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The Influence of Levels of Processing on Spanish-English Bilingual False Memory

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THE INFLUENCE OF LEVELS OF PROCESSING ON SPANISH-ENGLISH BILINGUAL FALSE MEMORY

by

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Abstract

In this study we investigated the role of semantic-processing on memory for Spanish-English bilinguals using the DRM paradigm (Deese, 1959; Roediger & McDermott, 1995), a procedure commonly used to elicit false memories. Participants were tested in within-language (i.e., encoding language and recall language match) and across-language (i.e., encoding language and recall language mismatch). The results indicated higher levels of recall for semantic processing in all conditions, however at the cost of higher thematically-related intrusions. These findings are consistent with the "more is less" pattern (Toglia, Neuschatz, & Goodwin, 1999), wherein greater correct recall is accompanied by greater false recall. In addition, the cross-language conditions resulted in higher semantically relevant intrusions and lower recall overall when compared to the within-language conditions, what might be termed "less is less." Across all conditions non-semantic processing led to fewer false memories leading to overall accuracy exceeding that in the semantic-processing. In addition, greater levels of accuracy were observed in the within-language conditions. The study highlights the effects of semantic-processing on associative memory by exploring linguistic conditions that lead to false memories and provides insight into the procedure involved in transferring information from one language at encoding and another at retrieval and how false memories occur during this transferring process. Spanish-English bilinguals represent more than half of all bilinguals in the United States, and this population continues to increase (Grosjean, 2012). Implications for forensic interviewing (as in avoiding suspect interrogations always being conducted in English) and eyewitness testimony are among the applications that are discussed.

Keywords: bilingualism, false memory, semantic processing

The Influence of Levels of Processing on Spanish-English Bilingual False Memory

The purpose of this thesis was to further investigate both accurate and false memory in balanced Spanish-English bilingual participants. There has been very little research in this area, however there is a rich literature devoted to accurate and false memory that allows one to contextualize the current thesis. Several of the early sections below address this literature beginning with human memory.

Human Memory

Humans process information in line with a multi-model approach. To acquire knowledge, early approaches stressed that humans transfer information from short-term memory (STM) and store it in long term memory (LTM) for future retrieval (Atkinson & Shiffrin, 1968). However, this implies a more passive memory system. Baddeley and Hitch (1974) suggested that memory and information processing is an active progression. Instead of passively transferring information from STM to LTM, humans purposefully process information in working memory (WM) where information is filtered through subsystems and transferred into LTM for storage and later retrieval (for a recent review see Alloway & Alloway, 2012). Because we routinely and efficiently retrieve information from LTM, it is clear that LTM/semantic memory must be organized. The spreading activation model is based on the notion that information is organized hierarchically in a network. Specifically, concepts are linked by their semantic relationships, and when a concept is processed, activation is spread out in the semantic network and other concepts are then activated and retrieved (Collins, & Loftus, 1975). However, this model is based on the structure of the brain in a monolingual human. It has been noted that the structure and organization of a bilingual's brain is not the sum of two monolingual structures; bilinguals have a unique structure of their own thanks to the co-occurrence of two languages. Bilinguals and monolinguals process information differently, because when bilinguals encounter information they typically give attention to it in both coexisting languages (Grosjean, 1989). A bilingual individual uses two languages in everyday life and this may be a contributing factor to having different memory performance than a monolingual individual. Bilingual individuals often encounter information in one language (e.g., English at work) and then relate this information in another language (e.g., Spanish at home); (Marmolejo et al., 2009). Currently, there are four hierarchical models that have been proposed to represent language in the brain of a bilingual individual, wherein each language known has a separate lexical store. However, for the purposes of this thesis, because only one model has been associated with balanced-bilinguals (i.e., individuals with equal proficiency in both languages) it is the model that is discussed next. According to the Mixed Conceptual Mediation Model for balanced-bilingual individuals (Potter, So, Von Eckardt, & Feldman, 1984), there exists a direct link between language one (L1) and language two (L2) as well as a direct link to the concept being processed. Therefore there is a direct link to the semantic meaning from lexical representations for two words, when one is in one language and the other is in the second language (i.e., *perro* and *dog*, for English and Spanish respectively). If bilinguals do perform differently in memory tasks when compared to monolinguals, then it is imperative to identify how they do so in order to understand what mechanisms are involved in the transfer of information when encoding and retrieval differ in language. Furthermore, what conditions within encoding and retrieval lead to maintaining accuracy as well what conditions produce more intrusions in memory that would reduce overall accuracy?

False Memory and the Levels of Processing Approach

Although fascinating, as just alluded to, memory is not perfect and it is prone to error. Such errors result in false memories, events that people remember as happening when they in fact never did or they remember them in a distorted fashion (Roediger & McDermott, 1995). False memories can either be implanted through external suggestion (Loftus 1997) or spontaneous through implicit overlapping of word association (Roediger & McDermott, 1995). According to the misinformation effect phenomenon, false memories are implanted through the suggestion of misleading information (Loftus, 1979; Loftus, & Hoffman, 1989), such that, misleading post-event information influences human memory by altering the recollection of an event (Tousignant, Hall, & Loftus, 1986). It has been noted that no one seems to be immune to the misinformation effect, and low cognitive abilities that promote not fully attending, result in higher susceptibility for false memories (Frenda, Nichols, & Loftus, 2012). Even bilingual eyewitnesses have been shown to be as susceptible to the misinformation effect as are monolingual eyewitnesses, regardless of whether the event is recalled in the same language or another language (Shaw, Garcia, & Robles, 1997).

When it comes to spontaneous false memories, the Deese-Roediger-McDermott (DRM) paradigm is one methodology used to elicit such faulty recollections. In studies using the DRM procedure participants are presented with a lists of words (e. g., *affection, kiss, pain, life, friendship, everything, heart, tenderness, pleasure, and desire*) that are all generally associated to one critical word (e. g., *love*) not present in each list; participants are then asked to recall as many items from the list as possible. The critical items participants recall as being part of the list are evidence of false memories (Deese, 1959; Roediger, & McDermott, 1995). Surprisingly enough, participants in DRM studies tend to be as confident of the presence of false items in the list as they are confident for the presence of the study words in the list (Payne, Elie, Blackwell, & Neuschatz, 1996). The DRM paradigm has shown to be a significantly reliable measure of false memories. The false memories that are generated with the DRM paradigm appear to be stable even across time (Blair, Lenton, & Hastie, 2002; Toglia et al., 1999).

