The Effects of Bilingualism and Attention on False Memory

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Abstract

In this study, we used a mixed-factor design to investigate the effects of bilingualism and attention on false memory. Monolingual and bilingual participants studied six word lists from the DRM Paradigm (Roediger & McDermott, 1995). For half the lists, participants divided their attention between studying the words and monitoring a number stream. For the other half of the lists, participants studied the words under full attention. After studying the word lists, participants were given a memory test. Results showed a marginally significant main effect of attention on false memory and a significant main effect of attention on true recall, but did not show any significant effects of bilingualism or any significant interactions on either false memory or true recall. This research is important in helping us further our understanding of the costs and benefits of dual-language programs.
The Effects of Bilingualism and Attention on False Memory

**Definition of Bilingualism**

Defining bilingualism is more complex than it appears. There is no single definition for bilingualism, and no standard criteria for proficiency that must be met in order for someone to be considered bilingual. In simplest terms, bilingualism is the ability to speak two (or more) languages. The issue with this definition is controversy over what constitutes a language. According to Bialystok (2001), clearly identifying individual languages is nothing but an illusion. Dialects of the same language, such as Arabic or Chinese, actually have greater differences than do separate languages such as Hindi and Urdu or Dutch and Flemish.

Another barrier to defining bilingualism is the lack of agreement about the amount of proficiency needed in each language in order for a person to be bilingual. Bilingualism is not a categorical variable, but rather a scale, with one end of the spectrum signifying no knowledge of another language and the other end signifying fluency in both languages. At what point on this scale would someone be considered bilingual? Most people conceptualize a bilingual as someone who is highly proficient in two languages. Scholars, however, have differing views. On one hand, scholars such as Bloomfield (1933) assert that a bilingual must be fully fluent in both languages, such that they are indistinguishable from native monolingual speakers in either language. On the other hand, psychologists such as Grosjean (1989) argue that a bilingual is never equally fluent in both languages, due to the different circumstances in which they use each one (e.g., speaking one language at home, but reading and writing in another language at school). Rather, a bilingual is someone who is able to function in each language according to the needs of a given circumstance.
Although language proficiency is often the determining factor in whether or not someone is considered bilingual, language proficiency is difficult to measure. There are no objective tests or simple assessments of language proficiency. In studies involving bilingual children, parental report is frequently the only measure of the children’s competence in each language. Many studies utilize functional fluency as the criteria for bilingual participants. Although bilinguals’ proficiency in their first language may not be equivalent to their second, their functional proficiency is the same: they can carry on conversations and perform the same activities in both languages. This measurement may be vague, but it acknowledges that fluency is comprised of numerous factors, and it may be the best measurement of proficiency researchers can use, given that more rigorous proficiency testing is not always feasible (Bialystok 2001).

Language Use in the United States

The American Community Survey (ACS), which is administered each year, is currently the principal source of data on language use in the United States. Of the 291.5 million people ages 5 and over for which data was collected in the 2011 ACS, 60.6 million (21%) spoke a language other than English (U.S. Census Bureau, 2011). The Census Bureau has identified 381 languages, which they have categorized into four major groups: Spanish, which includes Spanish Creole; Other Indo-European languages, such as German, French, Russian, and Hindi; Asian and Pacific Island languages, including Chinese, Tagalog, and Tamil; and All Other languages, such as Arabic, Hebrew, and the indigenous languages of Central and South America. The most common second languages spoken in the U.S. were: Spanish (62%), Chinese (4.8%), Tagalog (2.6%), Vietnamese (2.3%), and French (2.1%).
Developmental Differences Between Bilinguals and Monolinguals

Bilinguals and monolinguals have been shown to have different patterns of development in both verbal and nonverbal areas. Research has shown that bilinguals have an advantage over monolinguals in areas such as word awareness (Ben-Zeev, 1977; Feldman & Shen, 1971), syntactic awareness (Galambos & Hakuta, 1988), and creativity and problem-solving (Kessler & Quinn, 1980, 1987; Ricciardelli, 1992). Research has also shown certain disadvantages of bilingualism, particularly in terms of vocabulary (e.g., Doyle, Champagne, & Segalowitz, 1978). This may be because learning vocabulary requires more intentional effort, which poses no problem when there is only one language involved, but may be much more difficult to maintain at the same level for two languages (Bialystok, 2001).

Bilingualism and Attention

Bialystok (1999) assessed cognitive complexity and attentional control in bilingual and monolingual preschool children. The children completed two tasks: the moving word task and the dimensional change card sort task. In the moving word task, children are shown two pictures of common objects such as a tree and a car. A card with the name of one of the objects printed on it is brought out, the children are told what the card says (they cannot yet read independently), the card is placed under the corresponding picture, and the children are asked an introductory question about what the card says. The children’s attention is diverted and the card is placed under the wrong picture. The children are asked what the card says (inconsistent question). The children’s attention is diverted again, the card is placed back under the correct picture, and the child is again asked what the card says (consistent question). This sequence was presented three times. Children received a point for each question they answered correctly, getting a total score out of three for each of the introductory, inconsistent, and consistent questions.
In the dimensional change card sort task, children are asked to sort a set of cards into two groups based on a feature of the items on the cards, then are asked to sort the same cards again using a different feature. The set of cards used in this study showed circles and squares that were either red or blue. In the first phase of this task, children sorted the cards by color. In the second phase, the cards were sorted by shape.

