2022-12-01

Who Said What to Whom?: Contextual Memory Processes in Bilinguals

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IN BILINGUALS

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Dedication

I dedicate my dissertation work to my parents who have always supported me mentally throughout my graduate work. They made me feel as if they were here with me even though they have been in another far country. They have never left my side and are very special. This is also dedicated to my friends. They have treated me as their family in El Paso and have always provided encouragement and support. Without their support, it would not have been possible to complete this work

WHO SAID WHAT TO WHOM?: CONTEXTUAL MEMORY PROCESSES IN BILINGUALS

by

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DISSERTATION

Presented to the Faculty of the Graduate School of

The University of Texas at El Paso

in Partial Fulfillment

of the Requirements

for the Degree of

DOCTOR OF PHILOSOPHY

Department of Psychology

THE UNIVERSITY OF TEXAS AT EL PASO

December 2022

Acknowledgements

I would like to acknowledge the Graduate School Dodson Research Grant provided by the Les and Harriet Dodson Endowment at the University of Texas at El Paso. This grant supported my research and made it possible. I would like to express my deepest gratitude to my mentor, Dr. Wendy Francis. I could not have undertaken this process without her patience and support. I am also grateful to my dissertation committee members, Dr. Ana Schwartz, Dr. Ashley Bangert, Dr. Krystia Reed, and Dr. Carla Contemori, and my lab mates, Bianca Gurrola and Liam Gleason, for their helpful feedback and support throughout the dissertation process. Finally, I would like to acknowledge my research assistants, Alexa Perez, Paula Rodriguez, Jennifer Liams, Ashley Vargas, Brianna Marchael, Cristina Zapata, and Leslie Johnson, for their assistance in data collection of these projects. This work has not been possible without them.

Abstract

Source memory is memory for sources of information (*who* gave the information), whereas destination memory is memory for destinations of information (*to whom* the information was given). Prior literature found that source memory exceeded destination memory, and destination memory was impaired remarkably under high cognitive demand tasks. These findings supported the attention hypothesis, the idea that greater attentional resource availability leads to better source and destination memory. The current study extended prior source and destination research to bilingualism because bilinguals are thought to have a greater attention control ability than monolinguals. In the only published study to compare bilingual and monolingual source memory, bilinguals outperformed monolinguals, and there were no language proficiency effects within bilinguals. The current study examined for the first time whether the same pattern would be observed in destination memory and also investigated the allocation of attentional resources under different encoding situations.

In Experiment 1, bilingual and monolingual participants were asked to have conversations with a randomly assigned confederate on the computer screen (a direct-interaction setting). In Experiment 2, bilingual and monolingual participants were asked to observe conversations of two randomly assigned confederates (an observational setting) so that no self-generation processing was involved. Source and destination memory did not vary as a function of language proficiency, providing evidence that contextual information is associated with item information at a conceptual level. Bilinguals outperformed monolinguals in source and destination memory when no self-generation was involved, suggesting that bilinguals form content-context associations more efficiently. Source memory was more accurate than destination memory in both experiments, indicating that people allocate less attention to

destinations than to sources, whether self-generation is required or not. Source and destination accuracy were negatively associated, suggesting that allocating more attention to one takes attention away from the other.

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Chapter 1: Introduction

Everyday conversation involves two directions of information transfer. One is an input where the information comes from someone; the other is an output where the information is provided to someone. In both ways, we form associations between the information and the person, but we often struggle to remember such associations later on. To date, the information-person association in input events, more broadly the content-context association, has been studied in single language processing, but the output processing and the bilingualism aspects have been studied very little. It is, therefore, unknown how the direction of information transfer and bilingualism influence the process and strength of content-context associations. The present study conducted content-contextual memory tasks in a direct-interactional conversation setting (Experiment 1) and in an observational conversation setting (Experiment 2) for both monolinguals and bilinguals to better understand the mechanisms of content-context association memory, particularly in terms of whether bilingualism and language proficiency play an important role in memory for content-context associations, how attentional resources influence content-context associations under different encoding situations, and how memory for the direction of information transfer is related to contextual memory.

1.1 Source Memory and Source-monitoring

Source memory refers to remembering the source or origin of information – a part of the contextual information surrounding a particular context memory (Johnson et al., 1993). Thus, this is a type of explicit memory for input information, and we require remembering *who* provided the information as source memory (an information-speaker association). Source memory retrieval processes are thought to be different from recall or recognition item memory processes. For example, prior meta-analysis research collected data from source memory studies and found age-related deficits in source memory performance and source memory impairment was reliably greater than item memory impairment (Old & Naveh-Benjamin, 2008; Spencer & Raz, 1995). The finding supports the idea that source memory is processed differently from recall and recognition memory (Shimamura & Squire, 1987).

Many studies have been conducted to understand the source memory process, and the main model used to account for the source memory retrieval process is the *source-monitoring framework* (Johnson, 1988; Johnson et al., 1993; Mitchell & Jonson, 2000). The source-monitoring framework was developed to explain memory processes of monitoring appropriate source of information, and in this framework, the term *source* is defined as the characteristics of the contexts that are related to a particular memory. The base model, called the reality monitoring model (i.e., the internal-external monitoring model), was established first. The reality monitoring model explains the memory processes where people distinguish externally exposed events from imagined or abstract thinking (Johnson & Raye, 1981). Then, this framework was further modified with two additional models to understand the more general memory processes of evaluating memory characteristics about the origins of information, and these characteristics are often used as decision-making criteria in a retrieval process. One of the additional models is the internal source-monitoring model, explaining the memory processes where people distinguish whether they said something or they imagined saying it. The other one is the external source-monitoring model, explaining the memory processes where people distinguish two or more external sources of information (e.g., who provided the information, friend or sister?).

According to this framework, both memory characteristics and judgement processes play an important role to process the source of the information. In source monitoring, different contextual characteristics of memories are encoded differently and used differently in different source-monitoring tasks (Johnson et al., 1993). Memories for self-generated information (internal information) involve more cognitive operations but less perceptual, spatial/temporal, semantic and affective information. In contrast, memories for perceived information (external information) include more perceptual, spatial/temporal, semantic and affective information but involve less cognitive operations. The different amount of cognitive operations used at encoding helps to distinguish internal sources from external sources more than to distinguish between two external or two internal sources because cognitive operations serve as cues to differentiate memory. Therefore, in general, reality-monitoring tasks are better performed compared to the external or internal source-monitoring tasks (Johnson et al., 1993).

Regarding judgement processes, two types of judgement processes (automatic and controlled processes) are involved (Johnson et al., 1993). Automatic processes are used more often and made more rapidly, whereas controlled processes are more strategic (Hasher & Zacks, 1979; Norman & Shallice, 1986; Posner & Snyder, 1975; Shiffrin & Schneider, 1977). Both processes depend on each other in source-monitoring decisions and are influenced by various factors such as high-order reasoning, prior knowledge, prior experience, biases, and current goals and agendas, although source judgments are typically made through more automatic processes (Johnson, 1988). Furthermore, more stringent criteria are likely to be used in source-monitoring decisions under some circumstances. For example, people would be more careful to evaluate the source of the information when they witness an accident and testify to what they saw in court than when they tell the incident to their friends. In such a situation, both automatic and controlled judgment processes are used instead of relying on a single type of automatic process.

1.2 Destination Memory and Attentional Resources

There is a closely related type of episodic memory called *destination memory*, referring to remembering the destination of information, or *to whom* the information was provided. Destination memory was first introduced by Gopie and MacLeod (2009) to compare source and destination memory differences. Both source and destination memory are part of the episodic memory system and involve memory for conjunctions between content (e.g., a story) and episodic context information (e.g., a speaker or a listener), but these two types of episodic memory are fundamentally differentiated due to the direction of information transfer. Source memory is memory for where the information comes from (an information-speaker association), whereas destination memory is memory where the information was provided (an information-listener association). In the source memory retrieval process, it is known that the source of the information is differentiated from the item information (content). Therefore, when source memory fails, we are no longer able to determine how reliable the information is, because its contextual information (e.g., how and when we received the information) failed to be retrieved (Johnson et al., 1993; Parker, 1995). That is, unlike item memory (i.e., remembering whether the item was previously encountered), the source memory process requires retrieval of the association between the particular item information and its source, and it is likely to be more difficult to remember the source memory compared with item memory. Similarly, when destination memory fails, the likelihood of repeating the same story to the same person(s) increases, because we are no longer able to remember the previous target destinations (i.e., *to whom* we already provided the information) even when we remember that the event itself occurred before. Therefore, the lack of destination memory leads to repeating the same information to the same people.

