reliance on verbatim and gist representations changes with these longer presentation times (e.g., longer presentation rates strengthen the verbatim representation).

The current study examined false memories in the DRM paradigm using a novel variable, language, to investigate false memories in individuals with varying experience with native and secondary languages. To our knowledge, only one previous study has looked at illusory memories using the DRM paradigm in other languages (Perez-Mata, Read, & Diges, 2002). They tested English speakers using four of the Roediger and McDermott (1995) lists (*sleep*, *anger*, *bread*, and *mountain*) in their first experiment, and Spanish speakers using similar associative Spanish lists (*balcón*, *joya*, *futuro*, and *odio*) in their second experiment. However, the purpose of their study was not to examine false memories in native and non-native speakers but rather to investigate the effects of divided attention and word concreteness on false memories. Thus, the current study appears to be the first to specifically examine false memories in native and non-native speakers.

In the current study, individuals were tested in their native and a secondary language with which they had less experience. We investigated illusory memories in monolingual individuals who had virtually no experience in a secondary language and bilingual individuals who had considerable experience with two languages. Briefly, there were several goals for the current study. First, the current study will explore false memories using the DRM paradigm in multiple languages with a focus on Spanish. Second, we will investigate false memories in Spanish-speaking individuals who have varying levels of experience with English as a second language. Third, we will develop a new set of Spanish normed lists similar to those developed by Deese (1959) and Roediger and McDermott (1995). Fourth, we will evaluate the major theories that have been proposed to explain the false memory phenomenon using the DRM paradigm and determine how well each accounts for the current findings.

EXPERIMENT 1

Experiment 1 investigated illusory memories in bilinguals in both their native and non-native languages as well as monolingual English speakers. Activation-based and fuzzy-trace theories each predict that monolingual English speakers will remember a greater number of critical lures compared to bilingual speakers tested in English, their second language. However, both groups (monolingual English speakers and bilingual speakers) would be expected to remember critical lures at the same level when presented with list items in their native language. The predictions of activation-based theories are dependent on the amount of experience that speakers have with the particular language used. Greater activation of list items as well as other related items (e.g., the critical lure) was expected when participants' study lists were presented in their native language, resulting in relatively similar levels of memory for list items and critical lures. However, when participants were presented with list items in a non-native language, less activation was expected, resulting in fewer list items and critical lures being remembered.

Fuzzy-trace theory would make similar predictions. According to fuzzy-trace theory, memory for critical lures is dependent on a gist representation. This gist representation would be relatively easy to form when participants are given semantically related list items in their native language. However, a gist representation would be more difficult to form for list items presented in the participants' second language, diminishing memory for the critical lure. Additionally, memory for list items, which is primarily dependent on verbatim representations, should be relatively strong for items presented in both the participants' native language and their second language. However, list item performance can also be partially driven by gist representations, which provide an added advantage in the participant's native language. Therefore, according to both theories, participants were expected to remember both the list items and critical lures more often when tested in their native language.

Method

Participants. A total of 36 Francis Marion University students participated. Of these, 24 participants were monolingual English speakers and 12 were foreign exchange students who reported English as a second language. Five students indicated Japanese as their native language, four indicated Spanish as their native language, and three indicated German as their native language. The Japanese students all originated from Japan. Two of the Spanish-speaking students originated from Bolivia, one from Mexico, and one from Venezuela. Of the German students, two originated from Germany and one was from Switzerland. The foreign exchange students reported 8.51 years ($SD = 5.47$) of experience with English as a second language.

Design. An incomplete 2 (Participant Language: monolingual, bilingual) × 2 (List Language: native, non-native) × 3 (Item Type: list, critical lure, nonlist) mixed-factor design was used in the current experiment. Participant Language was manipulated between-participants, while List Language and Item Type were manipulated within-participants. Monolingual participants were tested only in their native language. The dependent variable was the proportion of list items and critical lures recalled on the immediate recall tests, as well as the proportion of list items, critical lures and nonlist items recognised on the final recognition test.