Bartlett (1932) proposed a schema theory wherein he described information as being represented by schemas, mental packets that provide a cognitive framework to help organize concepts. Given such a structure to (semantic) memory, he explained that when humans encounter new information this knowledge interacts with knowledge already stored in schemas. When people commit errors in recall or recognition, most inaccuracies are related to information that was already stored (Bransford & Franks, 1971) suggesting new information was integrated with old, which in turn led to errors in memory. Schema theory stresses that humans are actively engaged in the processing of information that can be stored in mental packets that provide organizational strategies that support retrieval. However when representations dealing with semantic features are relied upon, as can be the case with schemas, distorted memories may be retrieved. Therefore, the integration of old and new knowledge within a schema may result in illusory memories. Individuals may access information in a distorted fashion, and claim to remember something as happening when it never did. In other words, actively retrieving stored memories after new information is presented, may result in the distortion of such memories, thus retrieving false memories.

As mentioned earlier, humans process information in an active fashion. However, models of STM/LTM propose a more passive view of information processing focusing on where items are stored. Shortly after such passive proposals, an alternative manner of viewing human memory was introduced that focused on how information is encoded, which implies that the learner is active. This is in fact the approach called Levels of Processing (LOP), first proposed by Craik and Lockhart (1972). According to the Levels of Processing theory, deeper levels of processing (e.g., semantic-processing) produce stronger memory traces than shallow levels of processing (e.g., non-semantic-processing, such as attending to structural or phonemic characteristics); (Craik & Lockhart, 1972). Until relatively recently, LOP experiments have mainly addressed accurate memory. In some more recent studies researchers manipulating LOP have examined both accurate memories and false memories.

The benefits of deeper processing have been shown to actually backfire and produce higher levels of false memory (Thapar, & Mcdermott, 2001; Toglia, Neuschatz & Goodwin, 1999). Toglia et al. (1999) found that, when using the DRM paradigm, semantic processing leads to higher true recall, but at the cost of higher false recall, a pattern known as “more is less” where there is a positive relationship in the increase of both true recall and false recall.

Several theories can account for the DRM illusion, including the spreading activation theory described above, when a list item is processed activation is spread out in the semantic network and other related concepts are then activated, therefore activating relative intrusions which can later be retrieved. As previously mentioned, bilinguals appear to have a different brain structure than monolinguals, wherein each language known has a separate lexical store. There is a direct link between languages and a direct link between the semantic representations of the words in its respective language (Wakeford et al., 2009). Therefore, activation is spread out through lexicons and related concepts on both languages may be activated. This spreading activation may trigger related words (some of which will result in intrusion errors) when a concept is processed in one language and retrieved it in another.

Fuzzy trace theory (FTT) may also explain the semantic processing influence found in Toglia et al.' (1999) study. According to FTT, humans encode information independently in two different representations, verbatim (i.e., surface contextual features) and gist (i.e., semantic features) and these representations are formed individually and in parallel (Reyna, & Brainerd, 1995; Reyna, & Kiernan, 1994). False memories have gist traces because the information seems familiar, but they do not have verbatim traces because they were never actually presented (Brainerd, & Reyna, 2002). Semantic processing results in stronger gist traces compared to non-semantic, resulting in higher true recall and higher intrusions (Toglia et al., 1999). Retrieval of concepts in one language when studied in another relies on gist traces, which in turn can increase the probability of intrusions.

Language's Influence on the DRM Illusion

The same pattern involving English-monolinguals in DRM studies has also been observed in Spanish-monolinguals. Spanish-monolinguals show susceptibility to the DRM paradigm; critical items are recalled as being part of the list (Garcia-Bajos, & Migueles, 1997). The DRM paradigm also elicits false memories in Portuguese monolinguals (Stein & Pergher, 2001) and Japanese monolinguals (Kawasaki, & Yama, 2006), and thus, the DRM paradigm is a reliable procedure to elicit false memory regardless of language.

Language appears to influence false memory, and different memory patterns are observed in bilingual participants when compared to monolingual participants (Cabeza, & Lennartson, 2005; Howe, Gagnon, & Thouas, 2008; Kawasaki-Miyaji, Inoue, & Yama, 2004; Marmolejo, Diliberto-Macaluso, & Altarriba, 2009; Sahlin, Harding, & Seamon, 2005; Wakeford et al., 2009). It appears that language does influence memory of critical items when bilingual participants study DRM lists. However, when compared to English-monolinguals different patterns tend to be observed. When investigating false memories in bilingual participants using the DRM paradigm it is common to compare differences in memory within-language (i.e., encoding language and recall language match) and across-language (i.e., encoding language and recall language mismatch). A particular pattern has been observed when Spanish-English bilinguals participants are involved; recall for old items (i.e., items present in the list) is higher for within-language conditions than cross-language conditions, and recall for critical items is higher for cross-language conditions than within-language conditions (Marmolejo et al., 2009; Sahlin et al., 2005; Wakeford et al., 2009). This same pattern holds also true for Japanese-English bilinguals (Kawasaki-Miyaji, Inoue, & Yama, 2004). Interestingly enough, research involving French-English bilinguals has shown that the pattern for old items recalled is the same as Spanish-English bilinguals, however the pattern is not the same for false recall; recall for critical items is higher for within-language conditions than cross-language conditions (Cabeza, & Lennartson, 2005; Howe et al., 2008).

The “more is less” pattern (Toglia et al., 1999) mentioned earlier has not yet been explored using bilingual participants. However, according to a recent study, semantic-processing led to memory interference in Catalan-Spanish bilinguals. Semantically related words (e.g., Donkey-Horse) produce higher memory interference than non-semantically related words (e.g., Donkey-Sunday); (Moldovan, Snachez-Casa, Demestre, & Ferre, 2012). The current study expanded upon previous investigations concerning memory of Spanish-English bilinguals using the DRM paradigm by exploring the influences of semantic-processing.

Current Study

Word-association influences bilinguals' false memory. However, the link between word-association and levels of processing in bilinguals has not yet been investigated. Unlike previous studies, the following experiment replicated previous findings on false memory for within and across language conditions and further explored semantic-processing and its effects on false memory. In this study, Spanish-English participants listened to six DRM word lists in either English or Spanish, and recalled in either the same language as the words were presented or in the opposite language. Procedurally different than most previous research, as DRM words were presented, participants performed a semantic task for half of the lists and a non-semantic task for the other half. English-monolingual participants listened to the six DRM lists in English and recalled in English as well as performing the semantic and non-semantic tasks accordingly to serve as a control group. The following outcomes were hypothesized within a 2(Language: Within-language or Across-language) x 2 (Levels of processing: Semantic or Non-semantic) mixed design:

1. There would be a main effect for language; cross-language conditions would have the lowest true recall and the highest false recall overall.
2. There would be a main effect for levels of processing; semantic-processing would lead to higher true recall and higher false recall; the "more is less" pattern is expected overall.
3. There would not be a levels of processing and language interaction, because semantic-processing together with cross-language conditions (i.e., Study in English, recall in Spanish; study in Spanish, recall in English) would have the lowest true recall and the highest false recall. A "less is less" pattern should emerge.