The results showed a bilingual advantage for both the moving word task and the dimensional change card sort task. Both of these tasks present children with a situation in which there is conflicting information, and in which they must pay attention only to the relevant information in order to perform the task correctly. Since bilinguals outperformed the monolinguals on both tasks, this shows that bilinguals have better attentional control than monolinguals.

Bialystok & Martin (2004) also used the dimensional change card sort task to examine attention and inhibition in bilingual children. Their study consisted of three different experiments. The first experiment showed that bilinguals outperformed monolinguals on versions of the task that had moderate representational demands. The second and third experiments showed that bilinguals performed better than monolinguals when the target dimensions were perceptual features of the items. The researchers concluded that bilinguals have better inhibitory control and are better able to ignore irrelevant perceptual information, confirming the results of Bialystok’s (1999) original study.

Carlson & Meltzoff (2008) looked at bilingual experience and executive functioning in children. They compared 50 kindergarten children who were native Spanish-English bilinguals, monolingual English speakers, and English speakers enrolled in second-language immersion kindergarten. The children were administered a battery of tasks assessing executive functioning,
including the Dimensional Change Card Sort Task, Simon Says, Visually Cued Recall, Kansas Reflection/Impulsivity Scale, Comprehensive Test of Nonverbal Intelligence, Attention Network Test, and Delay of Gratification. Results showed that the native bilinguals performed better on all tasks than both the monolinguals and the immersion children. The advantage was particularly significant for the Dimensional Change Card Sort Task and Attention Network Test where managing conflicting attentional demands is vital to the successful completion of the task.

Kapa & Colombo (2013) investigated attentional control in monolingual and bilingual children. Participants were 22 monolinguals, 21 early Spanish-English bilinguals (who had learned both languages by age 3), and 36 later Spanish-English bilinguals (who had learned both languages after age 3). Participants completed a variety of tasks, including the Forward Digit Span Task, the Peabody Picture Vocabulary Test-III, and the Attention Network Test (ANT). The ANT was adapted for use in children. In a typical ANT, adults are shown a series of arrows and are asked to indicate the direction of the target arrow. Attentional inhibition is not necessary on congruent trials where all the arrows are pointing the same direction (→ → → → →) since there is no conflicting information there. Attentional inhibition is required on incongruent trials when the target arrow is facing a different direction than the other arrows (→ → ← → →). In this study, the arrows were replaced with fish to make the task more fun and engaging for the children. The results of the ANT showed that early bilingual children outperformed both monolingual and later bilingual children, showing that bilinguals have better attentional inhibition and suggesting that advantages are stronger for bilinguals with higher proficiency/more experience using two languages.

Pelham & Abrams (2014) also used the ANT to examine attentional control in early and late bilinguals. The participants in this study were college students, comprised of 30 monolingual
English speakers, 30 early Spanish-English bilinguals, and 30 late Spanish-English bilinguals. Participants completed three blocks of 96 trials of the ANT. One third of the trials were congruent, one third were incongruent, and one third were neutral (the target arrow was flanked by horizontal lines instead of other arrows). The results showed that bilinguals performed better than the monolinguals. There was no difference between the early and late bilinguals, which is different from the results found by Kapa & Colombo (2013). This may be because not all of the bilinguals were equally fluent in their two languages in the study by Kapa & Colombo (2013), whereas in this study by Pelham & Abrams (2014), both the early and late bilinguals were fluent in English and Spanish. This suggests that age of acquisition may not be as important as proficiency in producing cognitive advantages of bilingualism.

Research on bilingualism and attention consistently shows that bilinguals have better selective attention and attentional control than monolinguals. This phenomenon can be explained by bilinguals’ extensive practice controlling their languages. Whenever bilinguals use one language, both of their languages are completely activated. This means that bilinguals must attend to the information from one language and ignore the information from the other language that they are not using. This constant practice of ignoring irrelevant information is thought to lead to better attentional control, which manifests itself in nonverbal tasks as well (Bialystok, 2001).

