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Source Monitoring in Bilinguals

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SOURCE MONITORING IN BILINGUALS

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Dedication

To my beautiful mother and grandmother, I could not have done this without your unconditional love, faith, and support. To my father and my sister, thank you for being my biggest cheerleaders! To my wonderful family for supporting me every step of the way, and to my El Paso friends that have become my family away from home, thank you. To my niece Aviana, you have given me a more beautiful perspective and drive on life, I love you. To my Bakersfield friends for sending your love and support from 1,000 miles away. To my mentor and co-mentors, Dr. Wendy Francis, Dr. Ashley Bangert and Dr. Ana Schwartz, thank you for your endless patience and support. This definitely would not have been possible without your endless guidance, kindness, and faith in me. Finally, I would like to thank Dr. Isabel Sumaya for mentoring me during my bachelor's degree, and continuing to mentor me from 1,000 miles away. You all have sacrificed so much for my success. I will forever be thankful. I love you; this is for all of you.

SOURCE MONITORING IN BILINGUALS

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Abstract

Source memory is memory for the context in which a particular target item is learned (Parker, 1995). The *source-monitoring framework* is the leading model of source memory (Johnson, Hashtroudi, & Lindsay, 1993). It remains unknown at what level context-to-word associations, including source contexts, are made (e.g., at the word form level or conceptual level). Three experiments examined the effects of word frequency and language proficiency on source memory, with each experiment addressing one of the different types of source monitoring identified in the source-monitoring framework. In Experiment 1, we examined how language proficiency and word frequency affect external source discrimination between auditory and visual stimuli. In Experiment 2, we examined how these same variables affect internal source discrimination between overt and covert picture naming. In Experiment 3, we examined how internal-external source monitoring is affected by language proficiency and word frequency by having participants remember whether they listened to words or only imagined listening to words.

The results revealed information about the level at which contextual information is represented. Prior to this study, it remained relatively unexplored about the level word-to-context associations were made. We hypothesized that if we observed an effect of word frequency, then word-to context associations are being made at the conceptual level. Furthermore, we hypothesized that if we observed an effect of language proficiency, then word-to-context associations are being made at the word-form level.

The frequency-lag hypothesis was developed to explain performance in lexical processing tasks, with logic that L2 words function like low-frequency words. It remains unknown whether this analogy works for explicit memory. Manipulations of word frequency were expected to yield an advantage in source memory for low-frequency words relative to high-frequency words in all three experiments based on the source-of-activation confusion theory (e.g. low-frequency item advantage in recognition memory). Indeed, participants did show better source discrimination for low frequency words. Manipulations of language were expected to yield better source memory for words in the non-dominant language relative to words in the dominant language across all three experiments based on an adaptation of the source-of-activation confusion theory where items in the nondominant language are expected to behave like low frequency words. However, no effects of language were observed for any of the three types of source monitoring. It has not yet been specified in any theories of source memory or bilingual memory at what level context-to-word associations are being made. Based on the current results, it seems as though the context-to-word associations are being made at the conceptual level rather than the level of the word form. This research adds to an important body of literature examining the bilingual experience from a long-term memory perspective.

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Chapter 1: Introduction

The question of how language affects memory has been an important problem in cognitive research. Specifically, the manner in which bilingualism impacts memory remains relatively unexplored, despite growth in this field over the last few decades. The majority of people in the world are bilingual (Harris & McGhee-Nelson, 1992) and despite this fact, theories of memory rarely address language proficiency or bilingualism. For example, little is known about how bilingual language proficiency and word frequency affect the encoding of contextual information into long-term memory. The level at which word-to-context associations remained relatively unexplored prior to this dissertation. The results of this dissertation will help to specify theories of bilingual memory and memory more generally about the level at which word-to-context associations are made. Three experiments examined how word frequency and bilingual language proficiency influence encoding and retrieval of source information in long-term memory. Specifically, we wanted to discover whether bilinguals have better source memory for information learned in their dominant language (L1) or their non-dominant language (L2) and whether bilinguals have better source memory for low-frequency items or high-frequency items. Discovering how bilinguals make associations between items learned and the contexts in which they are encountered will help inform theories of both source memory and bilingual memory.

The impact of bilingual language proficiency and word frequency on the different types of source monitoring described in the *source-monitoring framework,* the main model of source memory, (Johnson 1988; Johnson, Hashtroudi, & Lindsay, 1993) remains relatively unexplored. This is true for other theories of explicit memory as well. Additionally, the frequency-lag hypothesis was developed to explain performance in lexical processing tasks, with the idea that L2 words behave like low-frequency words. It remains unknown whether this analogy is true for explicit memory. The current study seeks to close the knowledge gaps between the bilingual and memory literature to gain a broader understanding of how the bilingual experience influences cognition, specifically, with respect to explicit memory and long-term retrieval.

1.1 Source Memory

Source memory is memory for the source or origin of information, an important part of the contextual information surrounding a particular memory. Sources can take the form of five "contexts" (e.g., perceptual, spatial/time, cognitive operations, conceptual, and affect), but contextual information can essentially be any contextual cue associated with a memory (Johnson, Hashtroudi, and Lindsay, 1993). It should be noted that there is disagreement in the literature about the specific definition of context. While some researchers argue that context refers only to specified sources, others say that context can take the form of any episodic detail that surrounds a memory.

People evaluate sources through decision-making processes at memory retrieval (Johnson et al., 1993; Parker, 1995). Source memory is a type of explicit memory that involves four major cognitive processes: mental experiences, memory, binding (an associative process), and decision-making (Johnson et al., 1993). Mental experiences are experiences that occur in our mind (e.g., reading a passage in a love story). Memory is the cognitive process by which our experiences are encoded, stored, and retrieved. The binding process (i.e., binding between a context and an item) happens during encoding, and access to and evaluation of source binding are made at retrieval (Johnson, 2005). It is when a specific context has been bound to a memory that a memory becomes unique. That is, the contexts associated with our memories help us to discriminate one memory from another; this process is known as *differentiation* (Johnson, et.al, 1993). Finally, decision-making is the cognitive process by which we make a choice about a particular situation. The target of retrieval is a critical process in source memory that distinguishes it from item memory. tem memory is memory for specific items. In an item memory task, a person might be asked at test, "do you remember seeing this word?" and have to respond yes or no. In contrast, in a source memory task a person might be asked "Did you see the word "bear" in List 1 or List 2?" and have to with the appropriate list.

In dual process models of item memory, a distinction is made between recollection processes (e.g. the process of recognizing an item using context for verification) and familiarity processes (e.g. the process of recognizing an item based on memory strength) (Mitchell and Johnson, 2010). Unlike dual process models of memory, the source-monitoring framework suggests that recollection and familiarity are similar cognitive processes rather than two qualitatively different processes. Detailed episodic information is important for recollection processes, and less differentiated information is important for familiarity processes. Thus, more differentiation helps people to remember specific episodic details surrounding a memory. Differentiation is a memory process that helps us to distinguish one memory from another. For example, many people go to school everyday, and it becomes difficult to distinguish one school day from another. However, if on April 20th you defended your dissertation, and then April 21st was a regular school day, you have more contextual information associated with April 20th, thus, resulting in greater differentiation to help in the recollection of the memory. In contrast, less differentiated memories are available more quickly. This is because you have many episodic experiences with less differentiated memories (e.g., a typical day at school). An important distinction between item and source memory is that item recognition relies on both recollection (including memory for contextual information in the episodic trace) and familiarity processes, whereas source memory relies only on recollection (Tosun, Vaid, & Geraci, 2013).

In the source-monitoring framework, a distinction is made between internal sources and external sources. An example of internal source memory is when someone has to discriminate between something that they did or something that they thought about doing. For example, did they actually send an email or did they only think about sending it? That is, people have to differentiate between two different internal sources (e.g., what I may have actually done and what I thought about doing). This is why internal source monitoring is also referred to as 'reality monitoring'. An example of an external source memory is discriminating between something that was heard versus something that was seen. That is, people have to differentiate between two external sources.

There is consensus in the literature that source memory helps to make episodic memory richer in detail (Johnson, 2005). These two psychological constructs may be best viewed as two sides of the same coin rather than distinct concepts (Siedlicki, Salthouse, and Berish, 2005). That is, all episodic memory tasks measure source memory either directly (e.g., indicating which side of the screen the word "popcorn" appeared on) or indirectly (e.g., recalling words from a list of words that were presented in Spanish). Furthermore, it is difficult to dissociate the cognitive processes involved in source memory from those involved in item memory (Johnson, 2005).

Remembering the source of information can be critical in everyday cognition. For example, it is important to remember the source of important medical information. Another example is that in writing, it is important to remember the sources of ideas to avoid plagiarism (e.g. confusing internal-external sources) and mis-citing information from the literature (e.g. confusing two external sources). For this reason, it is critical to understand the factors that lead to better or worse source monitoring.

1.1.1 Source-Monitoring Framework

According to the *source-monitoring framework (SMF)* there are three types of source monitoring. First, external monitoring involves discriminating between two external sources of information. For example, a patient may wonder, "Did my doctor tell me this was okay to double up on this prescription medicine or did a friend tell me that this was okay?" Second, internal monitoring involves discriminating between two internal sources of information, for example, whether I sent an email or imagined sending the email? Lastly, internal-external monitoring, also referred to as reality monitoring, involves discriminating between one internal source and one external source. For example, to discriminate between whether Wendy actually sent the email or whether I imagined her sending the email.

There is some evidence that these three forms of source monitoring are cognitively distinct. For example, in one study, older adults showed poor performance in internal and external source monitoring, but intact performance in internal-external monitoring (Hashtroudi, Johnson, & Chrosniak, 1989). However, this evidence should not necessarily be interpreted to indicate that the different types of source monitoring are fundamentally different; they still rely on similar memory and judgment processes.

The source-monitoring framework specifies five different types of context that can be associated with a particular memory. These are: conceptual, contextual, affective, and cognitive operations. Perceptual information is context for physical properties of the stimulus presentation. For example, if presented with a picture of a grape, the perceptual parts of this image include: the color, the edges, and the texture of the grape. Semantic information is information for the conceptual or meaningful aspects of context. For example, are grapes and bananas related? Contextual information is information for space and time, for example, where and when the grape may appear on the computer screen. Affective information is context for moods and feelings associated with a particular memory, for example, feelings of pleasure from eating a grape. Finally, cognitive operations are a context that can be associated with a particular memory; for example, a participant may remember that they were naming a picture of a grape during the encoding and test phase of an experiment.

Contextual cues play an important part in source encoding and retrieval. When the context of a particular memory is less familiar it is more likely that the source of that memory will be retrieved. Similarly, sources associated with low-frequency words (i.e., words that are considered less familiar, and more unique because of fewer episodic experiences with these words) are more easily discriminated than sources associated with high-frequency words (i.e., words that are considered very familiar, and less unique because there are several episodic experiences with these words) (Marsh, Cook, & Hicks, 2006).

According to the source-monitoring framework, source-monitoring decisions are made primarily through non-deliberative processes based on memories that have been activated (Johnson et al., 1993). However, we can also retrieve the source of information through more deliberate processes; this is a more strategic process that takes more time. We refer to these two types of processing as “automatic” or “heuristic” processing of source information and “controlled” or “systematic” processing of source information, respectively. Although most source-monitoring decisions are made heuristically, both of these processes entail some degree of decision-making. Both the heuristic and systematic routes to making source-monitoring decisions can be influenced by high-order reasoning, prior knowledge, prior experience, biases, metamemory, and current goals and agendas (Johnson, 1988; Lindsay & Johnson, 1991). For example, previous knowledge of weddings would bias source memory; it would be unlikely for a person to have feelings of shame at a wedding. Therefore, it would be less likely based on their prior knowledge of weddings to attribute "shame" as being the affective source associated with their memory of being at a wedding. This *extended reasoning* helps us to make source decisions based on what is likely or unlikely to have happened (Johnson and Raye, 1981).

Additionally, there are certain situations in which an individual will use more stringent criteria in source memory decision-making. That is, a person may need to have a certain threshold of perceptual information for a particular event before making a source decision. For example, you may use more stringent perceptual criteria to make a source decision regarding work as compared to the level of perceptual criteria used to make a source decision when gossiping with a friend. That is, when the outcome of the source decision has greater consequences, we change our criterion of what level of evidence we find acceptable to make a decision.