Materials and procedure. The current experiment used the *chair*, *needle*, *sleep*, *rough*, *mountain*, and *sweet* lists taken from Roediger and McDermott (1995). All lists were presented in a blocked format in descending order of associative strength and all instructions were given in English. Participants were given 45 index cards size 5″ × 7″, each of which had a 24-point font word typed in the centre. They were instructed to view each word at their normal reading rate and then turn the index card face down. Participants were informed that their memory for these words would be tested later in the experiment, and were then presented with a 45-item list (three 15-item lists). Bilingual participants were given the list in either their native language or in English. Monolingual English speakers were given the list in English. Following the study list, participants were given a 5-minute mathematics filler task with instructions to complete as many of the 51 mathematics problems as possible. Following the filler task, participants were given 5 minutes to write down as many of the list words as possible.

Once the recall test was complete, participants repeated this same procedure with another 45-item list (three 15-item lists). Bilingual participants were given the second list in either their native language or in English (opposite of the first list) followed by the filler task. Monolingual English speakers were given the second list in English. The lists were counterbalanced for the bilingual participants such that each list was presented equally often in English and in the bilingual participants' native language. The lists were also counterbalanced for order of presentation such that each block of word lists served equally often as the first and second 45-item list. Following the second recall test, participants were given a 48-item paper-based yes/no recognition test. The recognition test contained 24 list items (4 from each individual list), the 6 critical lures from the presented lists, and 18 unrelated, nonlist items. The list items and critical lures on the recognition test for the bilingual participants were given in the same language as the one in which they were originally presented (i.e., half in English and half in the participant's native language). In addition, half of the unrelated, nonlist items were given in English and half were given in the participant's native language. These nonlist items were taken from unrelated lists that were not used as study items. All recognition items were given in English for the monolingual English speakers.

Results

Recall data. Recall data from the current experiment are presented in Table 1. Given that an incomplete factorial design was used (i.e., monolingual participants were tested only in English), these data were analysed using three separate ANOVAs. The first ANOVA investigated the recall performance of the foreign exchange students in their native and non-native languages. The second ANOVA compared the recall performance of monolingual English speakers with the performance of the bilinguals in their native language. The third ANOVA was conducted to compare the recall performance of monolingual English speakers with the performance of the bilinguals in English, their second language.

A 2 (List Language: native, non-native) × 2 (Item Type: List, Critical Lure) within-participants ANOVA examined bilingual participants' recall of list items and critical lures in their native and non-native languages. Results showed no main effect of List Language, $F(1, 11) < 1$, and no List Language × Item Type interaction, $F(1, 11) < 1$. However, there was a main effect of Item Type, $F(1, 11) = 4.90$, $MSe = 0.06$, $p < .05$, as participants recalled a greater proportion of list items than critical lures. [Unless otherwise noted, the alpha level was set to .05.] Planned comparisons revealed that the bilingual participants recalled the same proportion of list items in their native language (.36) as they did in their non-native language (.39), $t(11) < 1$. In addition, bilingual participants also recalled the same proportion of critical lures in their native language (.22) as they did in their non-native language (.22), $t(11) = < 1$.

A 2 (Participant Language: monolingual, bilingual) × 2 (Item Type: List, Critical Lure) mixed-factor ANOVA was conducted to compare the list item and critical lure recall performance of monolingual English speakers with the performance of the bilingual participants in their native language. Results showed a main effect of Participant Language, $F(1, 34) = 7.60$, $MSe = 0.04$, indicating that monolinguals recalled a greater number of items (.44) than bilinguals when bilinguals were tested in their native language (.29) or in their secondary language (.31). No main effect of Item Type, $F(1, 34) < 1$, and no Participant Language × Item Type interaction was evident, $F(1, 34) = 2.69$, $MSe = 0.05$, $p = .11$. Monolinguals recalled the same number of list items (.41) as bilinguals (.36) when both groups were tested in their native language, $t(34) < 1$. However, monolinguals (.46) were more likely to recall critical lures than bilinguals (.22) when both groups were tested in their native languages, $t(34) = 2.45$.