**Bilingualism and Memory**

The effects of bilingualism on memory have been examined in both children and adults. Kormi-Nouri and colleagues (2003, 2008) have investigated the impact of bilingualism on both episodic and semantic memory in children. Episodic memory refers to memory of events, times, and places that are related to a specific experience. Semantic memory is general knowledge or information that is not connected to a specific experience.
Kormi-Nouri, Moniri, & Nilsson (2003) compared bilingual and monolingual children’s episodic and semantic memory performance. Episodic memory was tested using forty sentences in imperative form (e.g., “read the book”; “give me the spoon”) as the items to be remembered. Semantic memory was tested using a letter fluency test in which the children were given a letter and had to think of as many words as possible that began with that letter. Participants were 60 Swedish monolinguals and 60 Iranian-Swedish bilinguals ages 7-13. Participants listened to the forty sentences, which were presented one at a time using a tape recorder. Afterwards, they were given a word fluency test and were instructed to list as many words as they could beginning with the letter “S” or “B” in 2 minutes. Participants were then given a free recall test to remember as many sentences as they could in 7 minutes. After the free recall test, they were given another word fluency test. Finally, they received a cued recall test. The results showed a positive effect of bilingualism: bilinguals outperformed monolinguals in both episodic and semantic memory tasks. Kormi-Nouri et al. (2008) conducted a similar study using Persian monolinguals, Turkish-Persian bilinguals, and Kurdish-Persian bilinguals. Their study consisted of four different experiments, and in all four the results showed that bilinguals had better memory performance than monolinguals in both episodic and semantic memory.

Fernandes, Craik, Bialystok, & Kreuger (2007), Schroeder & Marian (2012), and Ljungberg, Hansson, Andrés, Josefsson, & Nilsson (2013) have investigated bilingualism and memory in adults. Schroeder & Marian (2012) compared bilingual and monolingual older adults (73-88 years old) on episodic memory using a picture scene recall task. During the encoding phase, participants viewed a slide show of 80 pictures depicting various scenes. The encoding was incidental since they were not told that they would have to remember these pictures later. During the retrieval phase, participants completed a delayed free recall test. They were instructed
to verbally report all of the pictures that they remembered seeing. Results showed that bilinguals recalled more pictures than monolinguals, demonstrating that bilinguals had better episodic memory.

Ljungberg et al. (2013) conducted a longitudinal study of memory in bilinguals. Participants were drawn from the Betula Prospective Cohort Study investigating aging, memory, and health, and included 104 bilinguals and 74 monolinguals ranging in age from 35-70 years. At each assessment, participants completed 3 different tasks assessing episodic memory. They also completed a letter fluency task and a category fluency task, both of which assessed semantic memory. Participants were assessed at baseline and then again at 4 different intervals. Results showed that while there was no advantage for bilinguals for category fluency, bilinguals performed better than monolinguals in episodic memory and letter fluency both at baseline and across time.

Fernandes et al. (2007) also found mixed results. They examined the impact of bilingualism, aging, and semantic relatedness on memory under divided attention. Participants were 52 college students and 52 older adults. Half of each age group were monolingual English speakers and half were bilingual speakers. The study utilized a within-subjects design, such that all subjects participated in each of the five conditions. In all five conditions, participants were instructed to memorize a list of semantically related words that were presented auditorily, and then completed a free recall memory test. In four different divided attention conditions, participants completed a distracting task either during the encoding or retrieval phase. The fifth attention condition was a baseline full attention condition where there was no distracting task. Results showed that under full attention, bilinguals performed worse than monolinguals, but under divided attention, the groups generally performed the same.
**False memory.** False memory is defined as the memory of events that never actually occurred. False memories are typically induced in experiments using the DRM paradigm (Deese, 1959; Roediger & McDermott, 1995). In this procedure, participants are asked to memorize various word lists; each list consists of words that are semantically related to a non-presented word, which is called the critical lure. When participants are asked to recall the words on a subsequent memory test, they often recall the critical lure, despite never having actually seen it. For example, participants may be asked to memorize a list of words that are all related to the critical lure “sleep,” such as “bed,” “pillow,” “blanket,” etc. When participants recall the words on this list, they also recall the word “sleep” even though it was not on the list. Hence, a false memory. These findings have been replicated numerous times, indicating that human memory is not perfect, that it is a constructive process, and that it can be easily manipulated.

**Attention and false memory.** Previous research has consistently demonstrated that attention has an effect on false memory. Smith & Engle (2011) examined the effects of resource availability on study modality in false recall. Typically, false memories can be reduced by presenting the words visually rather than auditorally. This is known as the modality effect in false memory. Smith & Engle (2011) showed that the modality effect can be eliminated when mental resources are limited or unavailable. Participants were presented with a single 72-item word list (comprised of six 12-item word lists from the DRM paradigm). During the study phase, words were presented one at a time; participants either saw the words on a computer screen or heard them played through the computer speakers. Following the study phase, participants were given 3 minutes to write down as many words as they could remember. Participants were randomly assigned to one of two attention conditions: full or divided attention. Those in the divided attention condition completed a distracting task while simultaneously studying the words. Results
showed that there was a significant modality effect in the full attention condition, but not in the divided attention condition. This indicates that limiting attentional resources increases false memories.