In contrast to source memory, destination memory has been studied very little. Due to that, it still remains unclear the mechanism of source and destination memory processes. Prior research suggests that the direction of information transfer may be an important factor to influence the formation of new contextual memories. For example, previous enactment studies found that the contextual features were remembered better when participants observed someone else performing actions rather than when participants themselves performed the actions (e.g., Engelkamp et al., 1989; Koriat et al., 1991). This finding suggests that contextual features are retained differently between input and output events such that input events facilitate forming richer associative memory than output events (e.g., Koriat et al., 1991). This finding has been applied to research on source and destination memory, and previous studies found a similar pattern; source memory was remembered more accurately than destination memory (e.g., Gopie & MacLeod, 2009). This source memory advantage over destination memory was found even in real interaction situations (Fischer et al., 2015; but see Lindner et al., 2015).

The main account of the source memory advantage over destination memory is *the attention hypothesis*. This hypothesis assumes that greater availability of attentional resources leads to greater contextual memory. Many previous studies have examined the relationship between attentional resources and associative memory performance (e.g., Troyer et al., 1999; Naveh-Benjamin et al., 2004; Kilb & Naveh-Benjamin, 2007), and some suggest that contextual information processing requires greater attentional resources at encoding compared to item information processing (e.g., Rabinowitz et al., 1982; Troyer et al., 1999). A divided attention approach has been commonly used to examine the impact of attentional resource availability on memory performance because this approach allows to reduce the amount of available attentional resources during encoding. A prior study used the divided attention approach to investigate the impact of reduced attentional resources on source memory (Troyer et al., 1999). The study tested both item and source memory under three conditions: full attention, divided attention using a finger-tapping task, and divided attention using a visual reaction time task. Participants were asked to remember a list of words presented (item memory) and which voice (male or female) presented each word (source memory). In addition to this task, participants in the divided attention conditions were asked to sequentially press four keys on the keyboard during the encoding and test phases. Worse item and source memory performance was found in the divided attention conditions, and source memory performance was impaired more than item memory performance. Thus, previous literature supports the idea that limited attentional resources influence associative memory performance, and source memory in particular was considerably impaired.

Gopie and MacLeod (2009) tested the attention hypothesis on both source and destination memory throughout their three experiments. In Experiment 1, destination memory performance was compared with source memory performance in a between-subjects design. Participants in the source condition were asked to listen to sentences seeing the facial pictures and imagine as if the persons pictured said the sentences to them and subsequently the spoken sentences appeared on the screen without the facial pictures, whereas participants in the destination condition were asked to read sentences and then tell the sentences aloud to facial pictures of famous people. The result showed that participants in the source condition remembered correct faces corresponding to items more correctly compared with participants in the destination conditions (the source memory advantage). The same finding was observed in real interaction situations (Fischer et al., 2015; but see Lindner et al., 2015) such that participants remembered their speakers corresponding to information more accurately than their listeners. Experiment 2 was conducted to examine to what degree self-focused context influenced destination memory performance. The results showed relatively poor destination memory performance in the high-self-focus group (i.e., telling their personal facts using first-person singular pronouns) in comparison with the low-self-focus group. In Experiment 3, they tested whether attentional shift to destinations of information improved destination memory. As the result, the refocus group (i.e., telling listeners' names before telling sentences) improved destination memory. Thus, focusing on oneself decreases destination memory, but shifting attentions toward listeners facilitates destination memory. The findings support the attention hypothesis.

Lindner et al. (2015) also tested the attention hypothesis in three experiments. The experiments incorporated real interaction situations. In Experiment 1 and 2, sentence stimuli were available when participants said the sentences. The difference between the two experiments was the type of encoding: Experiment 1 was intentional encoding and Experiment 2 was incidental encoding. In contrast to Experiment 1 and 2, In Experiment 3 participants were asked to remember sentences to tell to someone, which required more cognitive demands than the first two experiments. The results in Experiment 1 and 2 exhibited no difference between source and destination memory performance, whereas source memory performance exceeded destination memory performance in Experiment 3. The results suggest that higher cognitive demands at encoding leads to worse destination memory.

Previous studies provided evidence for the attention hypothesis that decreasing the attentional resource availability leads to less accurate contextual memory performance and the deficit is more remarkable for destination memory. The current study applied the attention hypothesis to bilingualism to better understand how the ability of attentional control influences source and destination memory.

1.3 Bilingualism on Contextual Memory

The attention hypothesis assumes that the availability of attentional resources is key to process source and destination memory. It raised a question of how the ability of attentional control influences memory performance of content-context associations. Do people with a greater attentional control ability remember source and destination memory better because they use their attentional resources more efficiently compared with those with a lower attentional control ability? To approach this question, the current study extended source and destination memory research to bilingualism. This is because bilinguals are thought to control their attentional resources more efficiently than monolinguals (Bialystok et al., 2012). Bilinguals always need to juggle two languages because the two languages are always active and competing regardless of a bilingual's intention to use one or both (Costa et al., 1999; Kroll et al., 2014; Marian & Spivey, 2003). The management of activation of the two languages facilitates developing a high cognitive and attentional control ability and leads to a greater efficiency of using attentional resources (Bialystok et al., 2012). Therefore, the comparison between monolingual and bilingual performance would lead to a better understanding of the mechanisms of source and destination memory.

There are two theories of source memory that have the potential to explain destination memory in bilingualism. One of the theories is the *source-of-activation confusion* theory (SAC, Buchler & Reder, 2007; Diana & Reder, 2006). The SAC model assumes that both concept nodes and context nodes are bound to particular memory episodes. An episode node is formed as a new memory trace when an item is encoded in memory and is bound to both a concept node and context nodes that represent contextual details that are processed when the item is encoded (e.g., where, when, how a word was encoded). The associations among the nodes are influenced by the availability of working memory resources.

In item and source recognition tasks, two memory processes are involved in processing discrimination of relevant item/source information: familiarity and recollection. Familiarity refers to memory processes based on more general memory representations and related to the activation of concept nodes. In contrast, recollection refers to retrieval of specific memory representations that have associated context nodes, and thus, it depends on the availability of the episode node such that recollection occurs when activation at the episode node goes beyond the threshold. Although both processes contribute to discrimination of items and/or sources, source recognition relies more on the recollection process than item recognition tasks do (Johnson et al., 1993; Mitchell & Johnson, 2009; Tosun et al., 2013). This difference is due to the different ways that items and sources are tested. In item recognition, previously displayed items were mixed with new items. Thus, familiarly processes are helpful to discriminate whether the items were previously provided or not. However, in source recognition, all of the test sources were previously displayed. Because all the sources are familiar, familiarity processes are less likely to be useful in discrimination among sources. In contrast, recollection processes can be helpful because recollecting different pieces of source information helps to differentiate one source from the other source(s), resulting in higher hit rates in source recognition tasks (Yonelinas, 2002; Yonelinas et al., 2010). Therefore, recollection is relied upon more than familiarity in source recognition tasks, although false recollection tends to occur when the contextual information has lower distinctiveness and less activation of the context node, because less activation leads to greater associative interference.

Prior literature proposed the application of the SAC model to bilingual language proficiency effects on recognition memory (Francis & Strobach, 2013). The SAC model is known as a framework to explain mirror effects for word-frequency in item/source recognition memory (e.g., Diana & Reder, 2006). Mirror effects are a phenomenon where low-frequency words elicit higher hit rates and lower false alarm rates than high-frequency words, and SAC proposes that two factors underlie these mirror effects. First, the fan factor is the idea that low-frequency words are associated with fewer episodic contexts, and thus, the words have less contextual competition in memory compared to high-frequency words (Buchler & Reder, 2007). When an encoded item is remembered, its concept node is activated, and the activation of concept node facilitates activation of all associated nodes. Thus, less competition facilitates activation of specific memory (recollection) and increases hit rates. Such recollection-based responses occur when the relevant episode node receives enough activation to facilitate recollection. If the relevant episode node does not receive sufficient activation, familiarity-based responses would occur depending on the strength of the memory. Second, the base factor is the idea that low-frequency items have a lower baseline familiarity level as compared to high-frequency items, and the low-frequency items are less likely to yield a false feeling of familiarity (Buchler & Reder, 2007). Therefore, low-frequency items facilitate lower false alarm rates. In fact, previous studies showed that low-frequency words were better recognized than high-frequency words although those high-frequency words were better recalled (e.g., Balota & Neely, 1980; Kinsbourne & George, 1974; MacLeod & Kampe, 1996; Mandler et al., 1982).