A 2 (Participant Language: monolingual, bilingual) × 2 (Item Type: List, Critical Lure) mixed-factor ANOVA was conducted to compare the list item and critical lure recall of monolingual

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TABLE 2
Mean proportion of items remembered for the final recognition test for Experiment 1

Language	*Corrected list items*	*Corrected critical lures*	*Nonlist items*
Monolingual English	.68 (.16)	.68 (.23)	.08 (.11)
Bilingual English	.75 (.20)	.43 (.37)	.06 (.10)
Bilingual native language	.75 (.21)	.46 (.28)	.09 (.15)

Standard deviations are in parentheses.

monolingual English speakers (.41) recalled the same number of list items as the bilingual speakers (.39) when both were tested in English, $t(34) < 1$. However, monolingual English speakers (.46) recalled significantly more critical lures than bilingual speakers (.22), $t(34) = 2.36$.

Recognition data. In order to control for differential false alarm base rates, recognition data in this and all subsequent experiments were analysed using corrected list item and critical lure scores.[1] Corrected scores were computed by subtracting the proportion of nonlist items recognised from the proportion of list items and critical lures recognised, respectively (see Budson, Desikan, Daffner, & Schacter, 2001; Lampinen & Schwartz, 2000). Summary statistics for the recognition data are presented in Table 2. Recognition data were analysed using three separate ANOVAs. The first analysis examined recognition performance of monolingual English speakers and foreign exchange students in their native language, utilising a 2 (Participant Language: monolingual, bilingual) $\times$ 3 (Item Type: list, critical lure) mixed-factor ANOVA. Results indicated that there was no main effect of Participant Language, $F(1, 34) = 2.01$, $MSe = 0.05$, $p = .17$. However, there was a main effect of Item Type, $F(1, 34) = 7.49$, $MSe = 0.04$, as well as a Participant Language $\times$ Item Type interaction, $F(1, 34) = 7.54$, $MSe = 0.04$. Planned comparisons revealed that monolingual English speakers (.68) recognised the same proportion of list items as the bilinguals tested in their native language (.75), $t(34) = 1.02$, $p = .19$. However, monolinguals (.68) were more likely to falsely recognise critical lures than bilinguals (.46), $t(34) = -2.54$.

The second analysis compared the corrected recognition performance of monolingual English speakers and foreign exchange students in their non-native language (English), in a 2 (Participant Language: monolingual, bilingual) $\times$ 3 (Item Type: list, critical lure) mixed-factor ANOVA. Results showed no main effect of Participant Language, $F(1, 34) = 2.36$, $MSe = 0.06$, $p = .13$, but a main effect of Item Type, $F(1, 34) = 7.67$, $MSe = 0.05$, was evident. This finding was qualified by a significant Participant Language $\times$ Item Type interaction, $F(1, 34) = 7.71$, $MSe = 0.05$. Specifically, monolingual English speakers recognised the same number of list items (.68) as bilingual participants tested in English (.75), $t(34) = 1.05$, $p = .30$. In contrast, monolingual English speakers recognised significantly more critical lures (.68) than did bilingual participants tested in English (.43), $t(34) = -2.51$.

Finally, recognition data for foreign exchange students were subjected to a 2 (List Language: native, non-native) $\times$ 3 (Item Type: list, critical lure) repeated measures ANOVA. Results indicated that recognition did not differ based on whether the participant was tested in their native or non-native language, $F(1, 11) < 1$, but did differ for the type of item, $F(1, 11) = 15.27$, $MSe = 0.07$, indicating that bilinguals recognised significantly more list items (.75) than critical lures (.45). A List Language $\times$ Item Type interaction was not present, $F(1, 11) < 1$. Thus, foreign exchange students' recognition data were the same regardless of language. Bilingual participants recognised the same proportion of list items, $t(11) < 1$, and critical lures, $t(11) < 1$, in both their native language and English.