Source memory does not rely on a single cognitive process, but rather it is influenced by multiple cognitive factors like memory and decision-making processes. For example, source memory decisions depend on the degree of confidence in the memory, degree of specificity, information that is available, the quality of the information that is available, and other criteria. There is experimental evidence to suggest that when two pieces of contextual information are similar (e.g., semantically or perceptually) then source confusion arises (Johnson et al., 1981, Lindsay & Johnson, 1991). For example, it would be difficult to distinguish between one introductory psychology class session and another. However, it would be easier to distinguish one class session where Philip Zimbardo came to lecture on the topic of the Stanford Prison Experiment from regular lecture sessions.

An important aspect of the decision-making process in source monitoring is the quality of information during encoding or test. Any problems that arise in any of the processing stages (e.g. decision making, encoding, or retrieval) or having less than ideal conditions during those processing stages will disrupt source monitoring. For example, if naming pictures is the task at encoding, but the participant can hear other participants naming pictures, they may be distracted and not appropriately encode the source or bind the source and item representations in memory.

Source memory errors can occur at any stage of memory processing (encoding, storage, or retrieval). An example of a source memory error is if Ashley were attributed as the source of information when Wendy was the actual source of the information about where Psychonomics will be held in 2017. Errors in source monitoring increase when two sources are similar. False memories are memories for episodes that never actually occurred. Veridical and false memories arise from the same cognitive processes. The source-monitoring framework assumes that memory is a constructive and reconstructive process (e.g., memories can be "built" or "rebuilt" upon recollection of these memories) and because of this, source errors can sometimes lead to false memories (Mitchell and Johnson, 2009).

1.2 Item Recognition and Source Monitoring

Participants who perform well on an item-recognition task may nevertheless perform poorly on a source-monitoring task (Johnson, 1993), which suggests that source monitoring and item recognition have different cognitive bases, even if they rely on some common processes. Both item recognition and source monitoring tasks require differentiation, but item-recognition tasks rely less on differentiation than do source-monitoring tasks (Johnson, Kounios, and Reeder, 1992). That is, source-monitoring tasks may require more differentiation than item-recognition tasks to make a correct decision, because it is much easier to confuse sources of information than to confuse something that has been perceived with something that has not been perceived.

Item recall and item recognition are impacted differently by word frequency. That is, high-frequency words are better recalled, while low-frequency words are better recognized (Balota & Neely, 1980; MacLeod & Kampe, 1996; Mandler, Goodman, & Wilkes-Gibbs, 1982; Guttentag & Carroll, 2013). In item recognition, a mirror-effect is observed, with higher hit rates and lower false alarm rates for low-frequency words relative to high-frequency words. High-frequency words have lower hit rates and higher false alarm rates. There are two explanations of the low-frequency item advantage in the source-of-activation-confusion theory (e.g. fan factor, and base factor). According to the source-of-activation-confusion theory, for the fan factor account, low-frequency words are associated with fewer episodic contexts than high-frequency words; thus there is less competition during recognition, and hit rates are higher relative to high frequency words (Buchler & Reder, 2007). Additionally, for the base factor account, low-frequency words are less familiar than high-frequency words, which decreases the likelihood of misattribution of familiarity and thus lowers false alarm rates (Buchler & Reder, 2007). The fan factor deals with only items that were studied, whereas the base factor deals with foil items (e.g., items that were not studied).

It has been shown experimentally that memories for external sources are more accurate for low-frequency words than for high-frequency words (e.g., remembering that the word popcorn was presented auditorially and not visually; Guttentag & Carroll, 1994; Marsh, Cook, & Hicks, 2006; Strobach, 2016). One explanation of the low-frequency word advantage in source memory has been the fan factor of the source-of-activation-confusion theory (see Figure 1.2) (Buchler & Reder, 2007). Specifically, for a low-frequency word there is less contextual competition (e.g., people have experienced a low-frequency item a smaller number of times, so therefore, in fewer contexts), which helps increase recollection, resulting in higher hit rates. The base factor is not relevant for source recognition (Tosun et. al., 2013) because there are no foil (non-studied) items at test. Although a small number of studies addressed the effects of word frequency on external source monitoring (Guttentag & Carroll, 1994; Marsh, Cook, & Hicks, 2006; Strobach, 2016), no previous study has addressed the effects of word frequency on internal source monitoring. One previous study investigated internal-external source monitoring and showed no word frequency effect (Marsh et al., 2006). However, the authors suggested that the results were inconclusive, because the particular internal source task used was much more memorable than the external source task, and item and source memory were tested simultaneously. Thus, because item and source memory were tested simultaneously it was impossible to dissociate the effects due to item memory and the effects due to source memory.

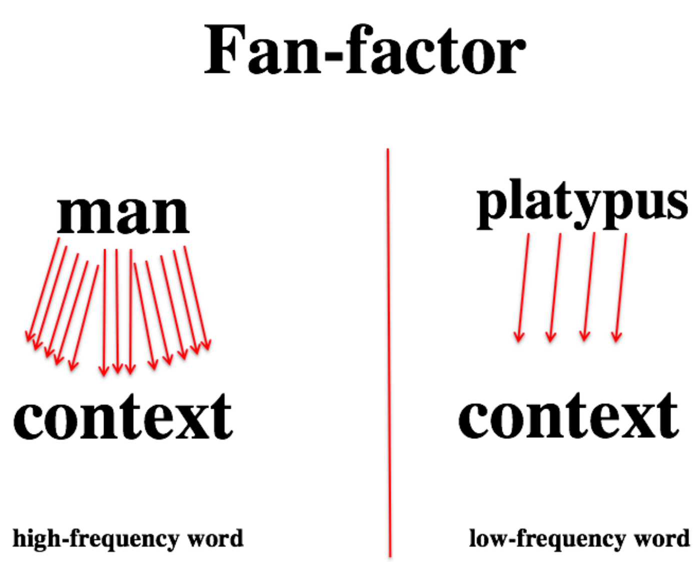

Figure 1.2: Illustration of Fan-factor account in the Source-of-Activation-Confusion Theory

1.3 Bilingual Lexical Access

Bilinguals are usually more proficient in one language (i.e. L1) than their other language(s) (i.e. L2). It is important to consider processing and representational differences between L1 and L2 words in bilingual individuals when making predictions about memory performance in the two languages. L2 words are more weakly associated than L1 words to their concepts in semantic memory (Gollan, Montoya, Cera, & Sandoval, 2008) This feature is incorporated into the major theories of bilingual lexical processing like the Revised Hierachical Model (Kroll & Stewart, 1994), the Inhibitory Control Model (Green, 1998), and the frequency-lag hypothesis (Gollan, Montoya, Cera, & Sandoval, 2008). Similarly, low frequency words (i.e., words that are less frequent in everyday language) are more weakly associated than high frequency words (i.e., words that are more frequent in everyday language) to their concepts in semantic memory (Gollan, et al., 2008). Thus, it is not surprising that lexical access is more difficult for L2 and low-frequency words than for L1 and high-frequency words (Kittredge, Dell, Verkuilen, & Schwartz, 2008). The similarities observed in the processing of L2 words and low frequency words suggest that L2 words in bilinguals are processed similarly to how low-frequency words are processed in monolingual speakers (Gollan, Montoya, Fennema-Notestine, &Morris, 2005; Gollan et al., 2008).

The frequency-lag hypothesis proposes a common mechanism for monolingual-bilingual differences, bilingual L1-L2 differences, and word frequency effects in lexical processing. According to the frequency-lag hypothesis, the effects of word frequency, language proficiency, and bilingual or monolingual language status on lexical processing can be explained by differences in the strengths of concept to word associations and upper limits on lexical accessibility (Gollan, et. al., 2008; Gollan, Slattery, Goldenberg, Van Assche, Duyck, & Rayner, 2011). For example, additional exposures to a very high-frequency word like "man" will not help substantially in accessing this word because "man" is a word that is very close to its limit of lexical accessibility. Under this hypothesis, experience with a language determines the strength of its concept-to-word associations in semantic memory. Similarly, experience with the production of any particular word strengthens the association between that word and its corresponding concept. Thus, words that occur frequently in a language (high-frequency words) have stronger concept-to-word associations in semantic memory than do words that occur less frequently (low-frequency words). Finally, because bilinguals must divide the frequency of use between their two languages, they have weaker concept-to-word associations in semantic memory than do monolinguals. Similarly, because bilinguals have less experience with L2 words than with L1 words, concept-to-word associations in semantic memory are weaker in L2 than in L1.

Evidence supporting the frequency-lag hypothesis comes from production tasks like picture naming and tip-of-the-tongue tasks, and other lexical processing tasks like lexical decision. For example, pictures with high-frequency names are named faster than pictures with low-frequency names (e.g., Gollan, Montoya, Cera, & Sandoval, 2008; Ivanova & Costa, 2008; Wheeldon & Monsell, 1992); bilinguals name pictures faster in L1 than in L2 (Francis, Corral, Jones, & Sáenz, 2007; Gollan et al., 2008; Potter, So, Von Eckhardt, & Feldman, 1984); and monolinguals name pictures faster in their only language than bilinguals name pictures in either their L1 or L2 (e.g., Gollan, Montoya, Fennema-Notestine, & Morris, 2005; Gollan et al., 2008; Ivanova & Costa, 2008; Penalver & Francis, 2016).

1.4 Bilingual Explicit Memory

Several studies indicate that bilinguals show an L1 advantage for recall tasks (e.g., Durgunoglu & Roediger, 1987; Glanzer & Duarte, 1971). In contrast, there is a bilingual L2 advantage for item recognition tasks (Francis & Gutiérrez, 2012; Francis & Strobach, 2013; Taylor, 2017). One explanation for the L2 advantage in item recognition was based on an application of the source-of-activation-confusion theory to bilingual L1 and L2 memory. The authors reasoned that L2 words should have fewer pre-experimental episodic instances than L1 words, making them more distinct, and that L2 words have a weaker strength in memory than L1 words, also making it less likely for them to elicit false alarm responses (Francis & Strobach, 2013). Thus, this reasoning included both the fan factor and the base factor of the source-of-activation-confusion theory.

There are no published studies addressing the effects of language proficiency on any type of source monitoring. There is only one known study that investigated the effects of word frequency and bilingual language proficiency on external source monitoring. In this study, there was an advantage for low-frequency words but no effect of language proficiency (Francis et. al., 2016). The authors reasoned that the fan factor, the idea that L2 words might have fewer pre-experimental episodes than L1 words, would only hold if the episodic contexts were associated at the word-form level rather than the conceptual level, because L1 and L2 translation equivalents have shared conceptual representations. They concluded that the absence of a language proficiency effect indicated that episodic contexts were associated at the conceptual level and therefore did not differ across languages. Because differences in word-form familiarity did not impact source memory, they also reasoned that the fan factor could not have contributed to the L2 advantage in item recognition; instead, the L2 advantage in item recognition could only be attributed to the base factor, where differences in the familiarity of L1 and L2 word forms could have an impact.

Although the parallels between language proficiency effects and word frequency effects is compelling, there is an important key difference between L2 words and low-frequency words at the conceptual level. Specifically, low-frequency words have less familiar concepts than high-frequency words, whereas bilingual L1 and bilingual L2 words have equally familiar concepts because they share the same conceptual representations (e.g., Francis, 1999). The frequency-lag hypothesis may only be relevant to memory to the extent that word forms (i.e., orthographic and phonological characteristics) rather than concepts are critical to performance. The frequency-lag hypothesis was developed to explain performance in lexical processing tasks, with the implication that L2 words function in a manner similar to low-frequency words. It remains unknown whether this analogy works for explicit memory.

1.5 The Present Study

The overarching theoretical question of the present study is whether when people encode words and their associated source context into memory is the contextual information associated to the word represented at the conceptual level or the word-form level? That is, does the encoding of the context depend on the familiarity of the word concept or word form? To answer this theoretical question, the present study empirically assessed whether language proficiency and word frequency impact source memory performance in bilinguals. The design of the experiments allowed for a systematic investigation of how bilingual language proficiency and word frequency influence the three types of source monitoring in the source-monitoring framework. In Experiment 1, bilinguals discriminated between two external sources. In

Experiment 2, bilinguals and monolinguals discriminate between two internal sources. Finally, in Experiment 3, bilinguals discriminate between an internal source and an external source.