This theory has been adapted to explain the bilingual L1/L2 mirror effect (Francis & Strobach, 2013). Bilinguals are more proficient in one language (L1) than the other language (L2), and it is known that L2 words are more weakly associated than L1 words to their concepts

(Gollan et al, 2008). In addition, the weaker association leads to an advantage for L2 words in bilingual recognition memory (e.g., Francis & Strobach, 2013; Francis & Gutiérrez, 2012). This is because L2 words have fewer episodic contexts and are less familiar compared with L1 words. That is, the SAC model explains the L2 advantage in hit rates and false alarm rates of item recognition using the same explanation given for word frequency effects. It is, however, unclear whether this pattern will extend to more complex information.

A prior study of bilingual source discrimination examined the effects of word frequency and bilingual language proficiency and found an advantage for low-frequency words but no language proficiency effect, although bilinguals had consistently more accurate source memory than monolinguals (Francis et al., 2019). The absence of language proficiency effects in source discrimination suggests that episodic contexts are associated at the conceptual level, not the word-form level, because L1 and L2 words share the same conceptual representations. Thus, the contextual details are associated at the conceptual level, and language proficiency may not influence source discrimination for words, but it remains unclear whether the same pattern will be seen in a more realistic conversational setting and indirect contextual information memory (destination memory). Therefore, the present study examined whether the bilingual advantage in source memory persists with more complex materials, whether forming and retrieving information-person associations varied as a function of language proficiency in both input and output events, and if so, how the nature of the content impacted these processes.

Fuzzy-trace theory (FTT; Reyna & Brainerd, 1995) is another framework that has the potential to explain both source and destination memory processes. According to this theory, people retain information in two different types of mental representations at the same time, and therefore, this model has been referred to as a dual-process theory of memory (Brainerd &

Reyna, 2002). The first type of memory trace is *verbatim* and contains item-specific detail representations, including perceptual information, and thus, this memory trace retains a precise and concrete representation of an event. In contrast, the second type of memory trace is *gist*, which is a meaning-based memory representation. Although gist traces are less precise than verbatim traces, people rely on gist in communication to make the reasoning process less cognitively effortful. In addition, gist traces have higher durability, whereas verbatim traces are more vulnerable and easily disrupted to interference and decline rapidly over time. For example, suppose the sentence "*She eats an apple in the morning*" is displayed on a computer screen. In a verbatim memory trace, people remember the surface form of the words such as the displayed item was an English sentence on the screen in black color. In a gist memory trace, people remember the overall information such as the displayed sentence was involved with fruit and a habit in the morning. Over time, people tend to remember they saw something related to fruit but may not remember the surface form of the words such as what was the print color.

According to the FTT model, the reliance of verbatim and gist representations varies based on expertise. More experience facilitates developing gist representations for relevant tasks/information, resulting in relying more on gist memory in decision making. In fact, previous studies found that people were likely to use less information and rely more on simple gist-based processing to make their decisions as their expertise increased (e.g., Reyna, 2004; Reyna & Lloyd, 2006; Reyna et al., 2014). The results support the FTT model assuming that decision making becomes less reliant on verbatim representations and more reliant on gist representations when people become more expert (Corbin et al., 2015). The idea of expertise can be extended to language proficiency in bilinguals such that gist memory for one language is assumed to improve when people become more proficient in that language. Bilinguals' dominant language (L1) is considered as more experienced language; their non-dominant language (L2) is as less experienced language. Thus, processing L1 words/sentences may rely heavily on gist representations compared with processing L2 words/sentences. In fact, prior research found that gist representations improved when people became better in processing word meaning and associating meaning between different words (Brainerd & Reyna, 2002).

The FTT model has been commonly used to explain false memory processes because this model explains how the confusion of memory and strengths of different kinds of memory traces can lead to memory errors. According to the FTT model, the strength of a false memory depends on both verbatim and gist memory traces, but the explanation of the false memory process is different in two memory traces due to the relative accessibility of verbatim and gist, retrieval cues, and forgetting rates. Perceptual features tend to be constructed based on memory of gist rather than verbatim, and verbatim memory representations decline faster than gist memories (Brainerd & Reyna, 2002). Due to these characteristics, item specific representations of a certain event become more loosely bound to the memory over time and part of the original traces can no longer be retrieved which leads to false memory. Thus, people need to rely on gist memories more than verbatim memories over time although verbatim memories facilitate discrimination of each encoded stimulus (Brainerd & Reyna, 2002). Although both verbatim and gist memories hold true memory information and help to monitor relevant sources, strong gist memory tends to lead to more false memories. When a retrieval cue is newly presented but classified into the same/similar categories with the previously presented stimuli, this cue shares the gist trace with the old stimuli and lead to be falsely identified as a previously presented. For example, if the word *begin* was presented for study, a person might falsely identify the word *start* as a studied word, because it shares some meaning with the word *begin*. In this way, stimuli not actually presented are more likely to activate gist memory traces when the presented and non-presented stimuli are more similar in meaning. In addition, repeated presentation of stimuli that are related to non-presented stimuli make gist memory traces stronger, resulting in greater false memory (Brainerd et al., 2001).

This model is relevant for the present study because a similar mechanism of memory errors may help to explain the confusions in source and destination memory. For example, suppose you plan on going to a road trip with two other friends. You first asked one of your friends if she wanted to go, she asked the other friend the same question, and both decide to go on a trip with you. After all conversations are done, you may falsely remember which friend you actually asked because both of them are in the same category "friend" and both agreed with coming with you. The gist memory (asking a "friend") is shared in internal thoughts and external events and used to make a decision. This is because the verbatim memory declines faster or because the strength of the verbatim memory was too weak at encoding. In this way, these types of errors may lead to memory errors and may underlie discrimination confusion in source or destination memory.

The current study compares bilingual and monolingual memory representations and also examines language proficiency effects. In the study, gist representations contain topics of conversations which are relevant to item recognition. Verbatim representations require identifying the specific speaker and listener information. Therefore, people would perform well on item memory but struggle with person identification tasks. If the idea of expertise can be extended to language proficiency, monolinguals would use gist-trace memory more than bilinguals because monolinguals have more experience with their language in life, while bilinguals have experiences in each language. If this is supported, it is expected that source and destination memory performance will be more accurate in bilinguals than in monolinguals. If the logic of expertise cannot be extended to language proficiency and bilinguals rely on gist more than monolinguals do, it is expected that person identification performance would be less accurate in bilinguals than in monolinguals. No differences between bilinguals and monolinguals would indicate similar reliance on the two types of memory representations between monolinguals and bilinguals. Furthermore, if gist memory is used more than verbatim memory to identify source and destination memories, the language proficiency levels would not influence source and destination memory performance. This is because gist memory is stored at the conceptual level and bilinguals share their concept between their languages. If bilinguals heavily use verbatim memory to identify source and destination of the information, it is expected that the L1 (more proficient language) would have an advantage over the L2 (less proficient language). This is because verbatim traces are referred to as recollection process, and typically L1 performance in recall is better than L2 performance (Durgunoglu & Roediger, 1987; Francis et al., 2020; Lopez & Young, 1974).

1.4 Present Study

The present study addressed three questions. One of the questions was how bilingualism and language proficiency impacted processing complex item information. The impacts of bilingualism and language proficiency have been studied in item memory tests involving isolated words. Prior research found that item memory recognition was more accurate in bilingual performance more than monolingual performance (Francis & Strobach, 2013).This phenomenon has been explained based on the strength of the word-concept association. It is assumed that bilinguals have weaker word-concept associations than monolinguals do. The language with weaker word-concept associations tend to be less familiar and be connected to fewer episodic contexts compared to a language with stronger word-concept associations, and thereby, the weaker associations lead to better recognition memory on bilinguals (Francis et al., 2019). The same explanation has been adopted for bilingual language proficiency effects. Within bilinguals, the less proficient language has fewer content-context associations compared to the more proficient language (Gollan et al., 2008). The smaller number of associations leads to better recognition memory in bilinguals' less proficient language (Francis & Gutiérrez, 2012; Francis & Strobach, 2013). Therefore, it is expected that bilinguals will outperform monolinguals in item recognition, and within bilinguals, L2 will outperform L1. However, if conversation information is stored and retrieved at a conceptual level and its conceptual information is used as a cue to discriminate studied from non-studied items, then we would expect no language difference nor language proficiency effects on item memory performance. If recollection processes are required to identify whether items were previously presented or not, then monolinguals should show an advantage over bilinguals, and within bilinguals, the L1 should show an advantage over L2 in item memory accuracy.