Discussion

Overall, the data of most interest concern list item and critical lure performance for monolinguals in comparison to bilinguals. Across both recall and recognition tests, the consistent finding was that while list item performance was equivalent, monolingual English speakers consistently

[1] We would like to thank Jason Watson for this suggestion.

remembered a greater number of critical lures than bilingual speakers. This is not surprising when comparing bilingual speakers tested in their non-native language (English), as they presumably have a less developed semantic network and, consequently, a reduced chance of activating the critical lure in comparison to native English speakers. However, these data also indicated that even when tested in their native language, bilingual participants recalled and recognised fewer critical lures than monolingual participants. They also remembered the same proportion of critical lures when tested in their native language and their second language, English. Taken together, these findings illustrate a potential problem with Experiment 1. Due to the nature of the lists used in Experiment 1, it is possible that the lists had greater associative power in English than they did in the other languages used. Specifically, the list items were translated into the bilinguals' native language using a direct translation of each list item. By doing so, the associative nature of the Roediger and McDermott (1995) lists may have been lost, as the associations inherent in these lists were based on norms from native English-speaking participants. Experiment 2 will examine this possibility by constructing lists using native Spanish speakers. Finally, it must be noted that the results from Experiment 1 should be interpreted cautiously due to the relatively low statistical power available with the small number of bilingual participants tested.

EXPERIMENT 2

In Experiment 2, we constructed lists for Spanish speakers using the same general format as Roediger and McDermott (1995). These Spanish lists were then used in conjunction with the original English versions of the Roediger and McDermott lists to test native Spanish speakers. Prior to the current experiment, 38 native Spanish speakers were presented with the Spanish equivalent of the 24 Roediger and McDermott (1995) critical lures and instructed to write down the first three words that came to mind.[2] Each list used in the current experiment was then constructed from the 15 most frequent responses to each critical lure. In the current experiment, native Spanish speakers were tested in both Spanish, their native language, as well as English, their second language.

There were several methodological changes for Experiment 2. First, as previously noted, Spanish word lists were created using native Spanish speakers, thus keeping the semantic, associative nature of the lists intact. These newly formed Spanish lists are consistent with how the DRM lists were originally created. Second, participants were tested using only a recognition test in the current experiment. This seems reasonable, as the pattern of data from Experiment 1 was identical for both the immediate recall and final recognition tests. One final difference was that the list items were presented using a timed computer presentation rather than the self-paced index card procedure used in Experiment 1. This change controlled for any presentation differences that might have arisen as participants were presented with the list items in their native and non-native languages. Although not measured in Experiment 1, it was possible that the bilingual participants spent more time studying the words presented in their secondary language. Consequently, this potential confound was eliminated.

The predictions of activation-based and fuzzy-trace theories are relatively straightforward. Activation-based theories would predict that memory for both list items and critical lures would be greater when list items were presented in Spanish, the participants' native language. Participants should have a more elaborate semantic network in their native language compared to their secondary language, leading to greater activation of both list items and critical lures. Less activation would occur in their second language, English, which should result in fewer list items and critical lures being remembered. Fuzzy-trace theory would make similar predictions. According to fuzzy-trace theory, native Spanish speakers should be able to easily form the gist when list items are presented in Spanish. This would increase the probability of falsely recognising critical lures, which are presumably dependent on gist representations. Fewer critical lures should be recognised when list items are presented in the participants' secondary language, English, as a gist representation would be more difficult to generate. Fuzzy-trace theory would predict better memory for Spanish list items, as both gist and verbatim representations could be utilised

[2] All 38 participants reported Spanish as their native language. Additionally, 84.2% of these individuals reported speaking Spanish as their primary language at home. The average age of the native Spanish speakers used to construct the Spanish lists used in the current study was 32.7 (*SD* = 10.1) and these individuals reported speaking Spanish for an average of 29.8 years (*SD* = 8.0).

whereas only verbatim traces would be available for English list items. Thus, participants should be able to utilise a verbatim representation equally for their native and secondary language but only their native language would have the added benefit of the gist representation.

Method

Participants. A total of 22 individuals participated in the current experiment. Participants were drawn from Arizona State University West and the surrounding community. The average age of the participants was 30.7 years (*SD* = 10.3) and the average number of years of education was 13.6 (*SD* = 3.7). All participants reported Spanish as their native language and English as their second language. All participants reported Mexico as their country of origin. A total of 75% of participants reported that they used Spanish in their home (50% reported using English at home), 45% reported using Spanish at work (75% reported using English at work), and 60% reported using Spanish with friends (80% reported using English with friends). The cumulative percentages exceed 100% as some participants reported using both languages in the various environments.