Method

Participants:

All participants in this study were 18 years or older. Twenty-five Psychology students were recruited through the online system SONA at University of North Florida and were selected for the English-English condition. Sixty-three Spanish-English bilingual participants were recruited from advanced Spanish classes (e. g., Spanish Literature, Spanish History, Advanced Spanish) from the Languages, Literature, and Cultures department at the University of North Florida and were randomly assigned to the Spanish-Spanish, Spanish-English, and English-Spanish conditions. Data for three of the bilingual participants had to be discarded due to their not following directions correctly. All Spanish-English bilinguals completed a short survey at the end of the study to determine demographics. Participants identified themselves from a variety of different nationalities including American, Colombian, Puerto Rican, Salvadorian, Peruvian, Mexican, Spanish, Argentinean, Cuban, and Caribbean. Participants rated their perceived ability on how well they speak Spanish on a scale from 1 (not well at all) to7 (very well). On average bilingual participants rated their ability on this scale at 5.3 (SD = 1.23). In addition, all participants were asked to report how long they had spoken Spanish. Figure 1 shows the distribution for the participants' answers and reveals that most participants stated that they had spoken Spanish for six or more years.

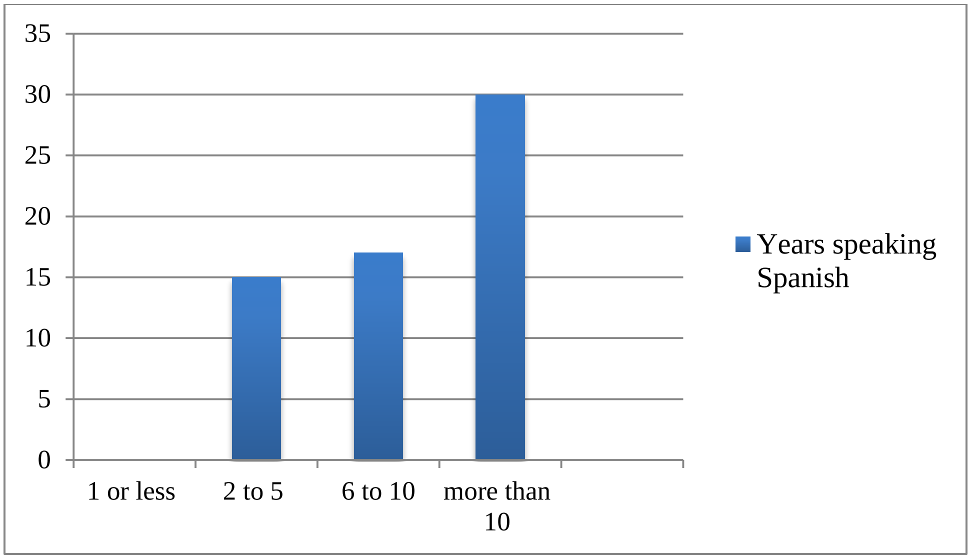

Figure 1: Number of years bilingual participants reported speaking Spanish.

Design:

Previous researchers addressing bilingual false memory designed their analyses around mean differences for across language vs. within language (Marmolejo, et al., 2009; Wakeford, et al., 2009). To keep consistent with previous research this study was framed as a 2(Language: Within-language or Across-language) x 2 (Levels of processing: Semantic or Non-semantic) mixed design. Within-language and across-language were manipulated between participants. Bilingual participants were randomly assigned to one of three conditions: Spanish-Spanish, English-Spanish, and Spanish-English. English-monolinguals were selected for the English-English condition. Levels of Processing were manipulated within participants; all participants studied half of the lists semantically and the other half non-semantically. To counterbalance, half of the participants in all conditions studied the first three lists semantically and the last three lists non-semantically; the other half studied the first three lists non-semantically and the last three lists semantically. All six lists were presented in different randomized orders for all conditions. However, a more detailed design was also employed to more fully examine the experimental results. Analyses were also studied in a 2(Language Studied: English or Spanish) x 2(Language Recalled: English or Spanish) x 2(levels of processing: Semantic or Non-semantic) wherein both language studied and language recalled where manipulated between participants, and type or studying was manipulated within participants.

Materials:

The study included six DRM lists, each containing 12 words (e. g., *affection, kiss, pain, life, friendship, everything, heart, tenderness, pleasure, and desire*) associated to a critical word (e. g., *Love*). All lists had an English and Spanish version (see Appendix). The six lists were acquired from Marmolejo et al. (2005). Using the recording software Garage Band the experimenter recorded both versions of all word lists. With the aid of a metronome all lists were recorded allowing 3 seconds in between each item. Each participant received a twelve-page booklet to record all answers. Three pages were relevant to the semantic-task and contained pleasantness-rating scales; with 12 scales ranging from 1(unpleasant) to 5(pleasant) and the directions indicating to rate each word they heard by how pleasant they found it. Another three pages pertained to the non-semantic task instructing participants to circle YES or NO if the word they heard contained the letter "A". Each task-page was followed by a recall-page instructing participants to record in any order as many words as they could remember. The booklets were either in English or in Spanish depending on which language condition the participants were presented the list items.

Procedure:

Participants were tested in groups of ten or more. In the within-language conditions participants listened to the lists in either English or Spanish and recalled the items in the same language; and in the cross-language conditions participants listened to the lists in either English or Spanish and recalled the opposite language. After signing a consent form all participants were instructed to listen to the word lists because they would later be asked to recall them, however none were told whether they would recall in a different language or the same language until they got to the recall page. Therefore, participants would be aware of what to expect after the second list was presented. Participants were instructed that a “beep” sound indicated the beginning and the end of each list. The initial “beep” indicated the words were about to be presented and the second “beep” indicated the list ended and they could move to the next page and begin free recall. All participants studied half of the lists semantically and the other half non-semantically. The non-semantic task consisted of indicating whether or not the word they listen to contained the letter “A” or not, and the semantic task consisted of rating each word they listened to on how pleasant they found it on a rating-scale from 1(unpleasant) to 5(pleasant). During recall participants were instructed to either recall in English or Spanish depending on the condition which they had been assigned, and were given one minute to recall as many items and they could from each list.

Analyses:

All analyses were performed using SPSS. The general linear model method Analysis of Variance (ANOVA) Repeated-Measures was used to analyze all data. Mauchly’s test of Sphericity was examined to determine whether the equal variances assumption had been met. An alpha level of .05 was set for all tests.