We also directly examined the impacts of bilingualism and language proficiency on source and destination information processing with complex information. To date, there has been only one published study that examined bilingualism in source memory (Francis et al., 2019) and no published studies of bilingual destination memory. In the source memory study, the studied items were isolated words, and they found that bilinguals had more accurate source memory than monolinguals. The explanation given for this phenomenon was that bilinguals use more efficient encoding strategies to associate between content and context information compared to monolinguals. However, unlike item memory, source monitoring performance did not differ for L1 and L2. This finding, combined with a word-frequency effect favoring low-frequency words, suggests that the contextual information establishes associations with content at the conceptual level. If the contention that bilinguals encode content-context association more efficiently than monolinguals is supported, source and destination performance would be more accurate in bilinguals than in monolinguals. In addition, if the assumption that content-context associations are formed at the conceptual level is supported, source and destination performance would not vary as a function of language proficiency. This is because concepts are language general. All known languages have access to the same conceptual information. However, differences in cognitive processing suggest both bilingual effects and language proficiency effects. Processing L2 sentences may require more effort and cognitive/attentional resources (especially when producing sentences in L2), and these cognitive demands may lead to a difference between L1 and L2 memory for sentence-person associations (especially in destination memory conditions). Considering this idea in combination with the attention hypothesis, we made the following predictions. In Experiment 1, if enough attentional resources are involved in processing information and if there are greater cognitive demands in processing L2 sentences than processing L1 sentences, then bilinguals who perform the task in their L2 would show less accurate contextual memory compared with bilinguals who perform the task in L1. In Experiment 2, if enough attentional resources are allocated to the destination of the information, no language proficiency effect is expected. If limited attentional resources are available for the destination of the information, then an L1 advantage over L2 in destination memory is expected.

Another question was how attentional resources impacted memories for sources and destinations with different encoding types. To address this question, the current study conducted two experiments: direct-interaction encoding and observational encoding. Experiment 1 was a direct-interaction study where participants were asked to carry on self-referential conversations with confederates. Thus, participants themselves would be their source and destination during encoding. In contrast, Experiment 2 was an observational conversation study where participants were asked to observe confederates' conversations. That is, sources and destinations were externally presented, and participants were indirectly involved with them. Sources, destinations, and directions of information transfer were involved in both experiments, but Experiment 1 made participants themselves source and destination, whereas Experiment 2 required participants to process someone else's sources and destinations. It is known that information related to the self is better remembered compared with other types of encoding (Rogers et al, 1977; Symons & Johnson, 1997). In recall tasks, self-referential encoding led to better item memory compared to other types of encodings. The same result pattern was observed in the source memory task such that memory for contextual information, which participants were asked to remember, was better remembered in a self-referential condition (Lawrence & Chai, 2021). However, they found that such a source memory advantage disappeared when participants were required to remember irrelevant contextual information that they were not instructed to remember. These findings support the attention hypothesis and suggest that self-referential encoding helps to make memory richer and more detailed, but the benefit may not be extended to non-focused information. The current study examined how source and destination information was processed in self-referential encoding and observational encoding to understand how attentional resources were allocated in each encoding type.

The other theoretical question was whether the direction of information transfer was independent from contextual information (person information in the current study) at input and output events. We considered three possible models involving the retrieval processes of source and destination memory (see Figure 1). In Model A, memory for the direction of information transfer is completely independent from contextual information. If Model A is correct, then we expect that failure to retrieve the direction of information transfer does not impact the retrieval of the person information, and vice versa. Model B and C are hierarchical models. In Model B, the direction of information transfer must be encoded before the person information was associated with the episode. Therefore, if Model B is correct, the person information is not able to be retrieved unless the direction of information transfer is retrieved. On the other hand, in Model C, sentence-person associations must be encoded prior to the direction of information transfer. If Model C is correct, the direction of information is not remembered unless the sentence-person associations are retrieved. To evaluate these models for source and destination memory, a multinominal processing tree (MPT) model analysis was conducted in Experiment 1 (Batchelder & Riefer, 1990; Riefer & Batchelder, 1998).

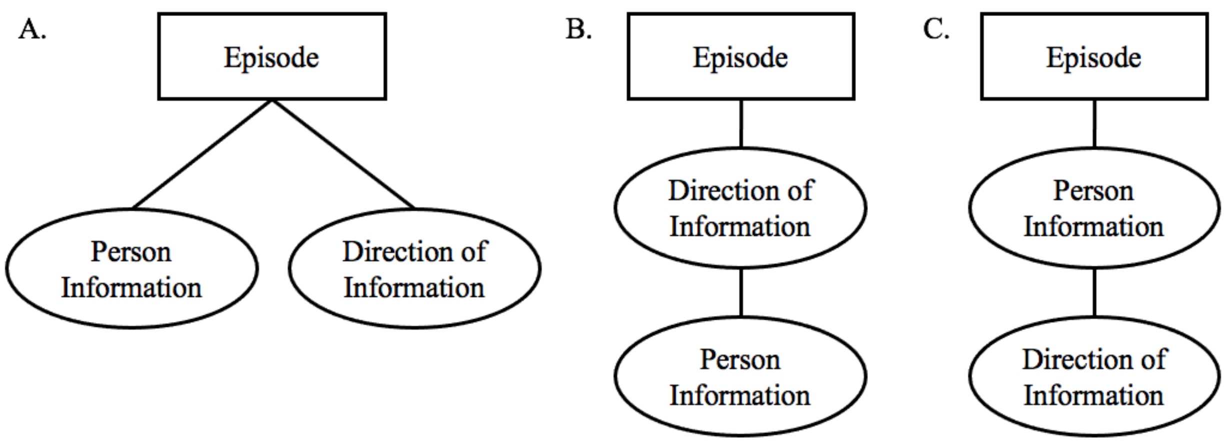

Figure 1. Possible Models.
Note. There are three possible models for the relationships between the direction of information transfer and person information. Model A represents the independence of the two processes. Model B represents the dependency of the person information process on the direction of information transfer. Model C represents the dependency of the direction of information transfer on the person information.

Chapter 2: Experiment 1

The major goal of Experiment 1 was to examine whether self-referential encoding facilitates forming information-person associations in both input and output processing and whether such memory processes vary as a function of language proficiency in bilinguals. Prior literature showed that the source memory advantage over destination memory in virtual and real-interaction conversations (e.g., Gopie & MacLeod, 2009; Fischer et al., 2015) and destination memory was more distorted in the high-self-focus conditions than in the low-self-focus conditions (Gopie & MacLeod, 2009). The findings suggest that the availability of attentional resources might be a key factor to form richer information-person associations. Therefore, Experiment 1 used phrase fragments of self-focused content, written with first-person singular pronouns (i.e., "My favorite movie is ________."). The use of first-person singular pronouns facilitated allocating attention to oneself in conversations (Gardner et al., 1999). If attentional resource availability plays an important role to store the content and person information together, people struggle with remembering their listeners (output events) rather than their speakers (input events) even when item memory is successfully retrieved. The other question is how bilingualism is involved in information-person associative memory performance. Previous bilingual research found no language proficiency effect on source identification although bilinguals outperformed monolinguals (Francis et al., 2019). Therefore, it may be reasonable to expect the same patterns of the results in each language group such that the bilingual advantage is seen in both source and destination memory performance but language proficiency does not influence such memory performance. However, the source-monitoring framework assumes that the differential use of cognitive operations is key in source-monitoring tasks. When greater cognitive operations are used in self-generation, the event is distinguished more accurately from the externally presented event. It is known that processing L2 itself requires greater cognitive resources than processing L1. Therefore, we hypothesized that participants with lower language proficiency would have better information-person associative memory than those with higher proficiency if the source-monitoring framework can be applied to destination monitoring.

2.1 Methods

2.1.1 Power and Sample Size

The language group was a between-subjects factor, and direction of information transfer and source/destination at study were within-subjects factors. The power analysis showed that in order to have 80% power for detecting a medium sized effect, this experiment required at least 43 participants in each language group. Due to counterbalancing considerations requiring a multiple of 6 in each group, 48 participants were tested in each language group.

2.1.2 Participants

Participants were 144 undergraduate students from the University of Texas at El Paso, and each language group had 48 participants. The participants received either course credits or $5 per 30 minutes for research participation. The sample consisted of 108 women and 36 men with a median age of 19, and 95.1% of participants reported Hispanic ethnicity (primarily Mexican-American). Summary information of participants is presented in Table 1. There were seven participants who completed at least part of the computerized protocol but were excluded from data analyses. Five participants were excluded because of failure to follow instructions, and the other two participants were excluded because of technical difficulties. Replacements were made for all excluded participants to preserve counterbalancing.

Table 1: Participant Characteristics in Experiment 1.