Design. A 2 (List Language: Spanish, English) × 3 (Item Type: List, Critical Lure, Nonlist) within-participants design was used in the current experiment. The dependent variable was the proportion of list items, critical lures, and nonlist items recognised.

Materials and procedure. The new lists used in the current experiment were derived in the same manner as the Roediger and McDermott (1995) lists. A group of 38 native Spanish speakers were given the Spanish names of the 24 Roediger and McDermott (1995) critical lures and were instructed to write down the first three words that came to mind. All instructions were given in Spanish. The 15 most common responses were used as list items, and those six lists with the greatest agreement for list items were used for the current experiment.[3] The Spanish lists used in the current experiment were composed of Spanish words, and were based on the following lures: *silla* (chair), *frio* (cold), *doctor* (doctor), *pan* (bread), *fruta* (fruit), and *pie* (foot). The Appendix pro-rrent ,n8qB9s5A08B

TABLE 3
Mean proportion of items recognised for native Spanish speakers in Experiment 2

Language	*Corrected list items*	*Corrected critical lures*	*Nonlist items*
English	.58 (.20	.55 (.30)	.15 (.16)
Spanish	.54 (.18)	.31 (.27)	.21 (.10)

Standard deviations are in parentheses.

6.62, $MSe = 0.03$. Follow-up *t*-tests indicated that native Spanish speakers remembered the same number of list items whether they were tested in Spanish (.54) or English (.58), $t(20) < 1$. However, contrary to predictions, participants in the current experiment recognised significantly more critical lures when they were tested in English (.55) compared to when they were tested in Spanish (.31), $t(20) = 2.68$.

Surprisingly, native Spanish speakers did not differ in their recognition accuracy of list items for English and Spanish words. However, native Spanish speakers demonstrated significantly more false memories in English than in Spanish, a finding contrary to all predictions. Although these results are contrary to both the activation-based and fuzzy-trace theories, there is a relatively simple explanation for these findings. All participants tested in the current study were native Spanish speakers who were also fluent in English. For example, 75% of the participants reported using Spanish in their home but 75% also reported using English at work and 80% reported using English with friends. In other words, our participants' native language was indeed Spanish but they frequently used English in their daily life. In addition, these participants reside in and were recruited from a university and surrounding community in the Phoenix area where English is the dominant language. Experiment 3 will correct this problem by testing monolingual Spanish speakers.

EXPERIMENT 3

Results from Experiment 2 were contrary to predictions. However, as noted, there is a plausible explanation for these findings, as a number of the participants tested in fact had extensive experience with English. The purpose of Experiment 3 was to test individuals who have extensive experience with their native language and little or no exposure to a second language. In Experiment 3, we tested monolingual Spanish speakers in both Spanish and English, a language with which they have little experience. Predictions for these participants are clear. Activation-based theories would predict better memory for list items as well as increased critical lure recognition when participants are tested in Spanish. Given that these participants are not fluent in English and have a less developed semantic network, recognition of list items and critical lures should be diminished when they are tested in English. Fuzzy-trace theory would make similar predictions. Participants should be able to utilise a verbatim representation equally for either language but extraction of a gist representation should only be possible their native language. Therefore, recognition of both list items and critical lures should be highest in their native language.

Method

Participants. A total of 31 individuals participated in the current experiment. All the individuals tested reside in the Phoenix, Arizona metropolitan area and were given $5 for their participation in the study. Ten participants were excluded from the study as they reported speaking English either at home or work, or with friends. These excluded individuals reported using Spanish 85% of the time at home, 68% at work, and 82% with friends. One additional participant was excluded for not completing the Spanish usage survey. The remaining 20 participants reported using Spanish 100% of the time at home, at work, and with friends. Therefore, all remaining participants reported being monolingual Spanish speakers and all reported Mexico as their country of origin. These participants averaged 10.3 years of formal education ($SD = 3.7$) with an average age of 29.7 years ($SD = 8.2$).

Design. A 2 (List Language: Spanish, English) × 3 (Item Type: List, Critical Lure, Nonlist) within-participants design was used in the current experiment. The dependent variable was the proportion of list items, critical lures, and nonlist items recognised.