Results

True Recall:

Mean differences were calculated using a 2 (Language: Within-language or Across-language) x 2 (Level of processing: Semantic or Non-semantic) mixed ANOVA. A main effect for level of processing was found $F(1,83) = 55.691$, $p < .001$, $\eta^2_p = .402$. Semantic-processing (M = 16.88, SD = 5.28) resulted in higher true recall overall than non-semantic processing (M = 13.80, SD = 5.35). Another main effect was found for language $F(1,83) = 63.75$, $p < .001$, η^2_p = .434. Participants in the within-language conditions (M = 18.48, SD = 4.59) recalled more studied list items than participants in the across-language conditions (M = 11.96, SD = 3.75). No interaction was found between levels of processing and language $F(1,83) = .037$, $p = .848$, η^2_p = .001.

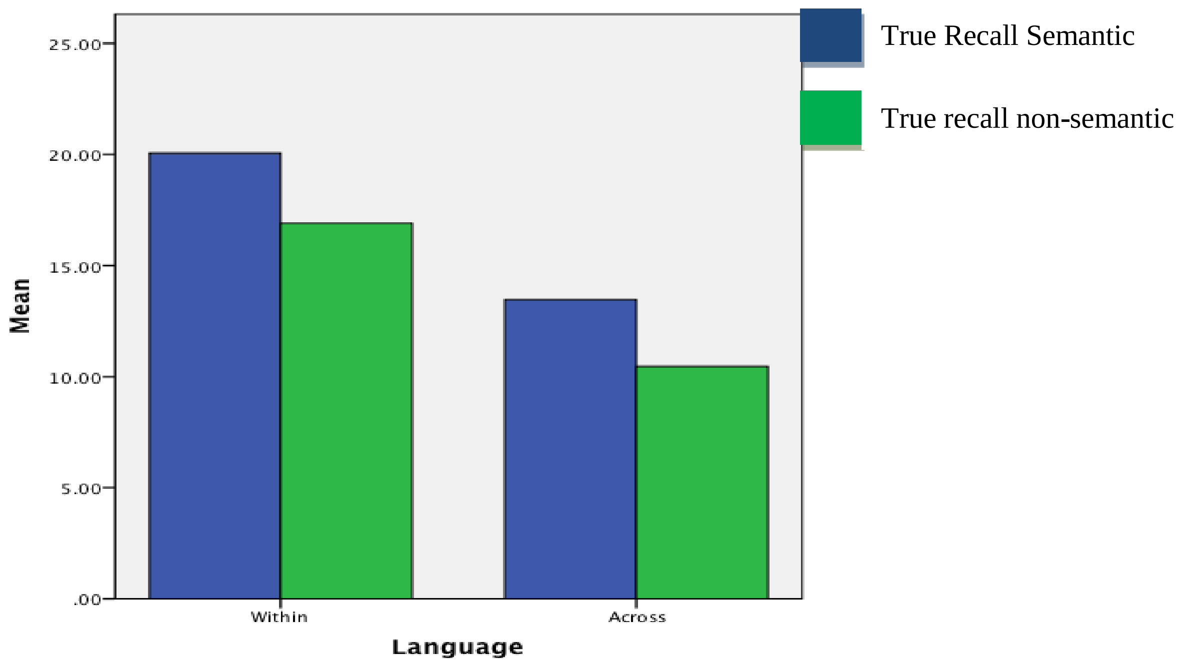

Figure 2: Mean correct true recall for studied items within-language and across-language

Figure 2 shows the means for correct (true) recall of studied items for both within-language and across-language and reveals the expected results congruent with previous research. Studying list items semantically as well as recalling the items the same language as the language studied, leads to higher true recall.

A more in detail analysis was conducted and mean differences were calculated using a

2(Language Studied: English or Spanish) x 2(Language Recalled: English or Spanish) x 2(Levels of Processing: Semantic or Non-semantic) mixed ANOVA. It revealed a main effect for language studied was found $F(1,81) = 17.13$, $p < .001$, $\eta^2_p = .175$. Participants who studied the lists in English ($M = 16.51$, $SD = 5.66$) recalled more list items than participants who studied the lists in Spanish ($M = 13.58$, $SD = 4.19$). Another main effect for language recalled was found $F(1,81) = 13.66$, $p < .001$, $\eta^2_p = .144$. Participants who recalled the lists in English ($M = 16.35$, $SD = 5.85$) remembered more list items than participants who recalled the lists in Spanish ($M = 13.74$, $SD = 4.02$). An interaction for language studied and language recalled was found $F(1,81) = 75.194$, $p < .001$, $\eta^2_p = .481$. Participants who studied the lists in English and recalled in English ($M = 20.89$, $SD = 3.59$) recalled the highest number of list items, followed by participants who studied in Spanish and recalled in English ($M = 15.34$, $SD = 3.8$), followed by participants who studied in English and recalled in Spanish ($M = 12.14$, $SD = 3.68$), and lastly participants who studied in Spanish and recalled in Spanish ($M = 11.83$, $SD = 3.75$) reported the least amount of list items. It appears the studying in English or Spanish but recalling in English leads to higher true recall. No other interactions were significant.

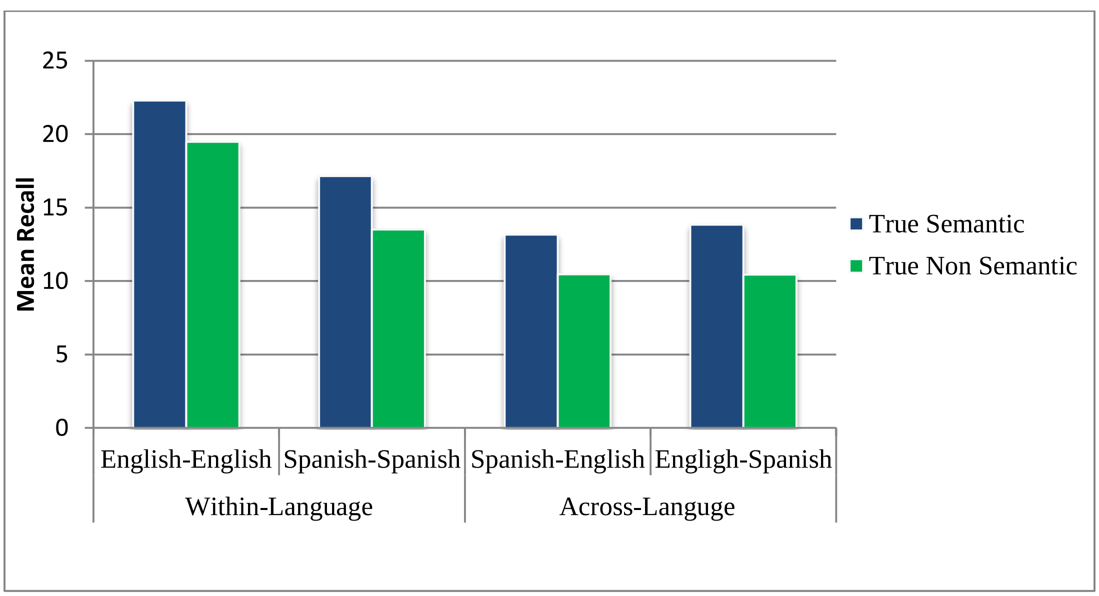

Figure 3: Mean correct for true recall for studied items in all four conditions.