Characteristic	English Monolinguals (N=48)	English-Spanish Bilinguals (N=48)	Spanish-English Bilinguals (N=48)
Median Age	20.1	21.6	19.0
Hispanic	87.5%	100%	97.9%
English Picture Vocabulary[a]	16.6 (5.0)	16.6 (5.3)	10.7 (2.2)
English Verbal Analogies[a]	18.8 (7.6)	19.3 (8.7)	13.6 (5.2)
English Oral Language[a]	17.2 (5.6)	17.4 (6.4)	11.4 (2.2)
Spanish Picture Vocabulary[a]	2.9 (1.0)	10.8 (1.9)	13.4 (2.3)
Spanish Verbal Analogies[a]	5.3 (1.3)	17.3 (9.4)	22.6 (8.4)
Spanish Oral Language[a]	3.4 (1.6)	11.7 (2.6)	15.9 (4.5)
Median Parental Education	Some College	Some College	Graduated College

[a]Scores indicate mean age-equivalency levels for performance on the WMLS-R (Woodcock et al., 2005).

2.1.3 Stimuli

Stimuli consisted of 120 experimental phrase fragments and 4 practice phrase fragments; 100 stimuli were selected from stimulus sets of Gopie and MacLeod (2009) and Fischer et al. (2015) (e.g., "I would like to travel to ____," "My hometown is ____") and we created the other 24 phrase fragment stimuli (e.g., "I usually wake up at ____"). All stimuli had a blank at the end of the sentence. 80 stimuli were randomly selected as studied stimuli, and the other 40 were new-control stimuli. Two female confederates recorded stimuli videos. Three different types of videos were recorded for the study phases by each female confederate from the front view: 1) Confederate introducing herself, 2) Confederate listening to participants' responses, and 3) Confederate telling sentences. The facial pictures of the two confederates were displayed prior to practice. The phrase fragments were randomly assigned to 6 sets of 20, and the 6 sets were rotated through the 6 experimental conditions across participants using a Latin square to control for specific-item effects.

2.1.4 Apparatus

Stimuli were presented on an Apple Macintosh computer monitor, and PsyScope X software was used to program the experiment and measure accuracy (Cohen et al., 1993).

2.1.5 Procedure

Participants were tested individually in a testing room with an experimenter and first asked to complete an informed consent form. Next, the language assessments in English and Spanish were administered to all participants to assess whether participants qualified for this experiment and which language group they were in. While the experimenter entered their assessment scores into a computerized scoring program, participants completed language background and demographic background questionnaires on a computer. After completing the questionnaires, participants were given instructions for the main, computerized experiment. First, the flow of the study was instructed to participants. Next, they were asked to watch two video clips where two women (the confederates: Ashley and Bethany) introduced themselves, saying "Hi, my name is Ashley [Bethany]." The confederates' names and facial pictures were displayed on the computer after the video clips, and participants were asked to remember their names and faces carefully. Then, participants completed four practice trials. In the practice, participants completed a source condition first and a destination condition next along with an experimenter. (Details of each condition were given in the Study Phase section below.) The other two practice trials were completed by participants themselves to ensure they understood the task. If they didn't follow the instructions, they started over the practice phase. After completing the practice trials, participants received the instructions and purpose of the study again and then began the study phase.

Study Phase. See Figure 2.1 for an illustration of the study phase. This study was self-paced, and therefore, all visual stimuli stayed on the computer screen until participants pressed a spacebar. The study phase was composed of four conditions: source condition with Confederate A, source condition with Confederate B, destination condition with Confederate A, and destination condition with Confederate B. In source conditions, the instruction “Listen” were displayed with a phrase fragment (e.g., “Listen: My dream job is _____.”). Participants were instructed that either Ashley or Bethany (a confederate) would fill in the blank with her personal fact and tell it to participants. They were to press a spacebar to listen to the stimulus sentence spoken by the confederate and remember who it was. The instruction and stimulus stayed below the video clip until participants press a spacebar. In destination conditions, the instruction “Tell” was displayed with a phrase fragment (e.g., “Tell: The movie I most enjoy is _____.”). Participants were instructed that they had to fill in the blank and be ready to tell the whole sentence before pressing a spacebar. When they pressed a spacebar, a confederate listening to participants’ response appeared on the screen and participants were asked to tell the whole sentence. The instruction and phrase fragment stayed on the screen. After participants finished listening to or telling a sentence, they pressed a spacebar to move to the next trial. The source and destination trials were randomly intermixed. This procedure was repeated until participants completed all 80 experimental trials.

Test Phase. See Figure 2.2 for an illustration of the test phase. All 80 studied sentences and 40 new sentences were presented in a random order at test. Up to three different subtest screens were presented for each stimulus. First, a phrase fragment appeared on the top of the screen, and a question asking whether the displayed sentence was presented during the study phase appeared on the bottom of the screen. Participants were asked to choose a corresponding

“Yes” or “No” key: a “z” key for yes and a “/” key for no. When participants identified a displayed sentence as a new item (a non-studied item), the test advanced to the next sentence. On the other hand, when participants identified a displayed sentence as an old item (a studied item), the following two identification tests were administered regardless of whether this response was correct or incorrect. Participants were first asked to determine whether they told or heard the sentence. They pressed a “z” key to indicate they told the sentence or a “/” key to indicate they heard the sentence. Next, the facial pictures and names of the two confederates appeared below the stimulus sentence, and participants were asked to indicate who was involved with the sentence. They pressed a “z” key to indicate it was Ashley or a “/” key to indicate it was Bethany. After participants selected their response, the next item appeared on the screen. This procedure was repeated until participants completed the 120 test stimuli.

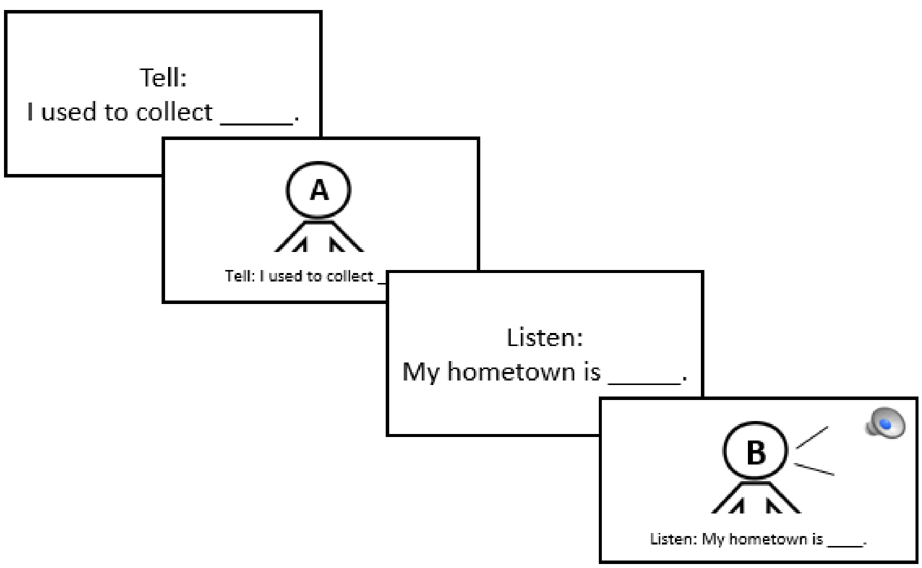

Figure 2.1. Study Phase in Experiment 1.