Based on the previous findings of a low-frequency advantage in external source monitoring and the fan factor account in the source-of-activation-confusion theory, it was hypothesized that all three types of source monitoring would be more accurate for low-frequency words than for high-frequency words. As explained in the previous section, the effects of language proficiency on all three types of source monitoring are unknown. However, based on the episodic distinctiveness of words in L2, as well as the parallels often found between word-frequency and language-proficiency effects, it was hypothesized that all three types of source monitoring would be more accurate in L2 than in L1. This is the result that would be expected if associations between the words and their sources were made at the word-form level. Alternatively, if the word-to-context associations were made at the conceptual level, we would expect to see frequency effects but no language proficiency effects. By studying how bilingual memory is affected by language proficiency and word frequency manipulations, we can learn more about the architecture and processing of memory more generally. If we can determine the level at which word-to-context associations are made in these studies (i.e., at the word-form or conceptual level), we can further specify theories of memory, such as the source-of-activation-confusion theory and the source-monitoring framework, to include the level at which word-to-context associations are made and further specify how theories of bilingual lexical access, such as the frequency lag hypothesis, might be appropriately applied to explicit memory.

The manipulations of word frequency and language proficiency were designed to test two hypotheses that led to specific predictions, as summarized in Table 1.1.

Prediction 1. Source encoding is more accurate for low-frequency words. This hypothesis leads to the prediction that there will be discrimination advantages in all three types of source monitoring for low-frequency words (e.g., popcorn) relative to high-frequency words (e.g., house).

Prediction 2. Bilingual source encoding is more accurate for words in L2. This hypothesis leads to the prediction that there will be discrimination advantages in all three types of source monitoring for words in bilingual L2.

Table 1.1: Predictions for Experiments 1-3

Experiment 1 - External	Experiment 2 - Internal	Experiment 3 - Internal-External
LF > HF	LF > HF	LF > HF
L2 > L1	L2 > L1	L2 > L1

Specifically, we hypothesized that the strengths of word-to-context associations would differ for high-frequency words and low-frequency words which would yield greater source discrimination scores for low-frequency words than for high-frequency words. Additionally, we hypothesized that the strengths of the word-to-context associations would differ for L1 and L2. We expected stronger word-to-context associations for bilinguals performing in L2 as compared to L1, which would yield greater source discrimination (e.g. accuracy) scores in L2 than in L1. The issue addressed in the present research is how bilinguals encode source information in episodic memory.

Chapter 2: Experiment 1

Experiment 1 focused on external source monitoring. Recall that external source monitoring is where one has to discriminate between two external events. For example, if a person is making an external source monitoring decision, they may have to decide whether Omar or Randy was the source of some piece of gossip. External source monitoring has been most extensively investigated by cognitive psychologists, and there is a stronger theoretical understanding of this type of source monitoring than other forms.

The source-of-activation-confusion theory (Buchler & Reder, 2007) was developed to explain the low frequency advantage in item recognition and has been adapted to explain the low frequency advantage in external source recognition. According to the fan factor component of the source-of-activation confusion theory, low-frequency words have been associated with fewer episodic contexts than high-frequency words. Because of this lower number of pre-experimental contextual associations, there is less contextual competition, which results in better recollection of contextual information, including source, from experimental presentations. Experiment 1 tested the hypothesis that external source encoding and retrieval would be more accurate for low-frequency words relative to high-frequency words consistent with previous research. Experiment 1 also extended this logic to bilingual memory to determine whether in external source memory bilingual L2 provides better access to contextual details of the encoding episode than L1. As explained in the introduction, if contextual associations were made at the word-form level, source memory would be more accurate in L2, but if contextual associations were made at the conceptual level, source memory would be equivalent for L1 and L2.

In the encoding phase, participants were presented with information from two external sources; that is, words were presented either visually or auditorially. Learning was incidental, in that they were not informed that there would be a subsequent memory test of any kind. At test, all words from the encoding phase were presented both visually and auditorially, and participants were asked to indicate whether they saw the word or heard the word at encoding. Half of the words were high frequency and half of the words were low frequency. Similarly, half of the words were presented in English and half of the words were presented in Spanish. We predicted that source recognition performance would be more accurate for low-frequency words than for high-frequency words and more accurate for L2 words than for L1 words.

2.1 Method

2.1.1 Participants

64 bilingual participants were recruited for this study through the UTEP SONA system psychology participant pool and through advertisements placed in the UTEP Psychology Building and different social media platforms. Participants either received one hour of SONA participation credit or $10 for their participation. We recruited two different bilingual groups: 32 Spanish-dominant bilinguals, and 32 English-dominant bilinguals. Participants qualified as bilingual and were classified as English dominant or Spanish dominant based on objective measures of proficiency using the Woodcock-Munoz standardized language assessments. Participant characteristics are summarized in Table 2.1.

2.1.2 Materials

Woodcock-Muñoz Language Survey Revised (WMLS-R NU)

The Woodcock-Muñoz Language Survey Revised (WMLS-R; Woodcock, Muñoz, Sandoval, & Alvarado, 2005) is a standardized battery of language assessments to determine language proficiency in English and Spanish. The short form of this assessment (tests 1-4), includes picture vocabulary (test 1), verbal analogies (test 2), reading (test 3), and dictation (test 4). The short form has been used in previous research to determine bilingual/monolingual status and bilingual language dominance (e.g., Francis & Strobach, 2013a). To determine language dominance, the picture vocabulary and verbal analogies tests were administered to all participants in both English and Spanish. Participants had to have at least the proficiency of an 8 year old in both English and Spanish to be considered bilingual in the study. A participant was considered dominant in the language for which they scored highest on the age equivalency measure.

Language Background Questionnaire

Participants completed the *ESPADA* (English-Spanish Proficiency and Dominance Assessment, Francis & Strobach, 2013a). This is a multiple-item untimed self-report questionnaire that gathers general information about different dimensions of the language history of the participant. The items include information on age of acquisition of each language, information regarding the proficiency of languages other than English and Spanish, information regarding where the participant has lived (US, Mexico, or other Spanish speaking country), family language usage, social language usage, educational language usage, self-rated proficiency levels on reading, writing, and speaking in each language and other general language background information.

Demographic Background Questionnaire

This is a multiple item untimed questionnaire that gathers general background and demographic information about the participant. This questionnaire was used to gather general information on age, sex, ethnicity, and parent education levels.

Stimuli

Stimuli for the external source-monitoring task consisted of 120 words, including 60 high-frequency words and 60 low-frequency words. The frequencies of the words were taken from word frequency norms in English and in Spanish. The CELEX (Baayen, Piepenbrock & Van Run, 1995) norms were used for English words and the Alameda and Cuetos (Alameda & Cuetos, 1995) norms were used for Spanish words. High-frequency words had frequencies of 25 words per million or higher in each language. Low-frequency words had frequencies of 15 words per million or below in each language. A set of English and Spanish words that fit these criteria was identified for a previous study (Penalver & Francis, 2016). These words were recorded for use as auditory stimuli by the same female native speaker for both English and Spanish. Items were randomly assigned to lists, counterbalancing the assignment of items to English/Spanish and to auditory/visual conditions across participants, and lists were matched on the number of high frequency and low-frequency words in each condition.

At encoding, participants encountered a sequence of visual and auditory words blocked by language and word frequency. At test, participants saw the same 120 words (in a different order), and each word was presented both auditorially and visually. Participants had to determine whether each word was originally presented in the auditory or visual modality.

Table 2.1: Participant Language Characteristics in Experiment 1

Characteristic	**English Dominant Bilinguals**	**Spanish Dominant Bilinguals**
Median Age	21.4	20.5

AoA English[i]	5.2	8.5
AoA Spanish	2.6	1.0
AE English[ii]	14.4	10.2
AE Spanish	11.0	15.8
%Speak English[iii]	58.5%	33.3%
%Speak Spanish	26.6%	54.1%
% Speak Mixture	18.6%	17.6%

[i] AoA= Age of Acquisition
[ii] Age Equivalency for the WMLS-R
[iii] Self-reported percentage of the time spent speaking the language

2.1.3 Design

The experimental conditions formed a 2 (language) x 2 (word frequency) x 2 (presentation modality) within-subjects design. The language variable was whether the target item was presented in English or Spanish. Frequency of the target word was low or high. Finally, we manipulated whether the target word was presented visually or auditorially to vary the external source. The outcome measure was the forced-choice discrimination score (accuracy measure) for external source recognition.

2.1.5 Apparatus

The experimental computer task was conducted on an iMac desktop computer with a 17" screen. The experiment was programmed using PsyScope X experiment software (Cohen, MacWhinney, Flatt, & Provost, 1993). Source decision responses were made using an ioLab Systems button box.

2.1.6 Procedure

Participants completed an informed consent form, Language Background Questionnaire and the Demographic Questionnaire. The experimenter administered the picture vocabulary and verbal analogies tests of the WMLS-R in English and Spanish. This objective assessment of language determined whether the participant was considered to be bilingual and whether they were English dominant or Spanish dominant.

The experimental computer task involved an encoding phase and a test phase. In the encoding phase, participants were told to pay attention to the instructions. In the encoding phase, 120 words were presented, blocked by language and frequency in an order that was counterbalanced across participants. Visual and auditory trials were randomly intermixed within each language and frequency block (see Figure 2.1). Participants saw a cue before each word that alerted them to the modality of presentation of the word to follow (the cue for the auditory modality was an ear, and the cue for the visual modality was an eyeball). The cue was presented for 1000 ms, and immediately following the cue a blank screen appeared. For the visual modality, each word was presented on the screen for 1000 ms. For the auditory modality, words were presented through the computer speaker; then, after the onset of each auditory stimulus (Because auditory word stimuli typically take less than 1000 ms to play, a delay was incorporated to equate to 1000ms before the blank screen to equate the amount of time that the participant devoted to the incoming auditory and visual stimuli.) The next external cue appeared after an inter-trial interval where a blank screen appeared.

At test, all words from the encoding phase were presented in a different random sequence. order of languages and frequency blocks were the same as in the encoding phase to keep the retention interval similar for all item types. Each word was simultaneously presented both auditorially and visually, and participants indicated whether they had previously seen or heard the word using the button box (e.g., participants pressed yellow if they remembered hearing the item and pressed green if they remembered seeing the item) (see Figure 2.2 for test phase). Each visual item appeared on the screen until the participant made the source decision, each auditory item appeared for as long as the item lasted.