Materials and procedure. The materials and procedure for the current experiment were identical to those used in Experiment 2. The only difference was that the participant population tested consisted of monolingual Spanish speakers.

Results and discussion

Descriptive statistics for Experiment 3 are provided in Table 4. Results were analysed using a 2 (Language: English, Spanish) × 3 (Item Type: List, Critical Lure) ANOVA. Results demonstrated a significant main effect of Language, $F(1, 19) = 20.99$, $MSe = 0.04$. A main effect of Item Type was also present, $F(1, 19) = 11.49$, $MSe = 0.05$, as well as a marginal Language × Item Type interaction, $F(1, 19) = 3.77$, $MSe = 0.02$, $p = .07$. Follow-up analyses showed that the monolingual Spanish speakers were more likely to remember list items presented in Spanish (.57) than those presented in English (.42), $t(19) = 3.32$. Moreover, they were significantly more likely to falsely recognise the critical lures when list items were presented in Spanish (.46) compared to when lists were presented in English (.18), $t(19) = 4.15$.

Consistent with both fuzzy-trace and activation-based theories, monolingual Spanish speakers demonstrated significantly more false memories in Spanish, their native language, than in English, a language to which they have little exposure. Native Spanish speakers also remembered more list items when tested in Spanish compared to when they were tested in English, consistent with both theoretical predictions.

EXPERIMENT 4

Experiment 4 was conducted to determine whether the findings from Experiment 3 generalise to other populations and to other languages. Specifically, monolingual English speakers were tested in both English, their native language, and in Spanish, a language with which they have little experience. Activation-based theories would predict better memory for list items as well as more false memories for critical lures when participants were tested in English, as their semantic network would be expected to be more developed for English. Critical lure recognition should be lower when participants are tested in Spanish, as there should be few associations, and little activation, for these items because these participants were not fluent in Spanish. Fuzzy-trace theory would make similar predictions. That is, a gist representation should be very unlikely to form for items presented in the participant's non-native language, resulting in very low levels of false recognition. Conversely, gist representations should be relatively easy to generate for lists that were presented in English, resulting in a greater number of false memories. Fuzzy-trace theory would also predict better recognition performance for list items presented in the participant's native language, as participants could utilise both verbatim and gist representations. However, only verbatim representations would be available for list items presented in a language to which they have little exposure.

Method

Participants. A total of 24 Arizona State University West students participated as part of a class requirement for research participation. All

TABLE 4
Mean proportion of items recognised on the recognition test for monolingual Spanish speakers in Experiment 3

Language	*Corrected list items*	*Corrected critical lures*	*Nonlist items*
English	.42 (.18)	.18 (.29)	.26 (.15)
Spanish	.57 (.14)	.46 (.25)	.13 (.10)

Standard deviations are in parentheses.

participants were native English speakers and reported no formal instruction in Spanish as a second language. Furthermore, all participants reported English as their only language.

Design. A 2 (List Language: Spanish, English) × 3 (Item Type: List, Critical Lure, Nonlist) within-participants design was used in the current experiment. The dependent variable was the proportion of list items, critical lures, and nonlist items recognised.

Materials and procedure. The current experiment used the same lists as Experiments 2 and 3. The procedure was identical to Experiment 3 with the exception that monolingual English speakers were tested and all instructions were given in English.

Results and discussion

Descriptive statistics for Experiment 4 are provided in Table 5. These data were analysed using a 2 (List Language: English, Spanish) × 3 (Item Type: List, Critical Lure) ANOVA. Results indicated there was both a main effect of both Language, $F(1, 23) = 71.04$, $MSe = 0.06$, and Item Type, $F(1, 23) = 105.92$, $MSe = 0.03$. A significant Language × Item Type interaction was also present, $F(1, 23) = 88.11$, $MSe = 0.02$. Planned comparisons showed that monolingual English speakers were more likely to remember the list items presented in English (.68) than those presented in Spanish (.55), $t(23) = 2.62$. In addition, they were more likely to falsely remember the critical lures when list items were presented in English (.60) compared to when list items were presented in Spanish (−0.09), $t(23) = 10.88$.