Peters et al. (2008) investigated the influence of attention and warning on false memory. Participants were shown 16 word lists from the DRM paradigm. Words were visually presented one at a time, and after each list participants were given 1.5 minutes to write down all the words they could remember. Participants then completed a filler task which lasted 30 minutes. After this filler task, they were given a delayed old-new recognition test in which they were shown 96 words and had to indicate which words they had previously seen on one of the 16 word lists. Participants studied the word lists either under full attention or under divided attention. Those in the divided attention condition completed an auditory oddball task at the same time that they studied the word lists. Participants were also randomly assigned to one of two warning conditions: warning or no warning, such that half of the participants had been warned ahead of time of the possibility of remembering false memories. Results showed that for recognition, forewarning participants reduced false memories, even under divided attention. However, this did not occur for free recall. Warning participants did not have an effect on false memories for those in the divided attention condition. Under divided attention, participants had a higher rate of false memory even when they had been warned beforehand that this would occur.

Otgaar, Peters, & Howe (2012) examined the effects of attention on false memories in children and adults. Participants studied 10 DRM word lists, which were presented in an auditory manner. After each list, participants were given 1.5 minutes to write down as many words as they could recall. Participants were randomly assigned to either the full attention condition or the divided attention condition. In the divided attention condition, participants completed a visual
oddball task during encoding that was adapted for use in children. Before and after the presentation of a word, a smiley face was shown. The smiley faces were either red or green. Participants were instructed to count the number of red smiley faces and report this number before they recalled the words they had studied. Results showed that dividing attention significantly reduced true recall for both children and adults. Results also showed that dividing attention decreased children’s false memories, but increased adults’ false memories.

**Bilingualism and false memory.** There have been few studies conducted that have examined bilingualism and false memory. Almost all of these studies (e.g., Cabeza & Lennartson, 2005; Howe, Gagnon, & Thouas, 2008; Sahlin, Harding, & Seamon, 2005; Marmolejo, Diliberto-Macaluso, & Altarriba, 2009) have focused on the question of whether or not false memories cross language boundaries. To our knowledge, only Anastasi, Rhodes, Marquez, & Velino (2005) have examined the differences between bilinguals and monolinguals in terms of false memory. Their participants were 24 monolingual English speakers and 12 bilinguals (from various backgrounds) who reported English as their second language. Participants were shown three 15-item word lists, presented in a blocked format, taken from Roediger & McDermott (1995). Participants were given 45 index cards that each had a word printed on the center. They were instructed to look at the cards one at a time and then place the card face down. Participants then completed a filler task in which they were given 51 math problems and were instructed to complete as many of the problems as they could within 5 minutes. Finally, participants were given a free recall memory test and were instructed to write down as many words as they could remember within 5 minutes. At the end of the recall test, the procedure was repeated using 3 different lists. However, this time the participants were given a recognition test instead of a free recall test. The results showed that for both free recall and
recognition, monolinguals and bilinguals remembered the same number of list items, but monolinguals remembered significantly more critical lures than did bilinguals. This suggests that bilingualism may play a role in reducing vulnerability to false memories.

The Current Study

Previous research investigating the question of whether bilinguals and monolinguals differ in regards to false memory is almost nonexistent. Only one study (Anastasi et al., 2005) has compared bilinguals and monolinguals in terms of false memory, and currently no study has examined the effects of both bilingualism and attention on false memory. The current study was designed to answer this question. The independent variables in this study were bilingualism and attention. Bilingualism was assessed using self-report. The dependent variables were false memory and true recall. False memory was measured as the proportion of critical lures recalled; true recall was measured as the proportion of list items correctly recalled.

Based on the previous literature showing that bilinguals have better memory (Kormi-Nouri et al., 2003, 2008; Schroeder & Marian, 2012; Ljungberg et al. 2013) and attention (Bialystok, 1999; Kapa & Colombo, 2013; Pelham & Abrams, 2014) than monolinguals, and previous research showing that divided attention hinders memory performance (e.g., Smith & Engle, 2011; Peters et al., 2008), we hypothesize the following: (1) Monolinguals will have greater rates of false memory than bilinguals, (2) Participants will have greater rates of false memory and lower rates of true recall under divided attention than under full attention, and (3) There will be an interaction between bilingualism and attention, meaning that bilinguals will be more resistant to the negative impact of divided attention than monolinguals.
Method

Participants

Fifty-eight undergraduate students from a small, liberal arts college in the Midwest participated in this study: 16 bilinguals from a 300-level Spanish course and 42 monolinguals from a 300-level psychology course. In order to be considered bilingual, participants had to be enrolled in Spanish 390 and report proficiency in (at least) two languages. To be considered monolingual, participants had to report having knowledge of only one language. Fourteen participants did not meet inclusion criteria and hence were excluded from the final analysis. The final subject pool consisted of a total of 44 participants, comprised of 10 males and 34 females ranging in age from 20-30 years ($M = 21.61, SD = 1.87$). Of the 44 total, 16 were bilinguals: 4 males and 12 females ranging from 20-24 years of age ($M = 20.81, SD = 0.71$). Two participants reported having proficiency in 3 languages: one participant reported speaking English, Spanish, and Chinese, while the other reported speaking English, Spanish, and Romanian. The remaining 14 participants reported proficiency in 2 languages: English and Spanish. Thirteen participants reported English as their first language, 2 reported Spanish as their first language, and 1 participant reported Romanian as their first language. Twenty-eight of the 44 total participants were monolinguals, comprised of 6 males and 22 females ranging in age from 20-30 years ($M = 22.07, SD = 0.71$). Participation in the study was completely voluntary.