Figure 3 shows the means for correct (true) recall of studied items for all conditions and reveals that studying list items semantically as well as recalling the items the same language as the language studied, leads to higher true recall. However, reveals an interaction between language studied and language recall. Although not consistent with the expected results, the interaction could be possible due to the English-English condition wherein participants were all English monolinguals.

False Recall:

For any given condition participants could falsely remember a maximum of three critical items. The vast majority of participants reported at least one critical item. Mean differences were calculated using a 2 (Language: Within or Across) x 2 (Level of processing: Semantic or Non-semantic) mixed ANOVA. There were no significant main effects for levels of processing $F(1,83) = 1.719$, $p = .193$, $\eta^2_p = .020$, nor for language $F(1,83) = .501$, $p = .481$, $\eta^2_p = .006$. The interaction between language and levels of processing was also non-significant, $F(1,83) = .099$, $p = .754$, $\eta^2_p = .001$.

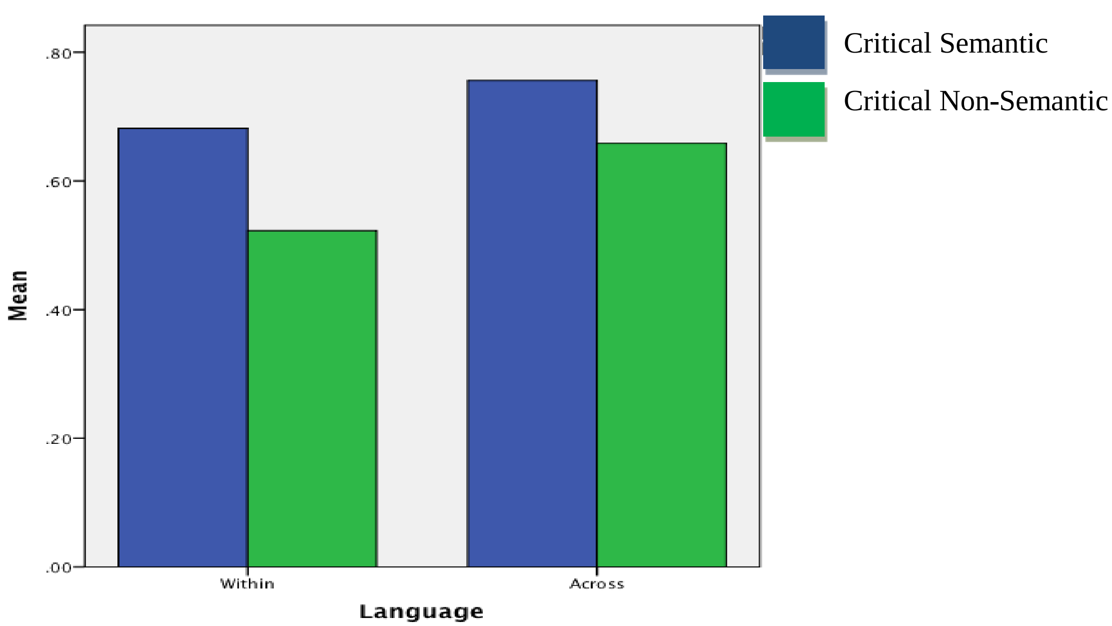

Figure 4: Mean critical items recalled for within-language and across-language.

Although all main effects and interactions were non-significant, Figure 4 shows the hypothesized pattern, as participants in the across- language condition who processed the lists semantically reported slightly higher recall of critical items.

A 2(Language Studied: English or Spanish) x 2(Language Recalled: English or Spanish) x 2(Levels of processing: Semantic or Non-semantic) mixed ANOVA revealed a main effect for language studied, $F(1,81) = 5.52$, $p = .021$, $\eta^2_p = .064$. Participants who studied the items in English ($M = .80$, $SD = .79$), reported higher critical items than participants who studied in Spanish ($M = .45$, $SD = .82$). Another main effect for language recalled was significant, $F(1,81) = 3.96$, $p = .033$, $\eta^2_p = .055$. Participants who recalled the items in English ($M = .79$, $SD = .91$), reported higher critical items than participants who recalled in Spanish ($M = .49$, $SD = .64$). The main effect for Levels of Processing and the interactions were not significant.

Critical Items and Relevant Intrusions:

In addition to false memories in the form of recalling critical items, participants also remembered non-list words that were thematically consistent with the list. These kinds of memory errors are referred to in this paper as relevant intrusions. To better estimate the degree of false memory exhibited by participants, a measure of total false recall was computed. This measure was calculated by adding critical item errors and relevant intrusions, thus producing an overall estimate of false memory. Mean differences were calculated using a 2 (Language: Within or Across) x 2 (Level of processing: Semantic or Non-semantic) mixed ANOVA. A main effect for level of processing was found $F(1,83) = 12.406$, $p = .001$, $\eta^2_p = .130$. Semantic-processing ($M = 1.87$, $SD = 1.71$) resulted in higher overall false recall than non-semantic processing ($M = 1.21$, $SD = 1.51$). Another main effect was found for language $F(1,83) = 19.245$, $p < .001$, $\eta^2_p = .188$. Participants in the within-language conditions ($M = .977$, $SD = 1.05$) committed fewer false recall errors than participants in the across-language conditions (*M* = 2.14, *SD* = 1.85). No interaction was found between levels of processing and language $F(1,83) = 1.863$, $p = .176$, $\eta^2_p = .176$.