Consistent with fuzzy-trace and activation-based theories, native English speakers had significantly more false memories in English, their primary language, than in Spanish, a language to which they have had little exposure. In fact, once critical lure scores were corrected for nonlist false alarm rates, participants remembered no critical lures in Spanish. Also predicted by both theories, native English speakers recognised significantly more list items when presented with the English lists than they did with the Spanish lists.

GENERAL DISCUSSION

The current study examined the performance of bilingual and monolingual participants in the DRM paradigm (Deese, 1959; Roediger & McDermott, 1995). Experiment 1 tested bilingual and monolingual participants. As predicted, results demonstrated that monolingual English speakers remembered a greater proportion of critical lures than bilinguals tested in their secondary language. However, contrary to predictions, monolingual English speakers exhibited more false memories than bilinguals who were tested in their native language. These findings were likely due to the fact that in translating the original Roediger and McDermott (1995) lists to other languages, the lists may have lost their inherent semantic associations. Experiment 2 modified the lists used in Experiment 1 by creating a unique set of Spanish associative lists with native Spanish speakers. Results were again contrary to predictions, as native Spanish speakers recognised significantly more critical lures in English than they did in Spanish. Based on participants' language-usage reports, these contrary results were most likely due to the extensive exposure the native Spanish speakers had to English. This trend was reversed in Experiment 3 when monolingual Spanish speakers recognised more critical lures in Spanish than in English. Experiment 4 replicated the findings of Experiment 3 with monolingual English speakers, who falsely recognised significantly more critical lures in English than in Spanish.

There are several key points to be taken from these data. First, the results demonstrate the robustness of the DRM false memory paradigm in other languages. Second, the current study provides a normed Spanish list for researchers interested in studying false memories with Spanish-

TABLE 5

Language	*Corrected list items*	*Corrected critical lures*	*Nonlist items*
English	.68 (.15)	.60 (.20)	.08 (.13)
Spanish	.55 (.18)	−.09 (.18)	.25 (.11)

Standard deviations are in parentheses.

speaking participants (although see Anastasi et al., in press, for the complete set of normed lists). Third, we employed a novel manipulation that allows one to assess how well the activation-based theories (Ayers & Reder, 1998; Roediger & McDermott, 1995; Roediger et al., 2001; Underwood, 1965) and fuzzy-trace theory (Brainerd & Reyna, 1998; Reyna & Brainerd, 1995) account for the current data.

Activation-based theories and the fuzzy-trace theory can accommodate the current data although the specific mechanisms that each theory uses vary. In the current study, critical lure recognition was diminished when participants were tested in a language with which they had little experience. Activation-based theories would suggest that this occurred because the chance of activating the critical lure during study decreases when encoding items in a non-native language (i.e., a language with a less developed semantic network). Fuzzy-trace theory would suggest that the extraction of a gist representation is hindered in a language in which a participant has less extensive experience. Thus, both theories seem to easily account for the critical lure data.

Both fuzzy-trace and activation-based theories can also adequately explain the general finding that list items were more likely to be recognised for individuals tested in their native language compared to a language with which they have little experience. Activation-based theories suggest that memory for list items and critical lures depends on greater semantic activation that is expected when participants are tested in their primary language. That is, individuals with a more completely developed semantic network (i.e., native speakers of a language) should have more activation of related items within the network, increasing the probability of list item and critical lure recognition. According to activation-based theories, list memory and false memories are dependent on each other—as one increases so must the other. Of course, adding the monitoring component to the activation approach can provide independence for list and critical lure memory (McDermott & Watson, 2001; Roediger et al., 2001; Seamon et al., 2003). For example, manipulations that enhance memory for list items could also enhance monitoring processes and thus decrease the chance of false memories for critical lures. Fuzzy-trace theory proposes that a dual representation (i.e., verbatim and gist) of the presented information is formed. For items presented in an individual's native language both a gist and verbatim representation would be available, whereas only a verbatim representation would be available for a language with which the individual is not familiar. Thus, memory for lists in one's native language would have the added benefit of a gist representation, enhancing memory for list items but also increasing the chance that critical lures are remembered. Therefore, fuzzy-trace theory also effectively explains the current findings.