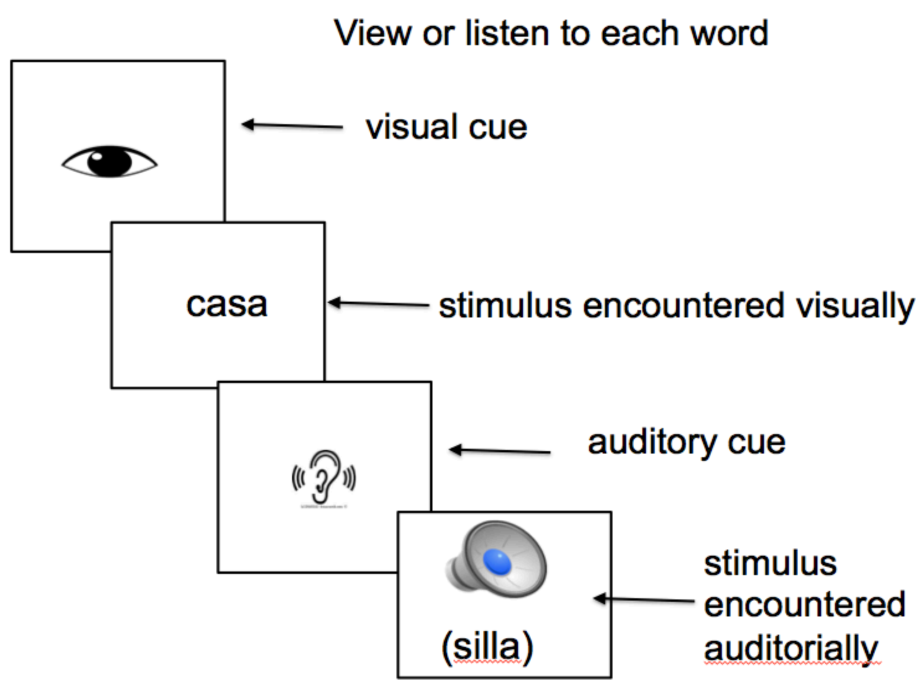

Figure 2.1: Encoding Phase in External Source Monitoring

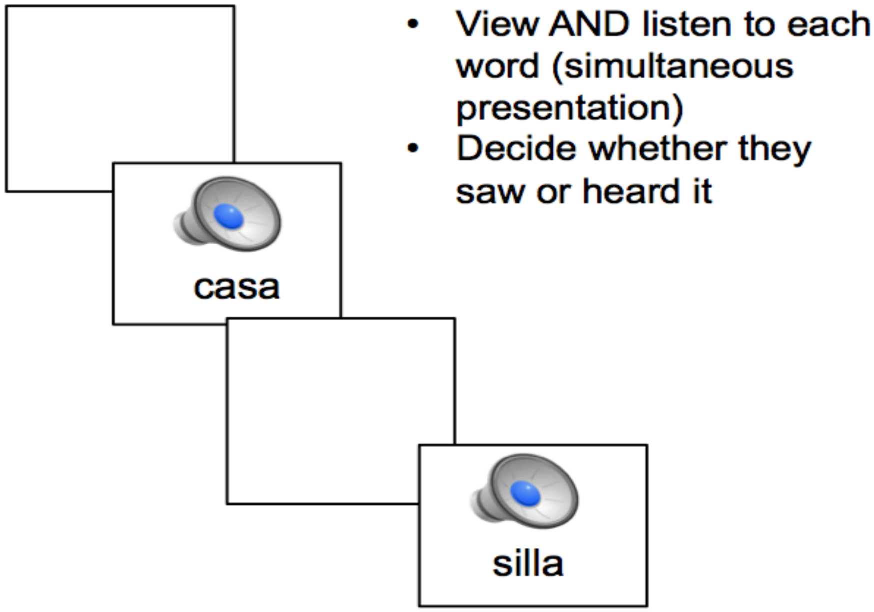

Figure 2.2: Test Phase in External Source Monitoring

2.2 Results

Using an equal-variance signal detection model, forced choice discrimination scores (d'_{FC}), and bias scores ($\log\beta$) were obtained for each participant. For bilingual participants, English and Spanish were recoded as L1 and L2 based on each participant's objective language proficiency scores.

Discrimination Scores. A forced choice model of d'_{FC} was used to analyze the scores (Wickens, 2002). The forced choice model of d'_{FC} is used when a participant must discriminate between two stimulus types to which they have had exposure. The forced choice model of d'_{FC} does not take false alarms or misses into account, because one source does not have priority over the other. The source decision is either correct or incorrect. All items at test had been presented at encoding, so there were no foil items. Higher discrimination scores indicate better source memory.

For each participant, a d'_{FC} score was obtained for each language at each frequency level. Mean discrimination scores are given in Table 2.3 and illustrated in Figure 2.3. Bilingual discrimination scores were submitted to a 2 (language) x 2 (word frequency) repeated-measures ANOVA. Bilinguals showed better source discrimination for low-frequency words than for high-frequency words, $F(1, 63) = 35.54$, $MSE = 5.75$, $p < .001$. However, there was no main effect of language proficiency, $F(1, 63) = .10$, $MSE = .07$, $p = .746$. The effects of word frequency and language proficiency did not interact, $F(1, 63) = 2.78$, $MSE = .948$, $p = .100$.

Table 2.3: Mean Discrimination Scores (d'_{FC}) in Experiment 1

Word Frequency	L1	L2
High Frequency	1.98	1.82
Low Frequency	2.16	2.25

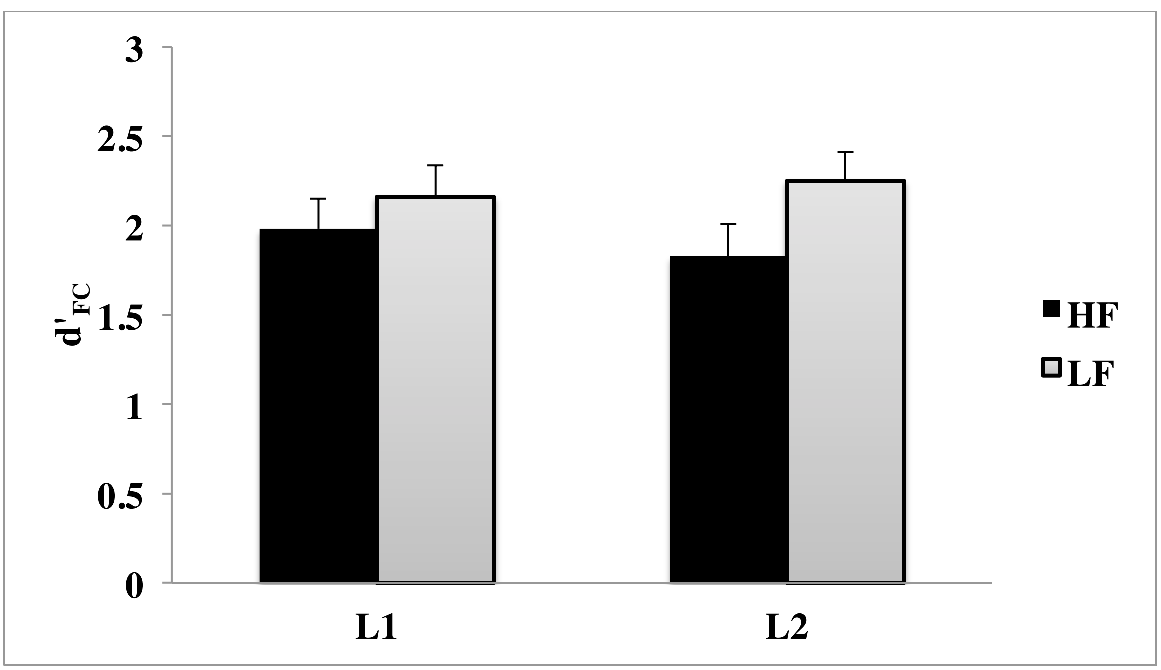

Figure 2.3: Discrimination Scores for Low- and High-Frequency Words in L1 and L2 for the External Source Monitoring task in Bilinguals

Bias Scores. Positive bias scores indicate bias toward auditorially presented sources; negative bias scores indicate bias toward visually presented sources. The bias was not significant for high-frequency words in L1 or L2. There was a reliable difference as a function of word frequency $F(1, 63) = 52.40$, $MSE = 17.49$, $p < .001$, but not language proficiency $F(1, 63) = .135$, $MSE = .35$, $p = .712$. There was not a significant interaction of word frequency and language proficiency, $F(1, 63) = .14$, $MSE = .04$, $p =$ .712. Single-sample t tests for each condition against a test value of was ran to see whether the degree of bias in a particular direction was statistically significant. Low-frequency words in bilingual L1, $t(63) = 5.36$, $p < .001$ and bilingual L2, $t(63) = 5.74$, $p < .001$ showed a significant bias toward an auditory presentation response. Specifically, participants are more likely to respond that a stimulus was presented auditorially at encoding than they are to say it was presented visually. Mean bias scores are given in Table 2.4 and illustrated in Figure 2.4.

Table 2.4: Bias Score (logβ) Means in Experiment 1

Word Frequency	**L1**	**L2**
High Frequency	0.002	0.000
Low Frequency	0.500	0.548

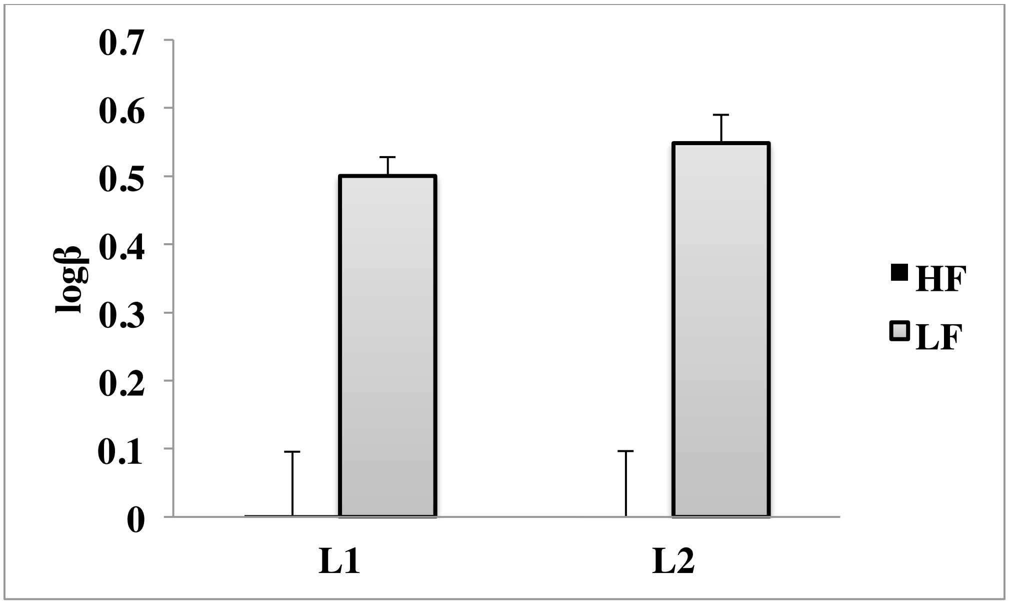

Figure 2.4: Bias Scores for Low- and High-Frequency Words in L1 and L2 for the External Source Monitoring task for Bilinguals

2.3 Discussion

The results of Experiment 1 show that low-frequency words lead to more accurate encoding of source information than do high-frequency words. This finding suggests that external source monitoring is more accurate for less familiar items than for items that are more familiar. According to the source-monitoring framework, sources associated with items that are more difficult and unique are more easily retrieved (Johnson et al., 1993), and this is indeed the case for low-frequency items. This low-frequency discrimination advantage also supports the source-of-activation-confusion theory (Buchler and Reder, 2007). Experiment 1 shows that memories have external source representations that can be accurately discriminated, and that low-frequency words make the source discriminations more accurate.

Experiment 1 provides evidence that informs the memory literature. In terms of the source-monitoring framework, encoding distinct and unique items makes source retrieval more accurate. However, the source-monitoring framework does not specify how language proficiency might affect source retrieval. The source-of–activation-confusion theory indicates that episodic distinctiveness increases the probability of recollection of items and their encoding contexts (fan factor). This same logic can be used to reason that because bilingual L2 is more episodically distinctive, the probability of recollection of items and sources will be higher in L2 than in L1. Thus, we expected more accurate source retrieval for words in L2 relative to words in L1. Experiment 1 shows that the greater distinctiveness of L2 word forms relative to L1 word forms does not make source retrieval more accurate. This pattern of results was also observed in the only other known study investigating the effects of the bilingual experience on external source monitoring (Francis et. al., 2016). These results stand in contrast to the L2 advantage in bilingual item recognition and the predictions of the frequency-lag hypothesis. The pattern of results showing a low-frequency advantage but not an L2 advantage indicates that the episodic associations formed between items and their sources or contexts are made at the conceptual level rather than the word-form level.

Chapter 3: Experiment 2

Experiment 2 focused on internal source monitoring, which is a type of reality monitoring where one has to discriminate between imagined internal events and perceived internal events. For example, if a person is making an internal source monitoring decision, they may have to decide whether they imagined they sent an email or actually sent an email. We tested the hypothesis that internal source monitoring would be more accurate for low-frequency words than for high-frequency words, and that internal source monitoring in bilinguals would be more accurate in L2 than in L1. We could find no previous studies that investigated the effects of word frequency or language proficiency on internal source monitoring.

Experiment 2 further tested the hypothesis that bilinguals would outperform their monolingual counterparts in internal source monitoring. The basis of this hypothesis is similar to the logic for the hypothesis that bilingual source monitoring will be more accurate in L2 than in L1. Specifically, because bilinguals have less experience with either of their languages than monolinguals have with their only language, they should experience less contextual competition than monolinguals and therefore better internal source discrimination. This logic assumes that the sources or contexts are associated at the word-form level. If, on the other hand, these associations are made at the conceptual level, then no monolingual-bilingual differences would be expected because (language-general) concepts in bilinguals ought to be experienced at the same rate as those concepts are experienced by monolinguals.

In the encoding phase, participants viewed pictures and were cued to name them either overtly or covertly. Learning was incidental, in that they were not informed that there would be a later memory test. Subsequently, at test, participants were presented with each picture and asked to decide whether they had named it overtly or covertly at encoding. Half of the pictures had high-frequency names and half of the pictures had low-frequency names. For bilingual participants, half of the pictures were named in English and half of the pictures were named in Spanish, and for monolingual participants, all pictures were named in English. We predicted that internal source encoding and retrieval would be more accurate for low-frequency picture names relative to high-frequency picture names, for bilingual L2 responses relative to L1 responses, and for bilinguals relative to monolinguals.