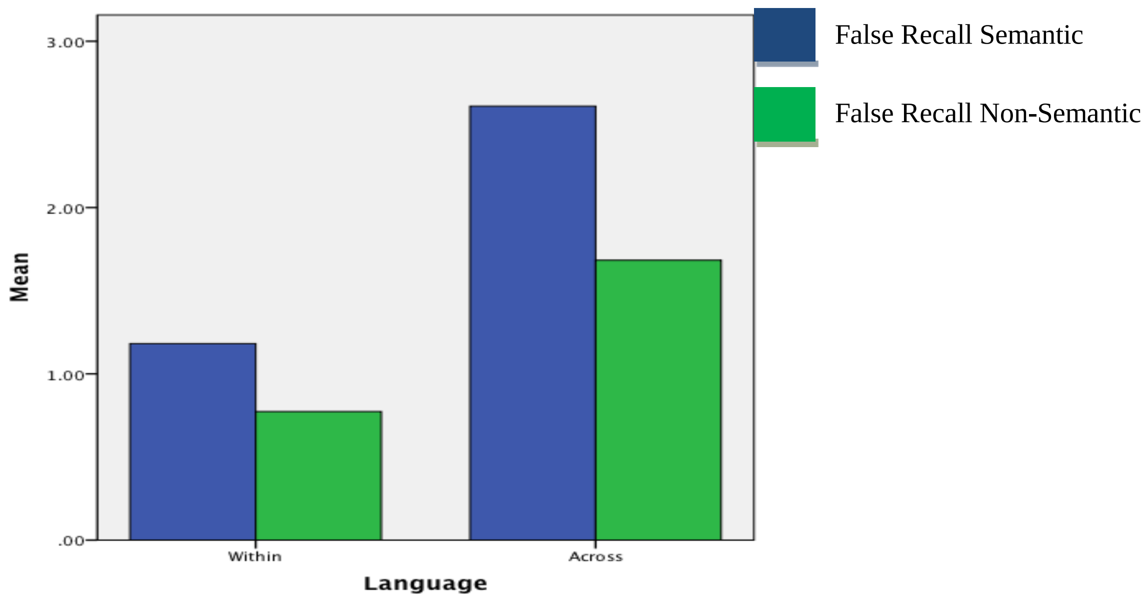

Figure 5: Mean false recall for within-language and across-language.

Figure 5 shows the means for total false recall for both within-language and across-language. It reveals the expected results congruent with past research, wherein studying semantically and recalling the items in the opposite language leads to higher false recall.

A 2(Language Studied: English or Spanish) x 2(Language Recalled: English or Spanish) x 2(Levels of processing: Semantic or Non-semantic) mixed ANOVA revealed that no main effect for language studied was found $F(1,83) = .195$, $p = .660$, $\eta^2_p = .002$. However, a main effect was found for language recalled $F(1,83) = 10.26$, $p = .002$, $\eta^2_p = .112$. Participants who recalled the items in English (*M* = 1.92, *SD* = 1.71) reported higher false items than participants who recalled in Spanish (*M* = 1.09, *SD* = 1.29). An interaction between language studied and language recalled was also found. Participants who studied the lists in Spanish and recalled in English (M = 2.45, SD = 2.05) recalled the highest number of false items, followed by participants who studied in English and recalled in Spanish (M = 1.75, SD = 1.51), followed by participants who studied in English and recalled in English (M = 1.38, SD = 1.11), and lastly participants who studied in Spanish and recalled in Spanish (M = .45, SD = .68) reported the least amount of false items. No other main effects or interactions were found.

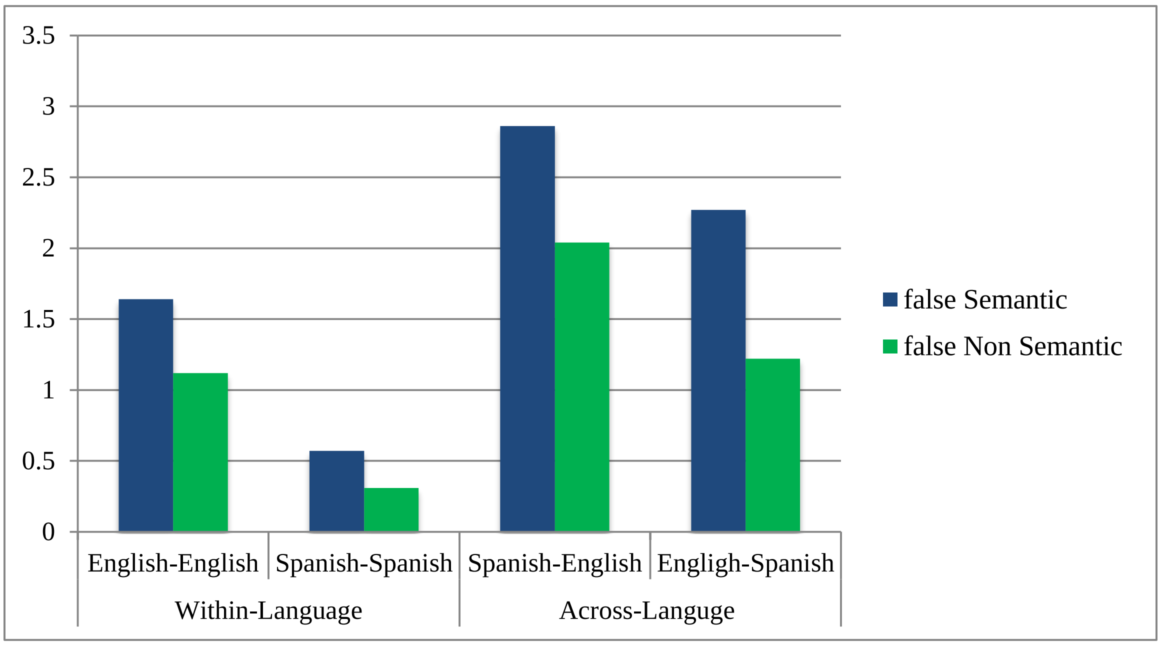

Figure 6: Mean false recall for all conditions.

Figure 6 reveals that studying semantically in one language and recalling in another leads to higher false recall. Results were consistent with previous research, however an interaction between language studied and language recalled was revealed and could be due to the English-English condition wherein participants were all English monolinguals.

Accuracy:

A global measure of accuracy was calculated using Howe & Derbish's (2010) formula to determine overall accuracy statistic [true recall/ (true recall + total false recall)]. A marginally significant main effect for Levels of Processing was found $F(1,83) = 3.074$, $p = .083$, $\eta^2_p = .036$. Semantic-processing ($M = .896$, $SD = .093$) resulted in somewhat lower accuracy overall than non-semantic processing ($M = .916$, $SD = .099$). A main effect was found for language $F(1,83) = 53.163$, $p < .001$, $\eta^2_p = .390$. The within-language condition participants ($M = .955$, $SD = .046$) achieved higher accuracy than the across-language condition participants ($M = .855$, $SD = .010$). No interaction was found between levels of processing and language $F(1,83) = .516$, $p = .475$, $\eta^2_p = .006$.