It is interesting to note that the addition of the monitoring component to the activation-based theories does little to explain the results in the current study and may, in fact, hinder explanation of these findings. As noted, the activation component of the activation-monitoring theory is reasonably uncomplicated. More activation should occur in an individual's primary language, which should result in more list items and critical lures. However, the monitoring process should be better for information that is more meaningfully encoded (i.e., the individual's native language) resulting in fewer false memories in their primary language. Of course, more false memories were evident in the current study when individuals were tested in their native language compared to a language to which they had little exposure. Thus, it seems that a simpler activation-based theory provides a better explanation of the current results compared to the activation-monitoring theory. A parallel to this can be found with work on levels of processing in the DRM paradigm. Specifically, this work has generally shown that shallow processing at encoding results both in fewer list items and critical lures remembered in comparison to deeper encoding tasks (Rhodes & Anastasi, 2000; Thapar & McDermott, 2001). Activation-based theories suggest that increased activation of list items will result in increased activation of other related items, including the critical lure. However, manipulations that enhance encoding should enhance monitoring. Therefore, activation-based theories seem to provide a better explanation of data from levels of processing manipulations. Clearly, if memory is at extremely high levels then monitoring should be proficient, resulting in few false memories. However, at present, it is unclear what combination of activation and monitoring are responsible for particular patterns of list item and critical lure memory (Cokely & Kelley, 2004).

As demonstrated in the current study, both activation-based and fuzzy-trace theories continue to successfully account for a great deal of data in the DRM paradigm and both theories are able to account for the findings of the current study. Although the mechanisms that each theory employs differ considerably, both allow for dissociations between list items and critical lure memories. However, our understanding of false memories would be greatly served by future endeavours to differentiate these two theories and the mechanisms responsible for producing illusory memories.

Manuscript received 19 November 2003
Manuscript accepted 26 August 2004

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APPENDIX

Spanish normed word lists used in Experiments 2, 3, and 4 with the direct English translation in parentheses.

Silla (Chair)	*Frio (Cold)*	*Doctor (Doctor)*
descanso (rest)	nieve (snow)	medicamentos (medicine)
sentarse (sit)	invierno (winter)	enfermo (sick)
mesa (table)	abrigo (coat)	enfermedad (illness)
madera (wood)	hielo (ice)	hospital (hospital)
comodo (comfortable)	caliente (hot)	dolor (pain)
sala (living room)	agua (water)	dinero (money)
cocina (kitchen)	sueter (sweater)	alivio (wellness)
mueble (furniture)	chamarra (jacket)	ayuda (help)
comoda (dresser)	helado (cool)	sangre (blood)
comedor (dining table)	viento (wind)	curar (cure)
color café (brown)	calenton (heater)	chequeo fisico (physical)
pupitre (desk)	lluvia (rain)	paciente (patient)
mecedora (rocker)	temblar (shiver)	salud (health)
relajar (rest)	café (coffee)	niños (children)
sofa (couch)	diciembre (december)	miedo (scared)

Pan (Bread)	*Fruta (Fruit)*	*Pie (Foot)*
dulce (sweet)	manzana (apple)	zapato (shoe)
leche (milk)	naranjas (oranges)	calcetin (sock)
delicioso (tasty)	nutritivo (nutricious)	dedo (toe)
blanco (white)	platano (banana)	uñas (nails)
comida (food)	piña (pineapple)	caminar (walk)
mantequilla (butter)	mango (mango)	pierna (leg)
blandito (soft)	uvas (grapes)	grande (large)
hambre (hunger)	frescura (fresh)	manos (hands)
pastel (cake)	fresas (strawberries)	apestozos (stinky)
bolillo (roll)	saludable (healthy)	sandalias (sandals)
torta (pie)	jugo (juice)	correr (run)
tostado (toasted)	comer (eat)	tacones (heels)
trigo (wheat)	sandia (watermelon)	talón (heel)
lonche (sandwich)	árbol (tree)	tobillo (ankle)
harina (flour)	jugosa (juicy)	medias (stocking)