3.1 Method

3.1.1 Participants

64 Spanish-English bilingual participants and 64 English monolingual participants were recruited for this study from the UTEP SONA system psychology participant pool and through advertisements placed in the UTEP Psychology Building and different social media platforms. Participants either received one hour of SONA participation credit or $10 for their participation. We recruited two different bilingual groups: 32 Spanish-dominant bilinguals, and 32 English-dominant bilinguals. Participants were classified as bilingual or monolingual, and as English or Spanish dominant based on objective measures of proficiency using the Woodcock-Munoz standardized language assessments. Participant characteristics are summarized in Table 3.1.

3.1.2 Materials

The language background questionnaire, demographic background questionnaire, and Woodcock-Munoz standardized language assessment explained in Experiment 1 materials were also used for Experiment 2. English Monolingual participants had to score 8 years old or below on the Spanish age equivalency to be considered monolingual. Spanish Monolingual participants were not included in this study.

Stimuli

Stimuli for the internal source-monitoring task consisted of 120 pictures, including 60 pictures with high-frequency names and 60 pictures with low-frequency names. The pictures corresponded to the words used in Experiment 1. Items were randomly assigned to lists, counterbalancing the assignment of items to English/Spanish and to covert/overt conditions across participants.

At encoding, participants encountered 120 pictures blocked by naming language and name frequency, with overt and covert naming trials randomly intermixed. At test, participants saw the same pictures in a different order within each block and indicated whether each picture was named overtly or covertly at encoding.

Table 3.1: Participant Language Characteristics in Experiment 2

Characteristic	English Monolinguals	English Dominant Bilinguals	Spanish Dominant Bilinguals
Median Age	20.0	21.5	22.0
AoA English[i]	1.3	5.0	7.2
AoA Spanish	--	1.3	1.2
AE English[ii]	17.6	17.2	14.6
AE Spanish	4.3	11.5	17.5
% Speak English[iii]	90.0%	56.5%	46.7%
% Speak Spanish	6.9%	31.5%	43.2%

% Speak Mixture	4.8%	11.9%	10.0%

[i] Age of Acquisition
[ii] Age Equivalency for the WMLS-R
[iii] Self-reported percentage of the time spent speaking the language

3.1.3 Design

The experimental conditions formed a 2 (language) x 2 (name frequency) x 2 (type of response) within-subjects design. The language variable was whether the target item was named in English or Spanish. The name of the target picture was either a high-frequency word or a low-frequency word. Finally, we manipulated whether the target picture was named overtly or covertly to vary the internal source. The outcome measure was the forced-choice discrimination score for internal source recognition.

3.1.5 Apparatus

The experimental computer task was conducted on an iMac desktop computer with a 17" screen. The experiment was programmed using PsyScope X experiment software (Cohen, MacWhinney, Flatt, & Provost, 1993). Source decision responses were made using an ioLab Systems button box.

3.1.6 Procedure

Participants completed the same questionnaires and assessments as in Experiment 1. The experimental computer task had an encoding phase, a test phase, and a final picture-naming phase. In the encoding phase, participants named pictures overtly or covertly, and were not told about the later memory task. Bilingual participants named a sequence of 120 pictures with high frequency and low-frequency names in English and Spanish, with trials blocked by language. Block order counterbalanced across participants. English monolingual participants named a sequence of 120 pictures in English with high frequency and low-frequency names, with trials blocked by frequency. Again, block order counterbalanced across participants. At the halfway point of the study phase (i.e. after the 60^{th} item), an instruction came on the screen to indicate the language in which the pictures were to be named. Overt and covert naming trials were randomly intermixed within each block, with a cue presented before each picture to indicate what type of response to make (see Figure 3.1). The cue for the overt picture naming response was a symbol of a man talking. The cue for the covert picture naming response was a symbol of a thought bubble. On each trial, the cue appeared for 1000 ms and was immediately followed by the picture to be named, which was presented for 4000 ms. Lastly, a blank screen was presented for 1000ms before the next cue appeared.

At test, participants saw the same pictures that they had named at encoding (see Figure 3.2). Here, the order of language blocks were the same as in the encoding phase to keep the retention interval similar for all item sets, but the items were presented in different random orders within each block. For each picture, participants indicated whether they had named the picture overtly or covertly at study using the button box (e.g., press yellow if you remember a covert item or green if you remember an overt item). Participants were presented with the picture until they made the source decision using the button-box.

There was a final picture-naming phase where bilingual participants were asked to name pictures in the same languages that they had been asked to name them at encoding. Participants had to receive over 50% accuracy on both English and Spanish picture naming to be included in the study. Errors were recorded for the final picture-naming phase. Errors were recorded to make sure participants knew most of the names in English and Spanish of the pictures they encountered. There were no participants excluded from the study because of the number of response errors. Similarly, monolingual participants were asked to name pictures but in English only. The order of language and frequency blocks was the same across the study and test phases.

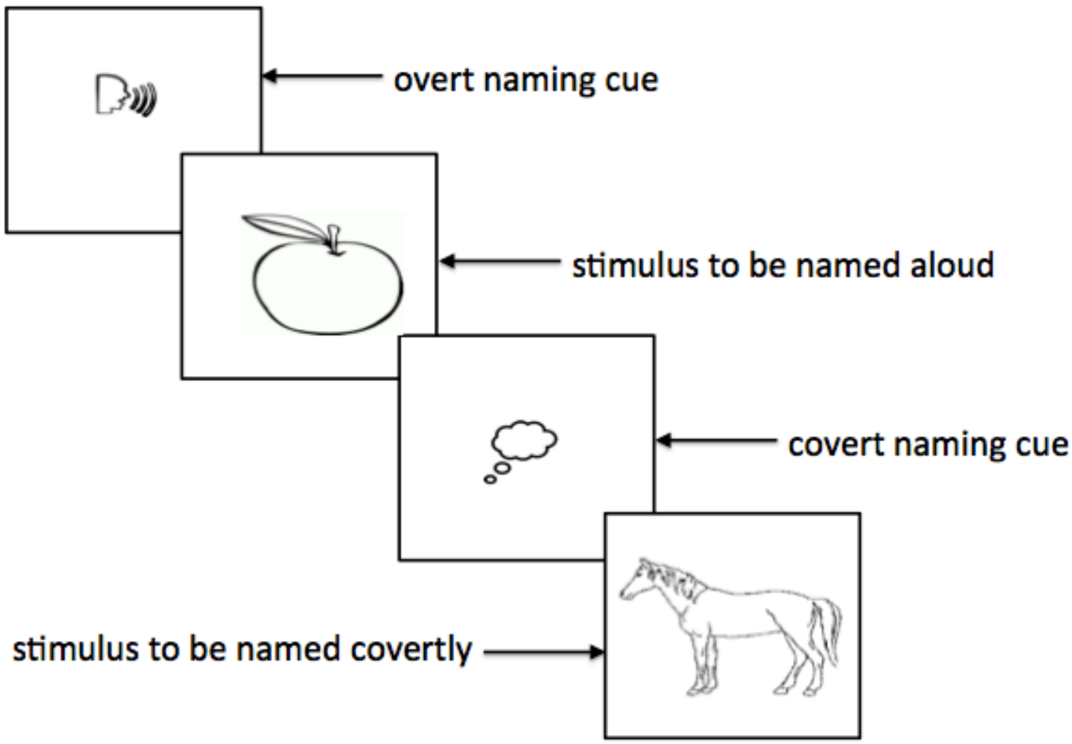

Figure 3.1: Encoding Phase in Internal Source Monitoring

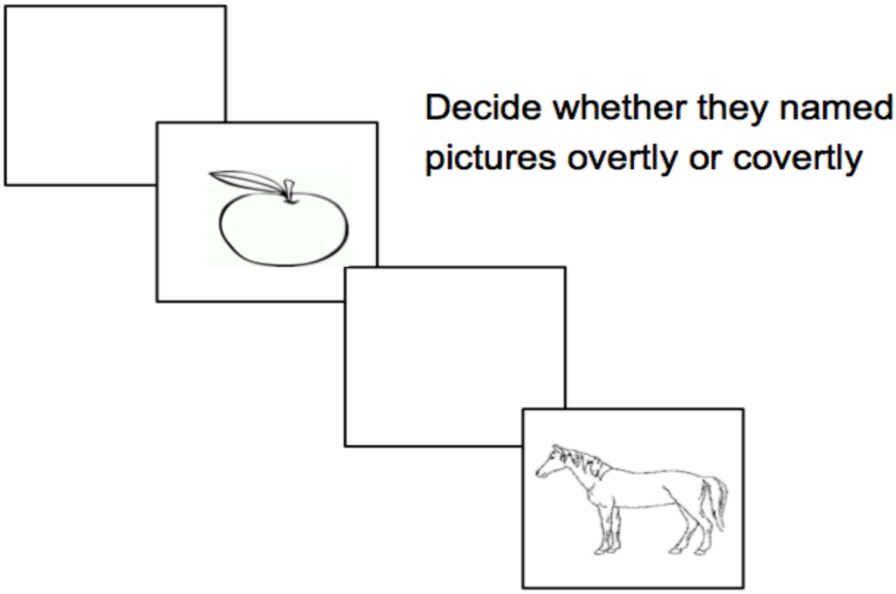

Figure 3.2: Test Phase in Internal Source Monitoring where participants had to decide whether they named pictures overtly or covertly

3.2 Results

Using an equal-variance signal detection model, forced choice discrimination scores (d'_{FC}), and bias scores (logβ) were obtained for each participant in each condition. For bilingual participants, English and Spanish were recoded as L1 and L2 based on each participant's objective language proficiency scores.

Discrimination Scores. For each participant, a d'_{FC} score was obtained for each language at each frequency level. Mean discrimination scores are given in Table 3.3 and illustrated in Figure 3.3. Bilingual discrimination scores were submitted to a 2 (language) x 2 (word frequency) repeated-measures ANOVA. Bilinguals showed better source discrimination for low-frequency picture names than for high-frequency picture names, $F(1, 63) = 8.25$, $MSE = 4.92$, $p = .006$. However, there was no main effect of language proficiency, $F(1, 63) = .01$, $MSE = .01$, $p = .927$. The effects of word frequency and language proficiency did not interact, $F(1, 63) = .12$, *MSE* = .05*, p* = .733. Monolingual d'_{FC} scores were submitted to a paired-samples t test, which showed that source discrimination was more accurate for low-frequency picture names than for high-frequency picture names, $t(63) = 5.34$, $MSE = .071$, $p < .001$.

To compare bilingual and monolingual performance, two mixed 2 (group) x 2 (word frequency) mixed ANOVAS were performed, one for comparing bilingual L1 to monolingual performance, and one for comparing bilingual L2 to monolingual performance. There were no significant monolingual- bilingual group differences for L1 or L2, *F*s ≤ 1. There were also no interactions of language group and word frequency, *F*s < 1.