Materials

Six word lists were drawn from Roediger & McDermott (1995). Each list is comprised of words that are semantically related to a non-presented word (i.e., the critical lure). The critical lures were: chair, mountain, needle, rough, sleep, and sweet. Only the first ten words from each list were presented. Words were presented in order of associative strength with the critical lure, from strongest associative strength to weakest. The word list for the critical lure needle was
comprised of the following words: thread, pin, eye, sewing, sharp, point, prick, thimble, haystack, and thorn. Complete lists for all six critical lures can be found in Appendix A.

**Procedure**

This study employed a mixed factor design. Bilingualism (bilingual vs. monolingual) was the between-subjects variable and attention (full vs. divided) was the within-subjects variable. Participants were randomly assigned to one of the attention conditions, which were counterbalanced such that half of the participants started in the full attention condition and the other half started in the divided attention condition.

Prior to the experiment, participants were asked to read and sign informed consent sheets. The informed consent told them of the anticipated benefits and risks of participating in the study, reminded them that their participation was voluntary and that they were free to withdraw from the experiment at any time, and also told them what they would be expected to do in the experiment. Participants were not told that the study concerned false memory; they were simply told that the study was about language learning and memory. The complete informed consent sheet can be found in Appendix B.

After giving consent to partake in the experiment, participants filled out a questionnaire asking for basic demographic information such as age, gender, and year in school. The questionnaire also asked for various information regarding participants’ language background. For example, participants were asked to report what their first language was, how many languages they spoke, and to evaluate how well they could read, write, and understand each language they knew. The questionnaire in its entirety is available in Appendix C.

The experiment began after all participants had finished filling out the demographic information. Participants completed the experiment in three phases. Phase 1 was the study phase,
in which participants studied three word lists which were presented in a blocked format. Words were presented one at a time for a duration of 3 seconds each, and between each word a number was presented for approximately 2 seconds. Those in the divided attention condition were instructed to study the words while simultaneously monitoring the number of odd values in the number stream. Those in the full attention condition were instructed to ignore the number stream and concentrate solely on studying the words. To see the exact instructions, refer to Appendix D.

Phase 2 of the experiment consisted of a digit recall task, which was a distractor task aimed at eliminating recency effects and ensuring that participants’ recall of the words studied in Phase 1 came from long term rather than short term memory. Prior to the start of this task, participants in the divided attention condition were asked to report how many odd values they had counted in the number stream. During the digit recall task, participants were shown three 7-digit number sequences. Sequences were presented one at a time, and after each sequence participants had 13 seconds to write down the digits in the order they were presented. For more details, see Appendix E.

Phase 3 was a free-recall memory test. Participants were given 5 minutes to write down as many of the studied words as they could remember. At the end of Phase 3, the procedure was repeated using the remaining three word lists, and participants who had started in the full attention condition switched to the divided attention condition and vice versa. At the conclusion of the experiment, participants were thoroughly debriefed and told of the true nature of the experiment. Refer to Appendix F for the complete debriefing form.
Results

False Memory

The results of a 2 (bilingualism: bilingual, monolingual) x2 (attention: full attention, divided attention) mixed factor ANOVA indicated no significant main effect of bilingualism, $F(1, 42) = 0.668$, $p > .05$, nor a significant bilingualism by attention interaction, $F(1, 42) = 0.141$, $p > .05$. Bilinguals did not have significantly lower rates of false memory ($M = 0.34$, $SD = 0.25$) than monolinguals ($M = 0.40$, $SD = 0.35$). Results did, however, indicate a marginally significant main effect of attention, $F(1, 42) = 3.212$, $p < .10$. Participants had higher rates of false memory under divided attention ($M = 0.44$, $SD = 0.34$) than under full attention ($M = 0.34$, $SD = 0.32$). See Figure 1 for details.

True Recall

The results of a 2 (bilingualism: bilingual, monolingual) x2 (attention: full attention, divided attention) mixed factor ANOVA indicated a significant main effect of attention, $F(1, 42) = 7.148$, $p < .05$. Participants experienced significantly lower true recall under divided attention ($M = 0.40$, $SD = 0.14$) than under full attention ($M = 0.47$, $SD = 0.16$). Results did not indicate a significant main effect of bilingualism, $F(1, 42) = 1.113$, $p > .05$, nor a significant bilingualism by attention interaction, $F(1, 42) = 0.376$, $p > .05$. As shown in Figure 2, bilinguals did not have significantly higher rates of true recall ($M = 0.46$, $SD = 0.15$) than did monolinguals ($M = 0.42$, $SD = 0.30$).