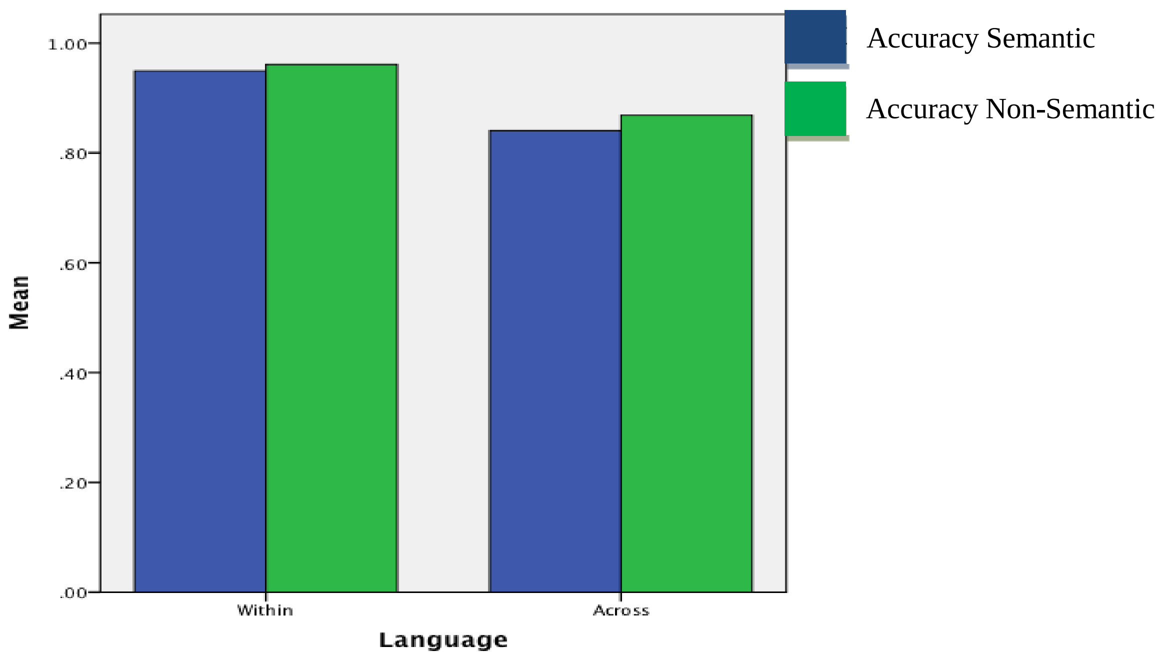

Figure 7: Mean accuracy scores for within-language and across-language.

Figure 7 shows the means for these accuracy scores for both within-language and across-language and reveals that studying non-semantically and recalling within language slightly increases accuracy.

The 2(Language Studied: English or Spanish) x 2(Language Recalled: English or Spanish) x 2(Levels of processing: Semantic or Non-semantic) mixed ANOVA revealed that no main effect for language studied was found $F(1,81) = .91$, $p = .766$, $\eta^2_p = .002$. However, a main effect was found for language recalled $F(1,81) = 6.62$, $p = .012$, $\eta^2_p = .076$. Participants who recalled items in Spanish (*M* = .92, *SD* = .10) achieved higher accuracy than Participants who recalled the items in English (*M* = .89, *SD* = .09) An interaction between language studied and language recalled was also found $F(1,81) = 54.914$, $p < .001$, $\eta^2_p = .404$. Participants who studied the lists in Spanish and recalled in English (*M* = .97, *SD* = .10) achieved the highest accuracy, followed by participants who studied in English and recalled in English (*M* = .94, *SD* = .05), followed by participants who studied in English and recalled in Spanish (*M* = .87, *SD* = .11), and lastly participants who studied in Spanish and recalled in Spanish (*M* = .84, *SD* = .04) achieved the lowest accuracy. No other main effects or interactions were found.

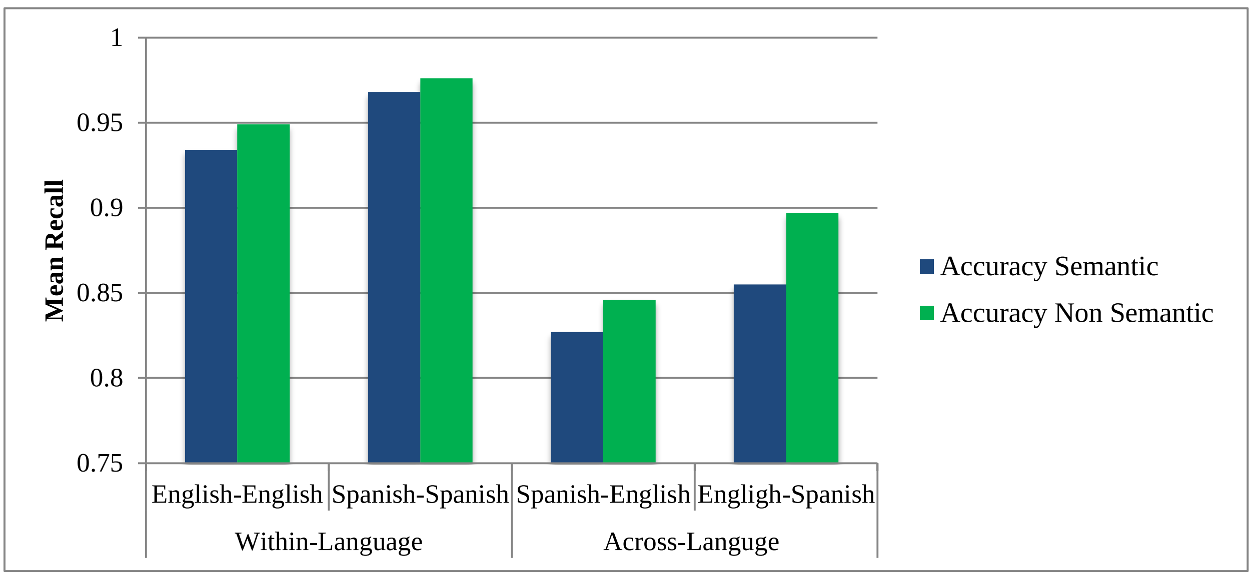

Figure 8: Mean accuracy scores for all studied and recalled conditions.

Figure 8 shows the means of accuracy scores for all conditions. It appears that that studying non-semantically and recalling within language slightly increases accuracy.