Table 3.3: Mean Discrimination Scores (d'_{FC}) in Experiment 2

Picture Name Frequency	**English Monolingual**	**Bilingual L1**	**Bilingual L2**
High Frequency	2.28	2.45	2.47
Low Frequency	2.66	2.76	2.72

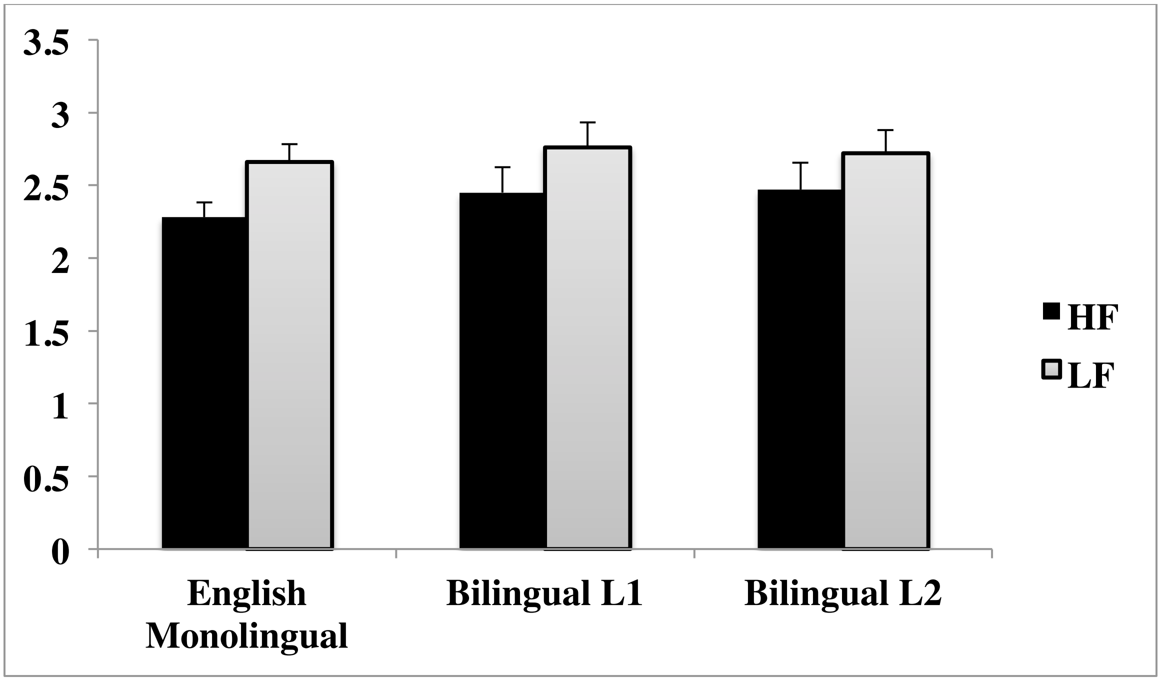

Figure 3.3: Discrimination Scores for Low- and High-Frequency Pictures for the Internal Source Monitoring task in English Monolinguals and Bilingual L1 and L2

Bias Scores. Mean bias scores are given in Table 3.4 and illustrated in Figure 3.4. Positive bias scores indicate bias toward covert sources, whereas negative bias scores indicate bias toward overt sources. Bias to respond overt or covert did not vary reliably as a function of word frequency, $F(1, 63) = 2.82$, $MSE = 1.72$, $p = .09$, or language, $F(1, 63) = .003$, $MSE = .003$, $p = .954$. Finally, there was not a significant interaction, $F(1, 63) = 2.98$, $MSE = 1.81$, $p = .089$. Single-sample t tests for each condition against a test value of was ran to see whether the degree of bias in a particular direction was statistically significant. However, for high-frequency words, bilinguals showed a significant bias toward reporting overt responses in both L1, $t(63) = 2.73$, $p < .001$, and L2, $t(63) = 2.55$, $p < .001$. Additionally, bilinguals showed a significant bias toward reporting overt responses for low-frequency words in L2, $t(63) = 2.04$, $p < .05$. Specifically, when they made errors, they were more likely to say covert was overt than to say overt was covert. That is, they were biased to think something happened that really did not happen rather than to think something did not happen that really did (e.g., a false memory).

Monolingual logβ scores were submitted to a paired-samples t test, and no frequency effect was observed, $t < 1$. However, for high-frequency words, monolinguals showed a significant bias toward reporting overt responses, $t(63) = 2.71$, $p = .009$. To compare monolingual and bilingual bias, two mixed 2 (group) x 2 (word frequency) mixed ANOVAs were performed, one for comparing bilingual L1 to monolinguals, and one for comparing bilingual L2 to monolinguals. No group differences or interactions were observed, Fs < 1.

Table 3.4: Bias (logβ) Means in Experiment 2

Picture Name Frequency	English Monolingual	Bilingual L1	Bilingual L2
High Frequency	-.211	-.390	-.215
Low Frequency	-.009	-.057	-.219

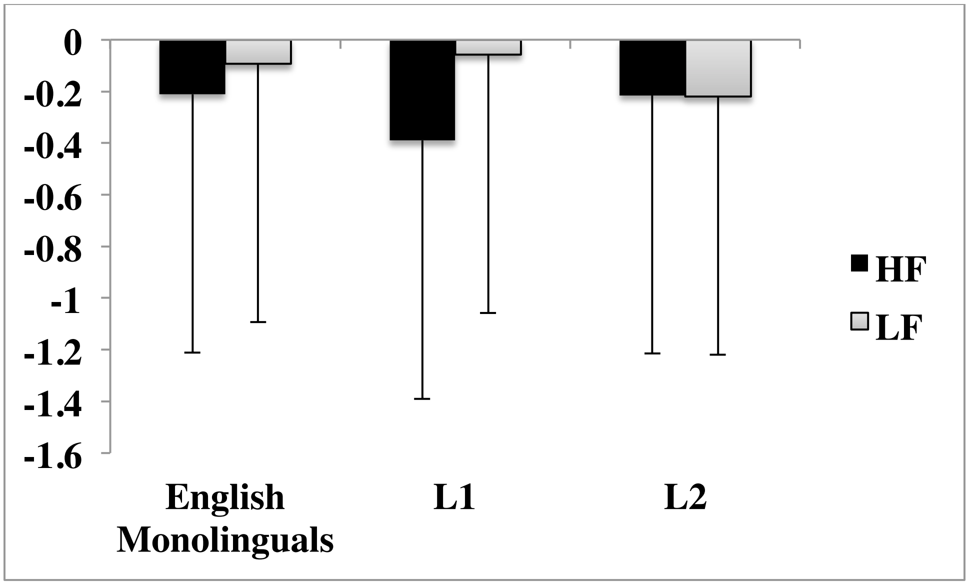

Figure 3.4: Bias Scores for Low- and High-Frequency Pictures in L1 and L2 for the Internal Source Monitoring task in English Monolinguals and Bilinguals

3.3 Discussion

In Experiment 2, source recognition was more accurate for low-frequency picture names than for high-frequency picture names. This result of suggests that internal source monitoring is more accurate for less familiar items than for more familiar items, consistent with the source-monitoring framework (Johnson et al., 1993). This low-frequency source discrimination advantage supports the source-of-activation-confusion theory. The effects of word frequency on internal source memory had not been examined prior to this study. Experiment 2 shows that internal source representations can be accurately discriminated and that low-frequency words make source discrimination more accurate.

Experiment 2 provides evidence that informs the bilingual memory literature, because this is the first study to have investigated the effects of language proficiency on internal source monitoring. In terms of the source-monitoring framework, encoding distinct and unique items makes source retrieval more accurate. The source-of–activation-confusion theory indicates that episodic distinctiveness increases the probability of recollection. Applying this logic to the bilingual case, because bilingual L2 word forms are more episodically distinctive, L2 words and their episodic contexts should have a higher probability of recollection. Therefore, we expected to observe more accurate internal source retrieval for words in L2 than for words in L1. Experiment 2 showed that the episodic distinctiveness of L2 word forms relative to L1 word forms does not make internal source recognition more accurate. This pattern of results was observed in similar studies investigating the effects of the bilingual experience on *external* source monitoring (Francis et. al., 2016) and in Experiment 1. However, these results stand in contrast to the bilingual L2 advantage in item recognition and the predictions of the frequency-lag hypothesis. Because we observed a low-frequency advantage and not a bilingual L2 advantage, the results of Experiment 2 indicate that the associations formed between words and their sources or contexts are made at the language-general conceptual level rather than the language-specific word-form level. This information can be used to further specify models of bilingual cognition and models of memory that do not take into account the level at which contextual representations are made.

Experiment 2 compared bilingual and monolingual internal source monitoring for the first time. We expected internal source monitoring to be more accurate for bilinguals compared to monolinguals if the sources were associated at the word-form level. Experiment 2 showed no group differences, which provides additional evidence that the associations between words and their sources or episodic contexts are made at the conceptual level rather than the word-form level. The only previous study to compare source monitoring in monolinguals and bilinguals focused on external source monitoring and had an intentional encoding task in which participants were made aware of the exact nature of the final test. In that study, bilinguals outperformed monolinguals (Francis et al., 2016). However, in that study, participants had the opportunity to use self-generated strategies for keeping track of sources, and bilinguals may have used different strategies than monolinguals. In the present study, participants were not aware that there would be any kind of test, which would eliminate the possibility that the language groups used different strategies.

Finally, it should be noted that Experiment 2 tested naïve participants on their ability to discriminate between overt and covert pictures. They were not instructed about the nature of the memory task that would be given at test. Picture naming requires identification of the object, phonological retrieval, and generation of the appropriate response. Because participants imagined naming or actually named pictures at encoding, they had to identify the object and retrieve phonology for both tasks. At test, participants had to decide whether they imagined naming a picture or actually named a picture. Despite the similarity of the cognitive processes involved in the overt and covert naming tasks, participants were remarkably good at discriminating these two internal sources. This may mean that there could be differences in performance for the different types of source monitoring, such that internal monitoring makes us generate internal information, which can lead to better memory performance.

Chapter 4: Experiment 3

Experiment 3 focused on internal-external source monitoring, otherwise known as reality monitoring. Recall that internal-external source monitoring is where one has to discriminate between one internal event and one external event. For example, if a person is making an internal-external source monitoring decision, they may have to decide whether the idea was their own idea or someone else's idea. Experiment 3 tested the hypotheses that internal-external source monitoring would be more accurate for low-frequency words relative to high-frequency words and that internal-external source monitoring in bilinguals would be more accurate in L2 than in L1. We could find no previous studies that provided clear evidence of the effects of word frequency or language proficiency on internal-external source monitoring; the results of a single study investigating the effects of word frequency on internal-external source monitoring were inconclusive (Guttentag & Carroll, 1997).

In the encoding phase, participants were presented with information from one internal source (e.g., imagine hearing a word) and one external source (e.g., actually hearing a word). Learning was incidental, in that they were not informed that there would be a memory test. Subsequently, at test, participants were presented with each word from the encoding phase and asked to decide whether they had actually heard it or only imagined hearing it at encoding. Half of the words were high frequency and half of the words were low frequency. Half of the words were presented in English and half of the words were presented in Spanish. We predicted that source recognition performance would be better for low-frequency words than for high-frequency words and better in L2 than in L1, but we did not predict an interaction.

4.1 Method

4.1.1 Participants

64 bilingual participants were recruited for this study from the UTEP SONA system Psychology participant pool and through advertisements placed in the UTEP Psychology Building and different social media platforms. Participants either received one hour of SONA participation credit or $10 for their participation. We recruited two different bilingual groups: 32 Spanish-dominant bilinguals, and 32 English-dominant bilinguals. Participants were classified as bilingual or monolingual, and as an English dominant bilingual or Spanish dominant bilingual based on objective measures of proficiency using the Woodcock-Munoz standardized language assessments. Participant characteristics are summarized in Table 4.1.

4.1.2 Materials

The language background questionnaire, demographic background questionnaire, and Woodcock-Munoz standardized language assessment explained in Experiment 1 materials were also used for Experiment 3.

Stimuli

Stimuli for the internal-external source-monitoring task consisted of 120 words, including 60 high-frequency words and 60 low-frequency words. The frequencies of the words were taken from word frequency norms in English and in Spanish. The CELEX (Baayen, Piepenbrock & Van Run, 1995) norms were used for the English language and the Alameda and Cuetos (Alameda & Cuetos, 1995) norms were used for the Spanish language. High-frequency words had frequencies of 25 words per million or higher in each language. Low-frequency words had frequencies of 15 words per million or below in each language. A set of English and Spanish words that fit these criteria was identified for a previous study (Penalver

& Francis, 2016). These words were recorded for use as auditory stimuli by a female for both English and Spanish. Items were randomly assigned to lists, counterbalancing the assignment of items to English/Spanish and to hearing/imagine hearing conditions across participants.

At encoding, participants encountered a sequence of auditory words and imagined auditory words blocked by language and word frequency. Participants were instructed to imagine the same speaker saying the words for the trials were they had to imagine hearing the words. At test, participants saw the same 120 words (in a different order) presented visually. Participants had to determine whether each word was actually presented auditorially or whether they imagined hearing the word. Participants were presented with the visual item until they made the source decision, and the auditory item for as long as the auditory item took to play.