Discussion

The main purpose of this study was to examine the effects of bilingualism and attention on false memory. Based on the previous literature, our hypotheses were: (1) Monolingual participants would have greater rates of false memory than bilingual participants, (2) Participants
would have greater rates of false memory and lower rates of true recall under divided attention than under full attention, and (3) There would be an interaction between bilingualism and attention, such that bilinguals would be more resistant to the negative impact of divided attention than monolinguals. Only our second hypothesis was supported: participants had significantly lower rates of true recall and marginally significant higher rates of false memory under divided attention.

Our results are in accordance with previous research that shows that attention has an effect on memory performance. Studies by Smith & Engle (2011), Peters et al. (2008), and Otgaar et al. (2012) have all shown that divided attention impedes memory performance, particularly by significantly increasing the rate of false memory. It is interesting to note, however, that our results show only a marginally significant higher rate of false memory under divided attention. This may be explained by the distracting task that was used for the divided attention condition. We used a digit-monitoring task in which participants had to count the number of odd values presented in a number stream. Since the task involved numbers instead of words, this may not have taken up the mental resources necessary to create sufficient interference during encoding. According to Fernandes et al. (2007), greater interference occurs when the materials used in the distracting task overlap with the materials used in the memory task. The rates of false memory under divided attention may have reached statistical significance if our distracting task had used verbal information.

Our results showed no significant main effects of bilingualism, meaning that any differences between bilingual and monolingual participants in terms of false memory or true recall could have been due to chance rather than the linguistic status of the participants. These results are not in accordance with previous research showing memory advantages for bilinguals.
Kormi-Nouri and colleagues (2003, 2008) and Ljungberg et al. (2013) found that bilinguals outperformed monolinguals on both episodic and semantic memory tasks. Schroeder & Marian (2012) also found that bilinguals had an advantage in memory performance. Our results are, however, in line with research done by Fernandes et al. (2007) which did not show any memory advantages for bilinguals. One reason that bilinguals did not perform better than monolinguals may have to do with the fact that the memory task involved verbal information. As explained by Fernandes et al. (2007), bilinguals have smaller vocabularies than monolinguals, and this smaller vocabulary is related to poor lexical access, including memory retrieval. This may be why other studies that use visual recall tasks (e.g., Schroeder & Marian, 2012) do find better memory performance for bilinguals.

Our results showed no significant interaction between bilingualism and attention. We had hypothesized that bilinguals would be less vulnerable to the negative effects of divided attention than monolinguals, but this hypothesis was not confirmed. Our bilinguals did not have better attentional control than our monolinguals, which is not in line with previous research (e.g., Bialystok, 1999; Kapa & Colombo, 2013) showing that bilinguals outperform monolinguals on tasks requiring attentional control and inhibition. However, these advantages are more pronounced in situations in which there is conflicting information and participants must attend to the relevant information while ignoring irrelevant information. It is possible that our experimental procedure did not create a situation with sufficiently conflicting information that would highlight these advantages in the bilinguals.

Although not statistically significant, our results showed that the data was trending in the direction that we had predicted. Bilinguals showed lower rates of false memory than monolinguals under both divided and full attention, and also showed higher rates of true recall.
under both attention conditions. This suggests that the lack of significant results may be related to the small sample size used. We had a total of 44 participants, of which only 16 were bilinguals. It is possible that our sample size simply lacked the statistical power necessary to produce any significant effects.

In addition to the small sample size, there were other limitations of this study that may also explain why we did not find any significant effects of bilingualism. One limitation was the proficiency (or lack thereof) of our bilingual participants. The majority of our bilinguals were second language learners who had started learning Spanish in school during late childhood or early adolescence. Students in foreign language programs are too often far below the level they are supposed to be at, as evidenced by students in 400-level classes whose skills are comparable to (and sometimes worse than) those of students at the 100-level. Because of time constraints and a lack of resources, we were unable to use more thorough measures to test the proficiency of our bilinguals, instead having to rely on self-reported levels of proficiency. It is very likely that our bilinguals were not proficient enough in their second language to gain the advantages of being bilingual and be significantly different from the monolinguals.

There may have also been an issue with the monolingual participants’ language skills. Some monolinguals may have had a fair amount of proficiency in other languages, but reported themselves as monolingual because they believed that they were not fluent enough to be considered bilingual. Thus, there may have been several “monolinguals” that were actually bilingual, making the two groups much more similar than what would be normally expected. This may have skewed the results, preventing any significant differences in memory performance between monolinguals and bilinguals.
The sample we used as our participants was also a limitation of this study. We did not use a random sample; we used a convenience sample of undergraduate students from a college in an affluent, predominantly White suburb. This is certainly not a representative sample, particularly for the bilingual population which is often comprised of minorities from a lower socioeconomic status background. Additionally, our groups of monolinguals and bilinguals were drawn from different classes. The bilinguals were students enrolled in Spanish 390, which is the second-highest level of Spanish offered at our school; the monolinguals were students enrolled in Psychology 345, which is a lower 300-level class. Since the classes were not at the same level, the two groups of students were likely not equal to each other on a variety of factors that may have impacted the results. Furthermore, because our monolinguals were psychology students, many of them were probably familiar with the concept of false memory and recognized the word lists along with their respective critical lures. Due to the various issues with our sample, we cannot justifiably say that our results can be generalized to the population.