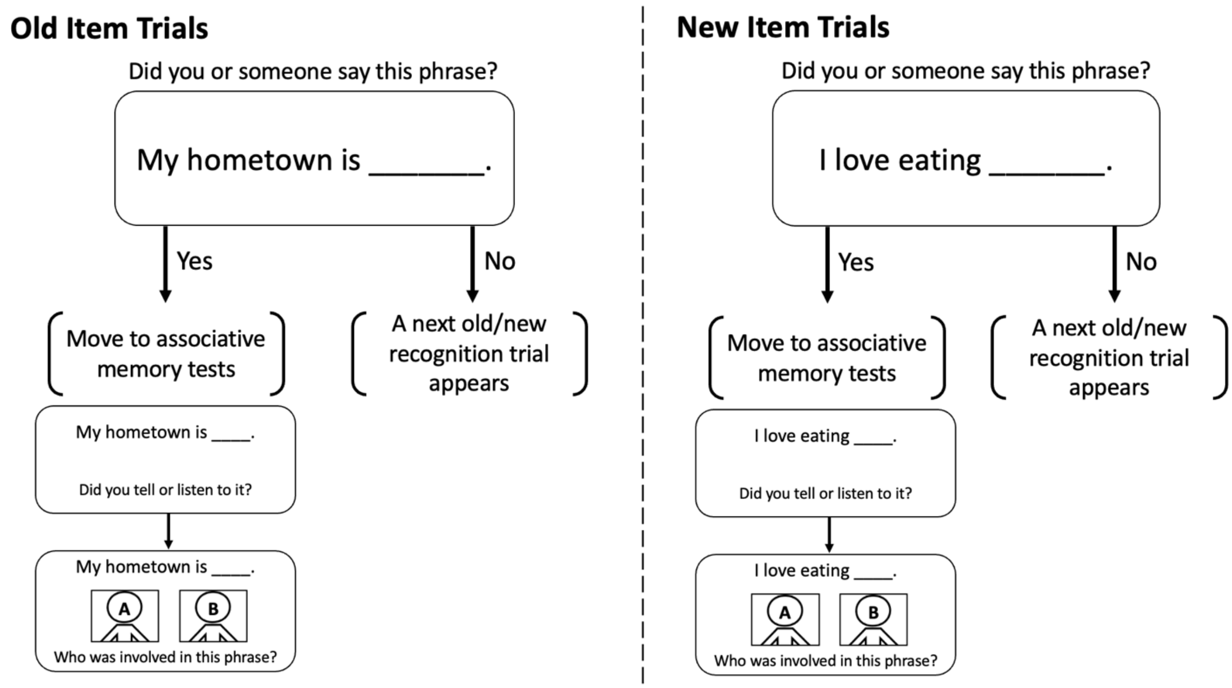

Figure 2.2. Test Phase in Experiment 1.

2.1 Results

2.2.1 Approach to Analysis

We conducted two types of analyses to examine the effects of bilingualism on memory for content-context associations. First, we performed repeated-measures ANOVAs on item recognition and identification (direction and person) recognition tasks. Hit rates and false alarm rates were used to compute the signal detection measure d' for each participant for each memory type. The individual language dominance group and individual English proficiency level were included in some analyses. In the second set of analyses, a multinomial processing tree (MPT) model (Batchelder & Riefer, 1990; Riefer & Batchelder, 1998) was used for crossed-source information with item judgments in each language to better understand the mechanism of source and destination memory processing. The language groups were compared in the simplified MPT model.

2.2.2 Signal Detection Analysis

2.2.2.1 Item Recognition Accuracy

Item recognition accuracy was defined as the proportion of correctly recognized new/old items. In this analysis, the signal detection measure d' was computed using hit and false alarm rates from the full set of item memory trials. As shown in Figure 3, overall item recognition memory performance did not differ across language groups (Fs < 1). Item recognition memory performance was better for spoken items compared with listened items in all language groups (monolinguals: $F(1, 47) = 165$, $MSE = 29.20$, $p < .01$; ED: $F(1, 47) = 230$, $MSE = 23.84$, $p < .01$; SD: $F(1, 47) = 307$, $MSE = 29.85$, $p < .01$). Item recognition performance did not differ across language groups for either listened or spoken items (Fs < 1). English proficiency levels were included as a continuous measure in the analysis.

We also conducted correlations of English and Spanish language proficiency levels and item memory performance. English-dominant bilinguals showed positive correlations with d' in the listened condition and overall item memory performance. Specifically, English-dominant bilinguals with higher English proficiency distinguished whether items were previously encountered more accurately than those with lower English proficiency, especially for listened conditions. In addition, in English-dominant bilinguals, d' in listened and spoken conditions had positive correlations with Spanish proficiency levels. However, monolinguals and Spanish-dominant bilinguals did not show a correlation in either condition. When the data of English-dominant and Spanish-dominant bilinguals were analyzed together, the language proficiency effects were not reliable.

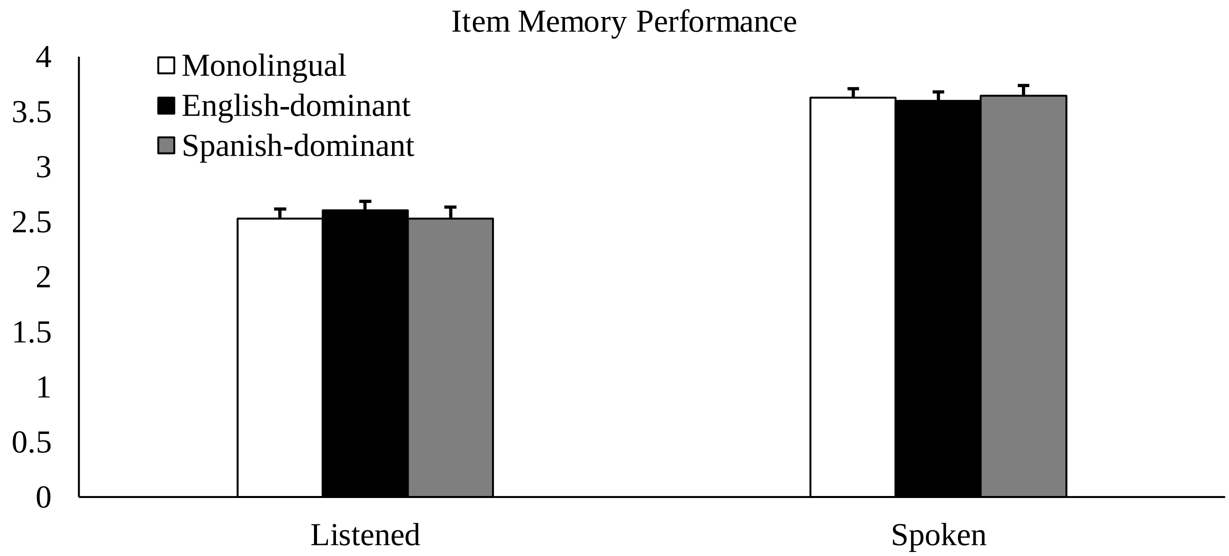

Figure 3. Item Memory Accuracy
Note. This figure represents item memory accuracy by the signal detection measure d' for each language group. Error bars indicate standard errors of the mean.

2.2.2.2 Source Discrimination Accuracy

Two types of source discrimination tasks were performed: direction identification and person identification.

Direction Identification. The first part of the identification test was to distinguish whether participants listened to or spoke about items that were recognized as previously presented. First, in this analysis, the z-scores corresponding to the correct response rates for each trial type were computed. Then, we summed the z-scores of listened and spoken trials on each participant to compute d'_{FA} scores of all participants for the direction identification task. No language group differences were observed in direction identification performance [monolinguals vs. English dominant: $F(1, 141) = 1.35$, $MSE = .09$, $p = .25$, $\eta^2_p = .01$; monolinguals vs. Spanish dominant: $F < 1$; English dominant vs. Spanish dominant: $F < 1$] (see Figure 4). English proficiency levels were added as a continuous factor in this analysis to examine whether English proficiency levels in bilinguals were correlated with direction identification performance. English proficiency did not correlate with direction identification performance in any language group or the combined bilingual group. The reason we did not see any language group or proficiency effects in direction identification performance may be because their d'$_{FA}$ performance was near ceiling.

Person Identification. The last subtest of the identification test was to distinguish who (confederate A or confederate B) was involved with items that were recognized as previously presented. The signal detection measure d'$_{FA}$ was computed separately for the listened and spoken conditions. First, we computed the z-scores corresponding to the correct response rates for each confederate on each condition. Next, we summed the z-scores of each confederate on each listened and spoken conditions to obtain d'$_{FA}$ for each confederate. As shown in Figure 4, person identification performance was better for listened items compared with spoken items in all language groups (monolinguals: $F(1, 47) = 231$, $MSE = .65$, $p < .01$; ED: $F(1, 47) = 331$, $MSE = .48$, $p < .01$; SD: $F(1, 47) = 183$, $MSE = .89$, $p < .01$). We conducted additional analyses to investigate the language group differences. For listened items, correct confederate identification performance did not differ across the language groups [monolinguals vs. ED: $F(1, 141) = 1.58$, $MSE = 2.2$, $p = .21$, $\eta^2_p = .01$; monolinguals vs. SD: $F < 1$; ED vs. SD: $F(1, 141) = 1.10$, $MSE = .30$, $p = .30$, $\eta^2_p = .01$]. For spoken items, a language dominance effect was observed, indicating that English-dominant bilinguals identified the correct listener confederate more accurately than Spanish-dominant bilinguals did: $F(1, 141) = 1.76$, $MSE = 4.8$, $p = .03$, $\eta^2_p = .03$. However, there was no difference between monolinguals and English-Spanish bilinguals on listener identification tasks [monolinguals vs. ED: $F(1, 141) = 3.15$, $MSE = 1.2$, $p = .08$, $\eta^2_p = .02$; monolinguals vs. SD: $F < 1$].