Table 4.1: Participant Language Characteristics in Experiment 3

Characteristic	**English Dominant Bilinguals**	**Spanish Dominant Bilinguals**
Median Age	20.8	22.0
AoA English[i]	5.0	8.5
AoA Spanish	1.7	1.0
AE English[ii]	14.3	10.7
AE Spanish	10.4	14.8
%Speak English[iii]	59.4%	35.8%
%Speak Spanish	27.8%	50.3%
% Speak Mixture	12.9%	12.6%

[i] Age of Acquisition
[ii] Age Equivalency for the WMLS-R
[iii] Self-reported percentage of the time spent speaking the language

4.1.3 Design

The experimental conditions formed a 2 (language) x 2 (word frequency) x 2 (type of presentation) within-subjects design. The language variable was whether the target word was presented in English or Spanish. Frequency of the target word was low or high. Finally, we manipulated whether the target word was presented both visually and auditorially or presented only visually with an instruction to imagine hearing the word to vary the internal-external source. The outcome measures were the forced-choice discrimination score (accuracy measure) for internal-external source recognition and the bias score (logβ).

4.1.6 Apparatus

The experimental computer task was conducted on an iMac desktop computer with a 17" screen. The experiment was programmed using PsyScope X experiment software (Cohen, MacWhinney, Flatt, & Provost, 1993). Source decision responses were made using an ioLab Systems button box.

4.1.5 Procedure

Participants completed the same questionnaires and assessments as in Experiments 1 and 2. The experimental computer task had an encoding phase and a test phase. In the encoding phase, participants either saw and heard words or saw and imagined hearing words, without mention of having to remember how they responded to the words. They were instructed to imagine hearing trials in the same voice where actual audio trials were presented. A sequence of 120 high frequency and low-frequency words in English and

Spanish were presented, with trials blocked by language and frequency. An instruction came on the screen at the beginning of the study phase and after the 60^{th} item to indicate the language in which the words would be presented. Auditory and imagined auditory trials were randomly intermixed within each block, with a cue presented before each word to indicate what type of response to make (see Figure 4.1). The cue for the hearing trials was a symbol of an ear. The cue for the imagine hearing trials was a symbol of a thought bubble. On each trial, the cue was presented for 1000 ms and followed immediately by a blank screen, which was presented for 1000 ms. After the blank screen appeared, the target item was presented for 1000 ms (e.g., for external source trials, the visual stimulus was presented for 1000 ms while the auditory stimuli played simultaneously, and for the internal source trials, the visual stimulus was presented for 1000 ms followed by a 1000 ms inter-trial interval before the next cue appeared.

At test, participants saw and heard the same words that they had encountered at encoding (see Figure 4.2). The order of language and frequency blocks was the same as in the encoding phase to keep the retention interval similar for all item sets, but the items were presented in different random orders within blocks. For each word, participants indicated whether they had actually heard the word or imagined hearing the word at encoding using the button box (e.g., press yellow if you remember imagining hearing an item or green if you remember actually hearing an item). Participants were presented with the visual item until they made the source decision using the button-box, and presented with the auditory item for as long as the item took to finish playing.

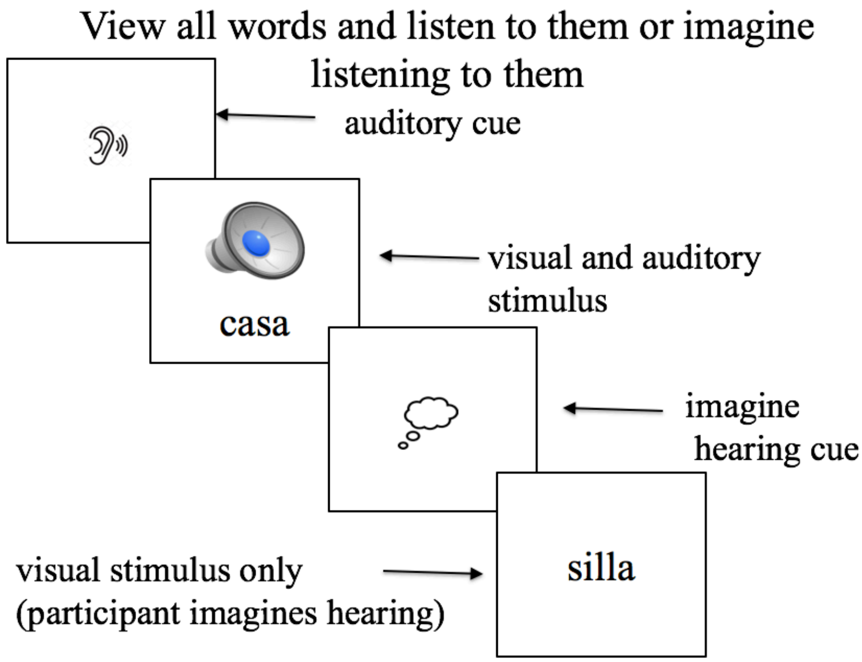

Figure 4.1: Encoding Phase in Internal-External Source Monitoring

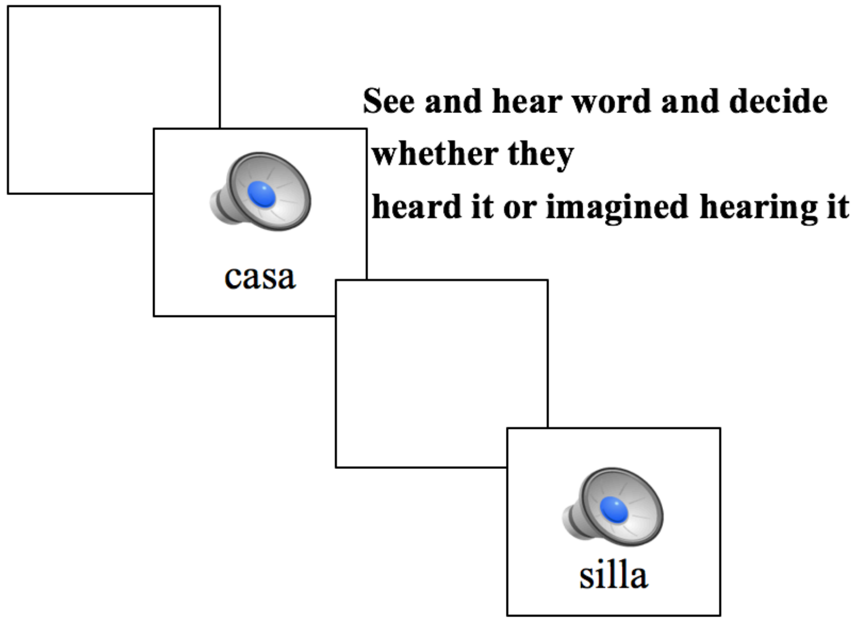

Figure 4.2: Test Phase in Internal-External Source Monitoring

4.2 Results

Using an equal-variance signal detection model, forced choice discrimination scores (d'_{FC}), and bias scores ($\log\beta$) were obtained for each participant. For bilingual participants, English and Spanish were recoded as L1 and L2 based on each participant's objective language proficiency scores.

Discrimination Scores. For each participant, a d'_{FC} score was obtained for each language at each frequency level. Mean discrimination scores are given in Table 4.3 and illustrated in Figure 4.3. Bilingual discrimination scores were submitted to a 2 (language) x 2 (word frequency) repeated-measures ANOVA. Bilinguals showed better source discrimination for low-frequency words than for high-frequency words, $F(1, 63) = 6.60$, $MSE = .94$, $p = .013$. However, there was no main effect of language proficiency, $F(1, 63) = .09$, $MSE = .05$, $p = .767$. The effects of word frequency and language proficiency did not interact, $F(1, 63) = .42$, $MSE = .16$, $p = .520$.

Table 4.3: Mean Discrimination Scores (d'_{FC}) in Experiment 3

Word Frequency	L1	L2
High Frequency	1.67	1.70
Low Frequency	1.76	1.88

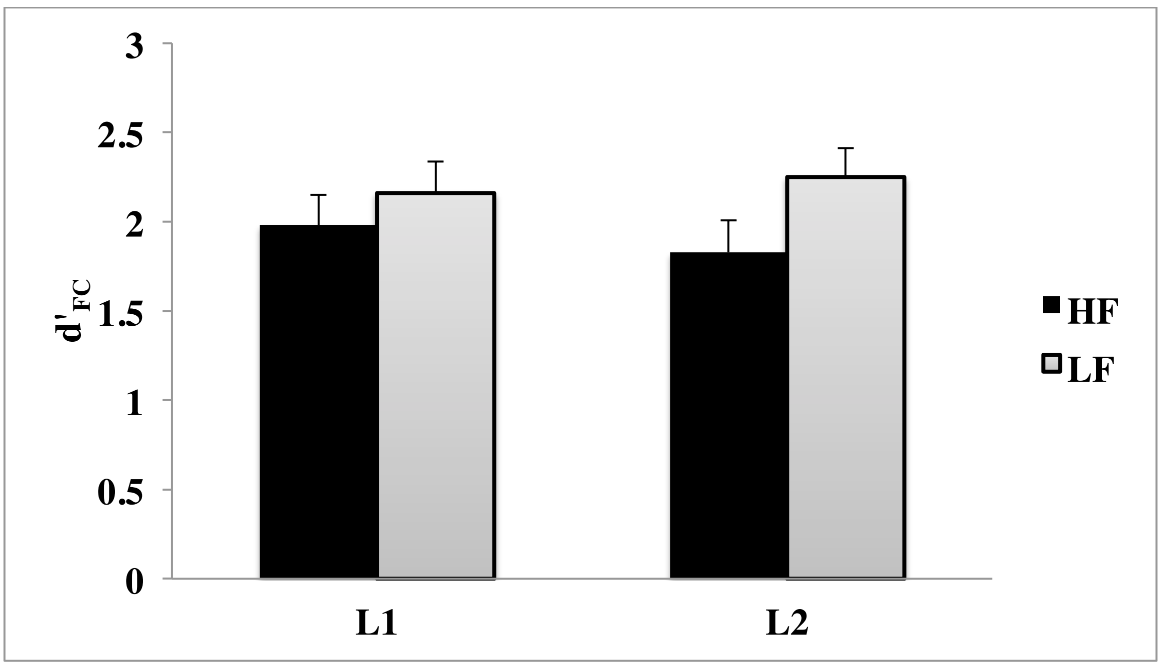

Figure 4.3: Discrimination Scores for Low- and High-Frequency Words in L1 and L2 for the Internal- External Source Monitoring task for Bilinguals

Bias Scores. Mean bias scores are given in Table 4.4 and illustrated in Figure 4.4. Positive bias scores indicate participant bias toward responding that they imagined having heard sources; negative bias indicates bias toward responding that they actually heard sources. There was a reliable effect of word frequency, $F(1, 63) = 52.40$, $MSE = 17.49$, $p < .001$, but not language proficiency, $F(1, 63) = .135$, $MSE = .04$, $p = .715$. Finally, there was not a significant interaction, $F(1, 63) = .14$, $MSE = .039$, $p = .712$. Single-sample t tests for each condition against a test value of was ran to see whether the degree of bias in a particular direction was statistically significant. Bilingual participants showed a bias to respond that auditory presentations were imagined for low-frequency words in L1, $t(63) = 4.84$, $p < .001$, and L2, $t(63) = 4.12$, $p < .001$, but this bias was not observed for high-frequency words. Specifically, when participants made errors they were more likely to say that the actual auditory presentation was an imagined auditory presentation than that the imagined auditory presentation was an actual auditory presentation.