Discussion

In this experiment the influence of levels of processing in Spanish-English bilingual false memory was investigated. The link between word-association and levels of processing in bilinguals was studied within the DRM paradigm (Deese, 1959; Roediger & McDermott, 1995). All of the proposed hypotheses for the current study that pertained to the 2x2 design were supported. Language and LOP both appear to influence false memories in Spanish-English bilinguals. Similar results to previous findings on false memory for within-language and across-language conditions were found. True recall was found to be higher for within-language conditions than cross-language conditions, and false recall was found to be higher for cross-language conditions than within-language conditions. (Marmolejo et al., 2009; Sahlin et al., 2005; Wakeford et al., 2009). In addition, semantic-processing led to higher true recall and higher false recall. Toglia et al.'s (1999) "more is less" pattern was observed in all conditions wherein greater correct recall was accompanied by greater false recall. Lastly, both levels of processing and language had a significant effect on false memory. A "less is less" pattern was established wherein semantic-processing together with cross-language conditions produced the lowest true recall and the highest false recall.

The spreading activation model is consistent with the experiment's results (Collins & Loftus, 1975). However, as noted earlier this model is based on a monolingual structure. The results largely support the mixed conceptual mediation hierarchical model. True recall appears to be lower in cross-language and false recall appears to be higher cross-language; the activation seems to be spreading across the lexicons (Wakeford et al., 2009). Furthermore, as mentioned earlier, Fuzzy Trace Theory may also explain the observed influence of language and semantic-processing on false recall. False memories have gist traces because the information in them is familiar, and they are not associated with verbatim traces (Brainerd, &, Reyna, 2002). Semantic-processing results in stronger gist traces than non-semantic-processing. Therefore, semantic-processing results in higher true recall and higher intrusions (Toglia et al., 1999).

The overall results in this experiment corroborate previous findings on language influence and present further demonstration of how memory is prone to error by investigating the influence of both language and semantic-processing together. Although it has been theorized that bilingual processing is advantageous within the Bilingual Inhibitory Control Advantage (BICA) hypothesis, little evidence has been shown to support it. According to the BICA hypothesis, the repeated use of inhibitory processes within language selection should result in efficient inhibition processes and should reduce interference effects in bilinguals (Hilchey, & Klein, 2011). In other words, constantly inhibiting one language when processing the other should result in efficient processing, which should in turn result in less faulty memory. The results of the present study stand in contradiction to the BICA hypothesis and demonstrate that bilinguals appear to be equally, if not more, sensitive to interference effects when compared to monolinguals.

Even though this study provided evidence of the influence of levels of processing in Spanish-English bilingual false memory it is important to clarify its restrictions. The present study employed a limited number of DRM lists (i.e., six) and previous studies have often used more than ten. Thus, future studies should consider adding more DRM lists to the encoding phase, of course with appropriate translations across languages. Because of the restricted resources and access to advanced Spanish classes at the University of North Florida, some group sessions were larger than others; sometimes double the size. Because of the restricted access to bilingual students, the English-English participants were English-monolinguals. Monolinguals and bilinguals process information differently; therefore a monolingual condition might alter the results of the study. Furthermore, the restricted access to bilingual participants made the present focus of the study only on investigating differences in balanced Spanish-English bilinguals. Future studies should include non-balanced Spanish-English bilinguals in order to further explore bilingual differences. Importantly, examining a broader spectrum of bilingual capabilities is more in line with the variety of Spanish-English bilingual individuals who are interviewed or interrogated by the police.

The results of this study contribute to the promising ongoing research on bilingual associative memory and provide insight into the procedure involved in transferring information from one language at encoding and another at retrieval and how false memories occur during this transferring process. Today, close to twenty percent of the population in the United States is bilingual; and Spanish-English bilinguals represent more than half of all bilinguals in the country (Grosjean, 2012). With this pattern it is easy to predict that the bilingual population individuals will increase in the future in the U.S. The experiment’s results provide some implications regarding forensic bilingual interviewing. According to the results it would be best if bilingual eyewitnesses were interviewed in the same language as the language involved when information was encoded. Although being able to process information in multiple languages would appear to be a cognitive advantage, the results of this study reveal that the transferring of information from one language to another when information is semantically encoded may backfire and result in low true recall and high false recall. This combination is often seen in Standard Police Interviews. It has been shown that better technique to interview suspects is the Cognitive Interview (Fisher & Geiselman, 1992; Kohnken, Milne, Memon & Bull, 1999) it would be beneficial to conduct the cognitive interview in the same language as the event was witnessed in. Therefore, it is important to take into account not only the language in which an interview is conducted, but also the manner in which one is interviewed. Finally, to the extent that an interviewer assumes a suspect or victim of a crime has a solid semantic recollection of an event, the questions may include thematically-based ones in addition to asking for specific (verbatim) details. As this study would suggest, questions targeting themes may be a prescription for inducing an interviewee to commit false memories. Thus, both the interviewer and the interviewee should be aware of the possibility that such false memories could be possible if the interview is not performed in the same language as the event was witnessed.

Appendix 1: Six English Spanish DRM Lists

CITY	**CIUDAD**	**COLD**	**FRIO**	**DANCE**	**BAILE (BAILAR)**
Town	Pueblo	Hot	Caliente	Party	Fiesta
State	Estado	Snow	Nieve	Fun	Diversión
Streets	Calles	Warm	Tibio	Joy	Alegría
Country	Pais	Winter	Invierno	Waltz	Vals
New York	Nueva York	Ice	Hielo	Discoteque	Discoteca
Village	Aldea	Wet	Mojado	Movement	Movimiento
Big	Grande	Heat	Calor	Shoe	Zapato
Suburb	Afueras /Suburbio	Weather	Clima	Step	Paso
County	Condado	Freeze	Congelar	Partner	Pareja
People	Gente	Shiver	Tiritar	Jump	Saltar
Building	Edificio	Frost	Escarcha	Song	Canción
Noise	Ruido	Dark	Obscuro	costume	Disfraz

TIME	**TIEMPO**	**SLEEP**	**DORMIR**	**LOVE**	**AMOR (AMAR)**
Hour	Hora	Bed	Cama	Affection	Afecto
Clock	Reloj	Rest	Descansar	Kiss	Beso
Years	Años	Awake	Despierto	Pain	Dolor
Past	Pasado	Tired	Cansado	Life	Vida
Short	Corto	Dream	Soñar	Friendship	Amistad
Age	Edad	Wake	Despertar	Everything	Todo
Space	Espacio	Snore	Roncar	Happiness	Felicidad
Eternal	Eterno	Nap	Siesta	Feeling	Sentimiento
Époque	Época	Peace	Paz	Heart	Corazón
Eternity	Eternidad	Yawn	Bostezar	Tenderness	Ternura
Century	Siglo	Drowsy	Cansado	Pleasure	Placer
Second	Segundo	Night	Noche	Desire	Deseo

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