English proficiency levels were included as a continuous variable. English monolinguals showed a negative correlation of English proficiency with person identification performance in spoken conditions, indicating that English monolinguals with lower language proficiency levels remembered their listener more accurately. Although neither English-dominant nor Spanish-dominant bilinguals had significant correlations of English/Spanish proficiency levels on the person identification tasks, when the English-dominant and Spanish-dominant groups were combined, bilinguals showed a positive correlation of English proficiency with person identification in the spoken conditions. This result suggests that bilinguals with higher language proficiency levels remembered their listener more accurately compared to those with lower language proficiency levels, which is inconsistent with the English monolingual result.

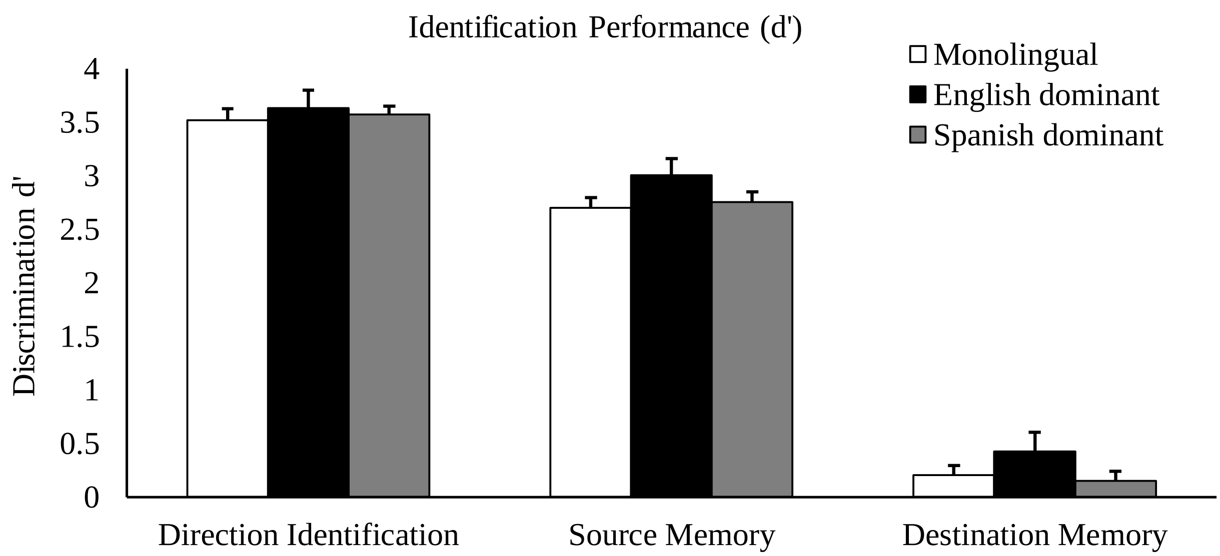

Figure 4. Identification Memory Performance.
Note. The figure represents discrimination d’ scores in the identification test. Error bars indicate standard errors by participants.

Furthermore, we examined whether source memory was remembered better than destination memory when the direction of information transfer was remembered and whether bilinguals were advantaged in remembering source and destination memory over monolinguals. All language groups showed the source memory advantage over destination memory when they remembered the direction of information transfer (see Table 2). However, there were no language group differences on source memory performance [monolinguals vs. ED: $F(1, 141) = 1.23$, $MSE = 1.75$, $p = .27$, $\eta^2_p = .009$; monolinguals vs. SD: $F < 1$; ED vs. SD: $F(1, 141) = 1.29$, *MSE* = 1.84, $p = .26$, $\eta^2_p = .009$] or destination memory performance [monolinguals vs. ED: $F < 1$; monolinguals vs. SD: $F < 1$; ED vs. SD: $F(1, 141) = 3.11$, $MSE = 1.58$, $p = .08$, $\eta^2_p = .022$] when the direction of information transfer was remembered.

2.2.2.3 Correlation between Item and Contextual Memory

Table 3 represents the relationship between item memory and person identification memory at the participant level. Item memory was positively correlated with overall person identification performance in all language groups. Positive correlations were observed for bilinguals, but not monolinguals, when the direction of information transfer was remembered. Thus, people who better remembered whether items were previously provided were more likely to identify their correct confederates compared to those who had worse item memory, and bilinguals were more likely to identify their confederates as their speaker and listener correctly, although remembering the direction of information was not predictive of person identification performance in monolinguals. For listened item conditions, item memory performance was positively correlated with source memory performance in all language groups. The same pattern was observed even when we included only source memory performance with correct direction identification performance. The results indicate that people with higher item memory identified the correct confederate more accurately than those with lower item memory, and they were more likely to recognize the confederate as their speaker. On the other hand, in the spoken item conditions, item memory was not correlated with destination memory performance in either language group. In addition, knowing the direction of information transfer did not change the correlation.

Table 2: Person Identification Performance (d' score) by Language Group When Direction of Information Transfer was Remembered in Experiment 1.

	Language Group			
	Monolingual	English Dominant	Spanish Dominant	All Bilingual
Source Memory	2.88 (.18)	3.15 (.15)	2.87 (.18)	3.01 (.12)
Destination Memory	.294 (.12)	.429 (.10)	.172 (.09)	.300 (.07)

Note. Values in parentheses are standard errors. The all bilingual group is combined between English-dominant and Spanish-dominant bilingual groups.

Table 3: Correlation of Person Identification Performance with Item Memory d' Performance in Experiment 1.

	Language Group			
	Monolingual	English Dominant	Spanish Dominant	All Bilinguals
Listened Item d'				
Source Memory	.359*	.358*	.037*	.330**
SM with Direction Information	.353*	.359*	.293**	.293**
Spoken Item d'				
Destination Memory	.156	.281^{M}	.066	.160
DM with Direction Information	-.048	.258	.131	.131
Overall Item d'				
Overall Person Identification	.302*	.462**	.377**	.404**
Overall Person ID with Direction Information	.229	.455**	.315*	.373**

^{M} $p < .1$, * $p < .05$, ** $p < .01$

Note. The all bilingual group is combined between English-dominant and Spanish-dominant bilingual groups.

2.2.3 Multinomial Processing Tree Models

The second part of the analyses of this experiment was administered using the multinomial processing tree model. Experiment 1 consisted of five conditions: 1) listened from confederate A, 2) listened from confederate B, 3) spoken to confederate A, 4) spoken to confederate B, 5) new conditions. These five conditions were also treated as response categories in this analysis. The response frequencies in the source memory task for the direction of information transfer and confederate with new/old item judgments on each language group are given in Table 4. This experiment had two dimensions of source information. The first dimension was the direction of information transfer (source *d*): listened or spoken trials. The second dimension was the relevant person (source *p*): confederate A or confederate B. Thus, the source combination was denoted with (*d*, *p*).

Table 4: Response Frequencies of Direction of Information Transfer and Confederate with New/Old Judgements of Language Group.

True Category	Response Category: Listened to (Input)		Spoken (Output)		New Item
	Confederate A	Confederate B	Confederate A	Confederate B	
	English Monolingual				
Listened to					
Confederate A	560	72	47	14	267
Confederate B	65	558	14	37	286
Spoken					
Confederate A	12	9	498	384	57
Confederate B	13	15	420	454	58
New Item	20	26	9	7	1858
	English-dominant Bilingual				
Listened to					
Confederate A	608	70	42	9	231
Confederate B	50	637	16	27	230
Spoken					
Confederate A	13	12	522	359	54
Confederate B	11	15	399	496	39
New Item	30	33	10	9	1838
	Spanish-dominant Bilingual				
Listened to					
Confederate A	570	69	50	17	254
Confederate B	69	594	11	36	250
Spoken					
Confederate A	6	13	478	418	45
Confederate B	9	15	429	474	34
New Item	31	25	13	18	1833

Note. This table represents sum scores of participants' responses on each condition for each language group.

2.2.3.1 Summary of Notation

The MPT model in this experiment had two trees, one for previously-presented items and one for non-presented items (see Figure 5). These trees were created based on the crossed-source model from Meiser and Bröder (2002). In total, thirteen parameters were used, and subscripts d and p represented source combination (d, p) which varied depending on item conditions. For example, if the participant listened to the item from confederate A, the subscripts were written with s (source) on the first dimension and a on the second dimension, or if the participant told the item to confederate B, the subscripts were d (destination) and b.

The parameter I_{dp} represents the probability of identifying a previously represented item as old. (Note that this is not the same as the probability of a correct response – this is the probability that the participant actually knows that the item was previously presented and is not guessing.) The parameter D_{dp} represents the probability of remembering correct direction of information transfer (reality monitoring) for items remembered as previously presented. The probability of remembering correct confederate for items whose direction of information transfer is remembered is denoted by P_{dpk} (source memory for previously listened items; destination memory for previously spoken items). If the direction of information transfer is correctly remembered but a confederate is not recollected, the person identification response is guessed with probability 1-P_{dpk}. In guessing, confederate A is guessed with the probability G_{dak}; confederate B is guessed with probability 1-G_{dak}.