Table 4.4: Bias (logβ) Means in Experiment 3

Word Frequency	L1	L2
High Frequency	-.02	-.09
Low Frequency	.46	.41

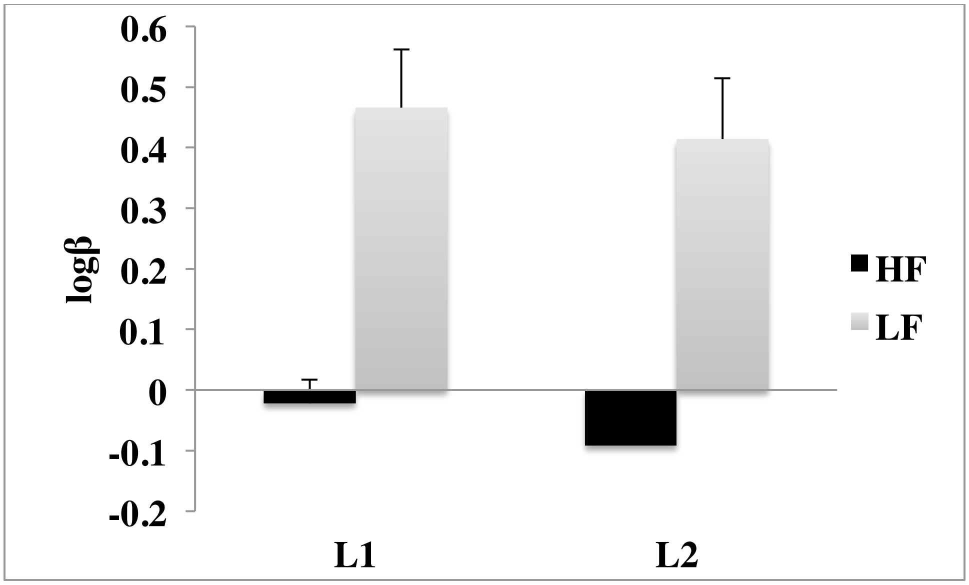

Figure 4.4: Bias Scores for Low- and High-Frequency Words in L1 and L2 for the Internal-External Source Monitoring task for Bilinguals

4.3 Discussion

In Experiment 3, source recognition was more accurate for low-frequency words than for high-frequency words. This result of suggests that internal-external source monitoring is more accurate for less familiar items than for more familiar items, consistent with the source-monitoring framework (Johnson et al., 1993). This low-frequency source discrimination advantage supports the source-of-activation-confusion theory just as the findings from Experiments 1 and 2 did with internal and external source monitoring. The effects of word frequency on internal-external source memory had not been examined prior to this study. Experiment 3 shows that internal-external source representations can be accurately discriminated and that low-frequency words make source discrimination more accurate.

Experiment 3 provides evidence that informs the bilingual memory literature. The source-of–activation-confusion theory indicates that episodic distinctiveness increases the probability of recollection. In applying this logic to the bilingual case, L2 word forms have greater episodic distinctiveness than L1 word forms, so if sources were associated at the word-form level, we would expect greater recollection of L2 items and their episodic contexts and therefore better source discrimination in L2 than in L1. Experiment 3 shows that the greater episodic distinctiveness of L2 word forms does not make source retrieval more accurate in L2 than in L1. This pattern of results is consistent with similar studies investigating the effects of the bilingual experience on *externa*l source monitoring (Francis et. al., 2016) and in Experiments 1 and *internal* source monitoring in Experiment 2. These results stand in contrast to the bilingual L2 advantage in item recognition and the predictions of the frequency-lag hypothesis. Because we observed a low-frequency advantage and not a bilingual L2 advantage, we conclude that the associations formed between words and their sources or contexts are made at the language-general conceptual level rather than the language-specific word-form level.

Chapter 7: General Discussion

The main theoretical question explored in this dissertation was whether word-to-context associations are stored at the word form or concept level. The source-monitoring framework does not address how item familiarity (e.g. word frequency and language proficiency) affects the different types of source monitoring. Each experiment tested the effects of word frequency and language proficiency on one of the three types of source monitoring identified in the source-monitoring framework: external, internal (reality), and internal-external (reality). External source representations are perceived through the senses (e.g., Did I hear that song or see the music video?), and internal sources are imagined, or derived from thought (e.g., Did I send that important email or did I only imagine I sent it?) (Johnson et al., 1993).

Across all three types of source monitoring the sources associated with low-frequency words were more easily discriminated than sources associated with high-frequency words. This finding is consistent with the results of previous studies showing better external source memory for low-frequency words (Francis et. al., 2016; Strobach, 2015) and indicates that it is easier to discriminate among possible sources when the items have low familiarity. According to the source-of-activation-confusion theory (Buchler & Reder, 2007), this is because when studied items have low familiarity, there is less contextual competition, thus resulting in higher recollection of the item and its episodic context, including its source. The present study is the first to demonstrate this frequency effect in internal and internal-external source monitoring.

In contrast, the discriminability of sources did not differ between L1 words and L2 words in bilinguals. These results are consistent with the results of Francis and colleagues (2016) who examined external source monitoring in bilinguals. Because low-frequency words have less familiar concepts than high frequency words, but translation equivalent words in L1 and L2 share the same conceptual representations, these results indicate that associations between studied words and their sources are made at the conceptual level rather than at the word-form level. This representational difference at the conceptual level, along with the present results showing a dissociation between the effects of word frequency and language proficiency, highlights an important limitation of the frequency-lag hypothesis. The frequency-lag hypothesis deals with the association between word concepts and word forms, but it does not seem to apply to tasks that depend primarily on conceptual representations, as appears to be the case for source memory. The frequency-lag hypothesis explains how bilinguals access words and concepts for comprehension and production of language; however, its current applicability to explicit memory is limited. It would need to be modified or qualified to explain the circumstances under which it can be appropriately applied to explicit memory.

Although previous studies showed an L2 advantage in *item* recognition (Francis & Gutiérrez, 2012; Francis and Strobach, 2013; Taylor, 2017), the present experiments showed no L2 advantage in *source* recognition. Given that item recognition depends on both recollection and familiarity processes (according to dual process models; Jacoby, 1991), but source recognition is thought to depend primarily on recollection (Tosun et al., 2013), the present results suggest that the L2 advantage observed in studies of item recognition is due primarily to familiarity differences at the word-form level.

Experiments 1, 2, and 3 showed consistent effects of word frequency on the three types of source monitoring, which indicates that word frequency has similar effects on external and internal source encoding. None of the types of source monitoring was affected by language proficiency, which indicates that language proficiency does not impact external or internal source encoding.

The source monitoring framework designates five different types of sources (e.g., perceptual, cognitive operations, space/time, affect, and conceptual) or “contexts”; in the current study we investigated perceptual sources. To date, two of these sources (e.g., perceptual and space/time sources) have been investigated with respect to manipulating language proficiency in bilinguals. Additionally, three of these sources (e.g. perceptual, cognitive operations, and space/time sources) have been investigated with respect to manipulating word frequency in bilinguals. It is currently unknown how cognitive operations, affective, and conceptual sources are impacted by language proficiency, and how affective and conceptual sources are impacted by word frequency in bilinguals. Because we observed the low-frequency item advantage for perceptual in the current study, and similarly, the low-frequency item advantage in other studies with cognitive operations, and space/time sources, it is likely that we would observe a low-frequency item advantage in affective and conceptual sources. Furthermore, because we did not observe a bilingual L2 advantage for the perceptual source in the current study, or space/time sources in a previous study, it is likely that we would not observe a bilingual L2 advantage in sources involving cognitive operations, affect, or concepts.

An important aspect of the procedure in the present experiments is that participants were unaware that they would have to remember the context in which they encountered each word or picture (or even that they had to remember the words or pictures themselves), so encoding of source information was incidental. Nevertheless, they were able to discriminate between similar sources at test, suggesting that to a certain degree, sources are coded automatically. This aspect of the procedure was different from that of the other two experiments investigating the bilingual experience on source memory (Francis et al., 2016), in which participants knew at encoding the exact nature of the test task to follow. The reason that the incidental learning procedure was adopted in the present study is because in everyday life, we are not typically told to remember the sources of information, and we wanted to increase ecological validity in these experiments. Because intentional learning had been previously investigated in experiments on how bilingual language proficiency and word frequency impact external source memory, we wanted to see whether we would observe similar patterns of results under incidental learning conditions.

Furthermore, it may be the case that some of the words presented were not actually in a bilingual individual's vocabulary. This would mean any of the words that were possibly unknown to a bilingual would behave similar to a very low-frequency word. If this was the case, it is likely we would still observe a low-frequency item advantage. That is, because there is much less contextual competition for an item that is virtually unknown than an item that an individual has some experience with, it would be easier to discriminate the word with much less contextual competition (e.g., the unknown word).

Many assumptions of the source-monitoring framework remain to be tested. However, the results of the present experiments help to further specify the framework. That is, these experiments clarify the role of item familiarity in source memory. According to the source-monitoring framework, sources associated with items that are more difficult and unique are more easily retrieved (Johnson et al., 1993). Because we now know that people better discriminate the source of information for low-frequency words, but that language proficiency does not impact how bilinguals discriminate the source of information, we can now qualify this claim. Specifically, we might propose changing this claim to say that sources associated with *concepts* that are more difficult and unique are more easily retrieved.

One of the aims of this dissertation was to bridge the gap between the bilingual literature and the long-term memory literature. Currently, the main models of bilingual memory do not address how the bilingual experience impacts explicit memory or the long-term consequences of the bilingual experience. Also, the main models of source memory and other types of memory do not consider the impact of bilingual experience on basic memory processes. The present experiments begin to pave the way to integrate the bilingual literature and source memory literature.

Issues for Further Study

It should be noted that source monitoring in everyday life involves more complex stimuli and more possible sources than in the controlled laboratory experiments reported here. As in the vast majority of source memory studies reported in the literature, in the present study, the target stimuli were isolated words or their corresponding pictures. It is unknown how item familiarity and language might affect source memory if more complex language stimuli, such as sentences or paragraphs were used. Further work should be done to investigate how stimulus complexity or the number of plausible sources might impact the three types of source monitoring in the source-monitoring framework.

Additionally, future research should investigate the degree of automaticity in source monitoring by manipulating the instructions given to participants. In a previous study that investigated the effects of bilingual proficiency on external source monitoring, participants knew the nature of the test task, and a low-frequency discrimination advantage was observed just as in the present study. Intentional learning instructions open up the possibility that participants adopt deliberate strategies for keeping track of the information sources. However, to understand the extent to which the encoding of source information is automatic or benefits from participant strategies, source memory performance under incidental and intentional encoding instructions must be compared directly in a single study. Additionally, in future research it would be fruitful to give participants an exit questionnaire and ask them whether they suspected in advance they would be given a memory test and what kind of memory test they expected.

It is also important to gain a better understanding of how source memory impacts everyday life. Confusion about the source of information could have dangerous implications. For example, an older adult with poor memory for source information could confuse important medical information told to them by their doctor for information told to them by a friend as a purported fact. Thus, source confusion could potentially have serious or fatal health risks. More generally, it is important to understand how people keep track of information from more and less credible sources, such as experts vs. novices or impartial vs. biased sources. In scientific writing, a person has to avoid the internal-external source confusion that might lead to plagiarism and the external source confusion that might lead to attributing a theory, finding, or claim to the wrong article from the literature. In patients with neuropsychological or psychiatric disorders, the failure to remember the source of information can result in delusions or confabulations. Delusions are personally held beliefs that could not have happened but that a person holds to be true despite evidence to the contrary (Johnson, et. al., 1991). Confabulations are memories that are misinterpreted or made up without the intent to deceive.

Additionally, it might be fruitful to investigate whether children whose ability to discriminate source information is not fully developed (because of frontal lobe maturation) or older adults whose ability to discriminate source information has declined (due to frontal lobe decline) are able to discriminate low-frequency words at the same rate as the young adults tested in the present study. Investigating the mechanisms by which source memory operates in different populations will further inform theories on the nature by which item-to-context associations are made.

Conclusions

In conclusion, all three types of source monitoring were more accurate when the items had low conceptual familiarity. Specifically, sources associated with low-frequency words were better discriminated than sources associated with high-frequency words in all three types of source monitoring, but there were no parallel discrimination advantages for sources associated with L2 words over sources associated with L1words in any of the three types of source monitoring. This pattern of results highlights an important difference between low-frequency words and L2 words. Specifically, whereas low-frequency words have less familiar concepts than high-frequency words, L1 words and L2 words have concepts that are equally familiar because conceptual representations for L1 and L2 translation equivalents are one and the same. We can conclude, therefore, that word-to-context associations are made at the conceptual level, and not at the level of the word form. Finally, combining mainstream memory theory and methodology with theory and methodology from research on bilingual cognition helps us to understand not only how the bilingual mind operates but also informs us about cognitive processes important to both monolingual and bilingual memory function.

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Vita

Renee Michelle Penalver began her undergraduate career at Bakersfield Community College and transferred to California State University, Bakersfield with a major in Psychology and earned her bachelor's degree in 2011. During her undergraduate work Ms. Penalver worked in a behavioral neuroscience laboratory for two years where she used rodent models to study short-term and long-term memory. In 2010 she was accepted into the Social Cognitive Neuroscience doctoral program in Psychology. She started her graduate studies in August 2011 under the direction of Dr. Wendy Francis in the Bilingual Cognition Laboratory. She completed her Masters Degree in Experimental Psychology in 2014.

Renee Michelle Penalver was able to teach three different undergraduate courses over six academic semesters. Renee Penalver has presented her research projects at several conferences. In the Fall, Renee will start a faculty position at Coe College.

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