This research has implications for dual-language and second-language immersion programs. Research looking at bilingualism acquired through these types of programs and its effects on cognitive functioning is still very limited. A study done by Nicolay & Poncelet (2013) investigated cognitive functioning in elementary school children who had been enrolled in a second-language immersion program for three years. Fifty-three children enrolled in English immersion classes and 53 monolingual French children were administered a battery of tests assessing attention and executive functioning. The results showed that the immersion children outperformed the monolingual children on tasks assessing selective attention, divided attention, and mental flexibility, among other cognitive processes. Research on bilingualism, attention, and false memory, such as our study, can help further our understanding of the impact of dual-
language/immersion programs, and may suggest that these programs are valuable not only for teaching a second language, but also for enhancing cognitive processes such as memory and attention.

Future research will, of course, want to replicate this study and address the limitations of sample size, type of sample, and participant language proficiency. Future research should also investigate why bilingualism seems to increase true recall while decreasing false recall. Studies examining levels-of-processing on false memory (e.g., Rhodes & Anastasi, 2000; Thapar & McDermott, 2001; Bui, Friedman, McDonough, & Castel, 2013) typically show that deeper processing during encoding increases true recall but also tends to increase false recall. Future research will want to examine why bilingualism does not seem to be a variable that follows this pattern and investigate the mechanisms that are involved in this.
References


BILINGUALISM, ATTENTION, & FALSE MEMORY


Figure 1. Average rate of false memory as a function of bilingualism and attention conditions.
Figure 2. Average rate of true recall as a function of bilingualism and attention conditions.
Appendix A: The Six Word Lists Used in Phase 1 of the Experimental Procedure

<table>
<thead>
<tr>
<th>Chair</th>
<th>Sleep</th>
<th>Sweet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table</td>
<td>Bed</td>
<td>Sour</td>
</tr>
<tr>
<td>Sit</td>
<td>Rest</td>
<td>Candy</td>
</tr>
<tr>
<td>Legs</td>
<td>Awake</td>
<td>Sugar</td>
</tr>
<tr>
<td>Seat</td>
<td>Tired</td>
<td>Bitter</td>
</tr>
<tr>
<td>Couch</td>
<td>Dream</td>
<td>Good</td>
</tr>
<tr>
<td>Desk</td>
<td>Wake</td>
<td>Taste</td>
</tr>
<tr>
<td>Recliner</td>
<td>Snooze</td>
<td>Tooth</td>
</tr>
<tr>
<td>Sofa</td>
<td>Blanket</td>
<td>Nice</td>
</tr>
<tr>
<td>Wood</td>
<td>Doze</td>
<td>Honey</td>
</tr>
<tr>
<td>Cushion</td>
<td>Slumber</td>
<td>Soda</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rough</th>
<th>Mountain</th>
<th>Needle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smooth</td>
<td>Hill</td>
<td>Thread</td>
</tr>
<tr>
<td>Bumpy</td>
<td>Valley</td>
<td>Pin</td>
</tr>
<tr>
<td>Road</td>
<td>Climb</td>
<td>Eye</td>
</tr>
<tr>
<td>Tough</td>
<td>Summit</td>
<td>Sewing</td>
</tr>
<tr>
<td>Sandpaper</td>
<td>Top</td>
<td>Sharp</td>
</tr>
<tr>
<td>Jagged</td>
<td>Molehill</td>
<td>Point</td>
</tr>
<tr>
<td>Ready</td>
<td>Peak</td>
<td>Prick</td>
</tr>
<tr>
<td>Coarse</td>
<td>Plain</td>
<td>Thimble</td>
</tr>
<tr>
<td>Uneven</td>
<td>Glacier</td>
<td>Haystack</td>
</tr>
<tr>
<td>Riders</td>
<td>Goat</td>
<td>Thorn</td>
</tr>
</tbody>
</table>
Appendix B: Informed Consent Sheet

Study Title: Language Learning and Memory

Purpose of the research
To better understand the effects of language learning on memory

What you will do in this experiment
You will be shown several lists of words. After each list, you will be asked to remember as many of the words as you can. For half of the word lists, you will be shown the list of words while monitoring a number stream and keeping track of how many odd values you see. For the other half of the word lists, you will simply study the series of words.

Time required
The study will take less than 30 minutes to complete.

Risks
There are no anticipated risks.

Benefits
At the end of the experiment, the experimenter will provide a thorough explanation of the experiment and of our hypotheses. If you wish, you can send an email message to Sabheen Mohsin at smohsin@noctrl.edu and she will send you a summary of the study’s results at the end of the term. You will also be given candy at the end of the study as a token of our appreciation.

Confidentiality
Your participation in this research will remain confidential, and your identity will not be stored with your data.

Participation and withdrawal
Your participation in this study is voluntary. If you feel uncomfortable at any point during the course of this study, then you should feel free to stop your participation. You may withdraw from the study at any time without penalty. You may withdraw by informing the experimenter that you no longer wish to participate.

Contact
If you have questions about this study, please contact Sabheen Mohsin at smohsin@noctrl.edu.

Agreement
The purpose and nature of this research have been sufficiently explained and I agree to participate in this study. I understand that I am free to withdraw at any time without incurring any penalty. I certify that I am 18 years of age or older _____

Signature: ______________________________ Date: __________________

Name (print): ____________________________________________
Appendix C: Demographic Information

**Participant Information**

Age: ______

Gender: Male Female

Year in School: Freshman Sophomore Junior Senior

What is your place of birth? ________________________

Do you consider yourself monolingual or multilingual? (Circle one)

What was the primary language spoken in your household when you were growing up?_________________________

Were there any secondary languages spoken in your household? Yes/No (Circle one)

If yes, please list all secondary languages:__________________________________________________________

List all the languages you speak:

1.________________________
   a) As of what age did you speak this language? ______
   b) From whom did you learn this language? _____________________________________________
   c) Do you use this language on a regular basis to communicate with others? Yes/No (Circle One)

On a scale of 1-10, how well do you:
   a) Understand ______
   b) Speak______
   c) Read/Write______

2.________________________
   a) As of what age did you speak this language? ______
   b) From whom did you learn this language? _____________________________________________
c) Do you use this language on a regular basis to communicate with others? Yes/No (Circle One)

On a scale of 1-10, how well do you:
   a) Understand ______
   b) Speak ______
   c) Read/Write ______

3. ________________________________
   a) As of what age did you speak this language? ______
   b) From whom did you learn this language?
       ________________________________
   c) Do you use this language on a regular basis to communicate with others? Yes/No (Circle One)

On a scale of 1-10, how well do you:
   a) Understand ______
   b) Speak ______
   c) Read/Write ______

Please rank all the languages you speak in order of fluency (from most fluent to least fluent):
1. 
2. 
3. 

Do not turn the page. When you are finished, please look to the experimenter for further instructions.
Appendix D: Experiment Instructions

Divided Attention Condition:

Part 1: Study Task
Instructions:
You will be shown a series of words. Study the words and memorize them to the best of your ability, as you will be asked to recall them later. The words will be presented to you one at a time, and before and after each word you will be shown a number. While you are studying the words, you must also count how many odd numbers you see. You must not, in any way, write down or make a written tally of how many odd numbers you see. You are to keep track of them mentally. You will be asked to write down this number later.

Full Attention Condition:

Part 1: Study Task
Instructions:
You will be shown a series of words. Study the words and memorize them to the best of your ability, as you will be asked to recall them later. The words will be presented to you one at a time, and before and after each word you will be shown a number. **DO NOT PAY ATTENTION TO THE NUMBERS.** Only concentrate on memorizing the words.
Appendix E: Digit Recall Task

Response Sheet
Please write down how many odd numbers you counted earlier: ______

Part 2: Digit Recall Task
Instructions: Now, you will be shown a sequence of seven numbers, and your task is to recall them in the order in which they were presented. After the sequence of seven numbers is shown, you will have thirteen seconds to write them down before the next number sequence is shown. There will be three number sequences total.

Sequence 1:_________________________________________

Sequence 2:_________________________________________

Sequence 3:_________________________________________

Do not turn the page until instructed to do so.
Appendix F: Debriefing Form

Study Title: Language Learning and Memory

Thank you for participating in our study!

This study is concerned with false memory, or the memory of events that did not actually occur. Past research (e.g., Roediger & McDermott, 1995) has demonstrated false memory by having individuals study a list of words that are all related in meaning to a specific non-presented word, called the critical lure. On a subsequent memory test, participants often “remember” seeing that critical lure. This phenomenon may occur because we organize information in our memory based on its meaning. When we try to remember that information later, we often think of other related information as well.

This experiment used a mixed-factor design to investigate the effects of bilingualism and attention on false memory. The within-subjects variable was attention (full or divided). The between-subjects variable was bilingualism (monolingual or bilingual). The dependent variable was the number of critical lures recalled.

We expect to find that monolingual participants will recall more of the critical lures than bilingual participants. We also predict that participants will recall more critical lures under divided attention than under full attention. Finally, we expect to find an interaction between bilingualism and attention.

If you would like to receive a summary of the results at the end of the term, please contact Sabheen Mohsin at smohsin@noctrl.edu. If you have concerns about your rights as a participant in this experiment, please contact Dr. Daniel VanHorn (637-5327, drvanhorn@noctrl.edu) in the psychology department.

If you are interested in learning more about false memory and the effects of bilingualism and attention on memory, you may want to consult the following:


Thank you for your participation!