If previously-presented items are identified as old but their directions of information transfer are not recollected, the direction is guessed with probability 1-D_{dp}. The probability of guessing items as listened is G_s. The parameter P_{dpu} represents the probability of remembering correct confederate information for items whose direction of information transfer is not recollected. If the correct confederate information is not remembered, with probability 1-P_{dpu}, the parameter G_{lu} denotes the probability of guessing items as listened from confederate A; the parameter 1-G_{lu} denotes the probability of guessing items as listened from confederate B. Similarly, the probability of guessing items as spoken is denoted by 1-G_s. With probability P_{dpu}, the correct confederate information is remembered. If the correct confederate information is not remembered, with probability 1-P_{dpu}, the parameter G_{tu} denotes the probability of guessing items as spoken to confederate A; the probability 1-G_{tu} denotes the probability of guessing items as spoken to confederate B.

If previously presented items are not remembered as old, with probability 1-I_{dp}, the participant has to guess whether the item is old or new. The parameter G_o represents the probability of correctly guessing items as old. The parameter T represents the probability of guessing unrecognized old items as listened items. The parameter T_s represents the probability of guessing confederate A for unrecognized old items which are guessed as listened items, and the 1-T_s represents the probability of guessing confederate B. Unrecognized old items are guessed as spoken items with probability 1-T. The parameter T_d denotes the probability of guessing confederate A for unrecognized old items which are guessed as spoken items, and the parameter 1-T_d is the probability of guessing confederate B. The parameter 1-G_o represents the probability of guessing unrecognized old items as new.

In the tree for new-item conditions, the parameter I_n represents the probability of identifying previously non-presented items as new. If new items are not remembered to be new, with probability 1-I_n, participants guess whether they are old or new. The parameter G_o represents the probability of incorrectly guessing new items as old. The parameter T represents the probability of guessing that these new items were listened items. The parameter T_s represents the probability of guessing confederate A for new items which are guessed as listened items, and 1-T_s represents the probability of guessing confederate B. New items incorrectly guessed to be old are guessed as spoken items with probability 1-T. The parameter T_d denotes the probability of guessing confederate A for these items, and 1-T_d denotes the probability of guessing confederate B.

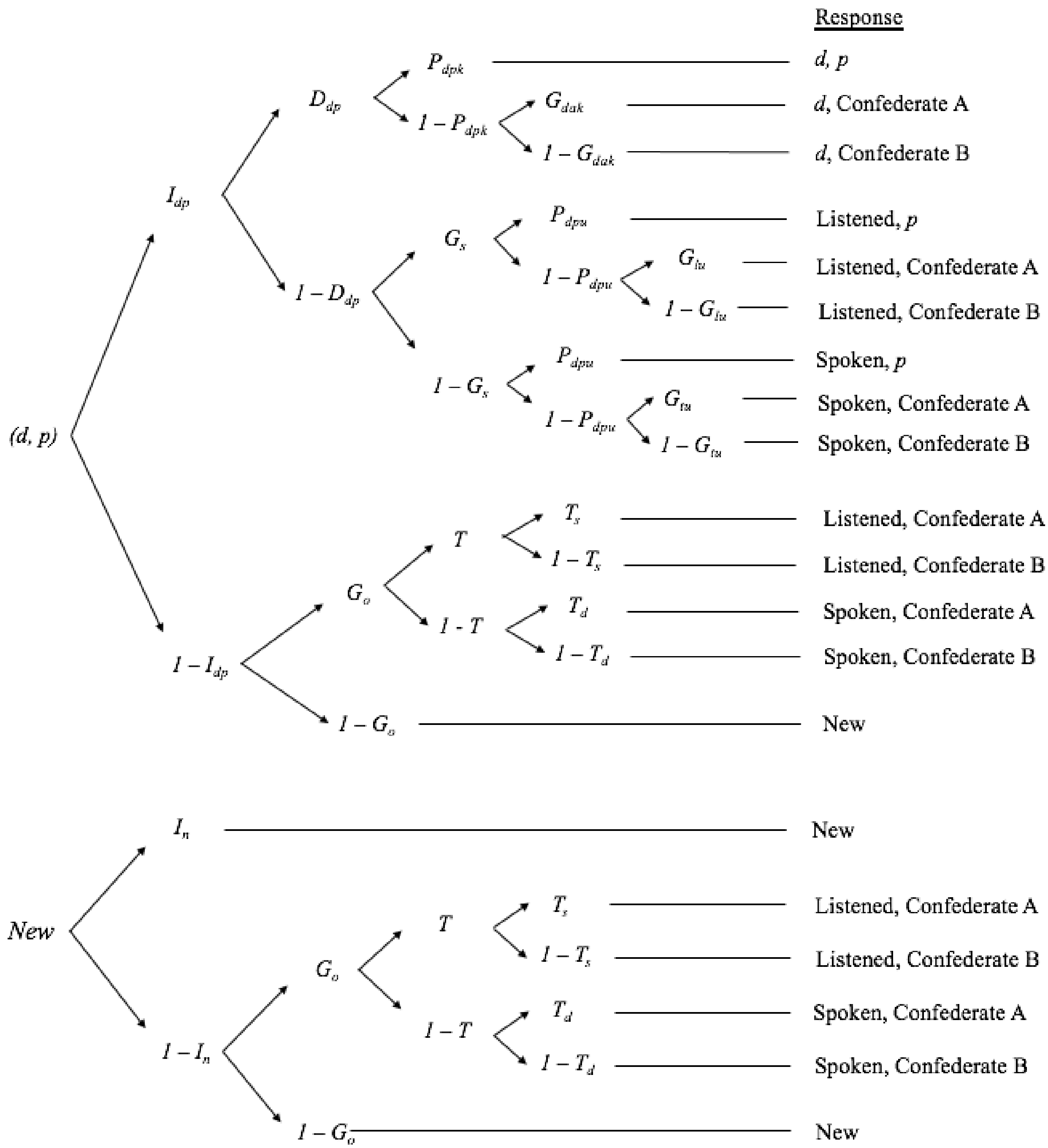

Figure 5. Multinomial Processing Trees for Crossed Source Information.
Note. (d, p) represents items from source d of the first dimension (direction of information transfer: listened and spoken conditions) and source p of the second dimension (person: confederate A and B). *New* represents non-presented items. I_{dp} = probability of recognizing previously presented items as old; I_n = probability of identifying non-presented items as new; D_{dp} = probability of remembering source d (correct direction of information transfer) for recognized old items from source combination (d, p); P_{dpk} = probability of remembering source p (correct confederate) for recognized old items from source combination (d, p) given recollection of direction of information transfer; P_{dpu} = probability of remembering source p (correct confederate) for recognized old items from source combination (d, p) given no recollection of direction of information transfer; G_{dak} = probability of guessing confederate A trials for recognized old items given recollection of correct direction of information transfer; G_s = probability of guessing listened trials for recognized old items; G_{lu} = probability of guessing confederate A for recognized old items given assignment to listened trials; G_{tu} = probability of guessing confederate A for recognized old items given assignment to spoken trials; G_o = probability of guessing that an item is old; T = probability of guessing a listened item for unrecognized old items and unidentified new items; T_s = probability of guessing confederate A for unrecognized old items and unidentified new items given assignment to listened trials; T_d = probability of guessing confederate A for unrecognized old items and unidentified new items given assignment to spoken trials.

2.2.3.2 Goodness-of-Fit Test in MPT Model

We simplified the MPT model through four assumption tests prior to the primary data analysis. All assumptions were tested in all language groups, and the simplest model that applied to all language groups was used for further analyses (EM = English monolingual; ED = English-dominant; SD = Spanish-dominant).

First, we tested the assumption of whether the probability of remembering confederate A could be set equal to the probability of remembering confederate B in each test condition. Thus, we tested the following combinations: $I_{sa} = I_{sb}$, $I_{da} = I_{db}$, $D_{sa} = D_{sb}$, $D_{da} = D_{db}$, $P_{sak} = P_{sbk}$, $P_{dak} = P_{dbk}$, $P_{sau} = P_{sbu}$, and $P_{dau} = P_{dbu}$. Tests of all relevant combinations supported this assumption, indicating that knowing whether the item was presented, knowing the direction of information transfer, and knowing the person did not depend on which confederate was presented in any condition. [$I_{sa} = I_{sb}$: $\Delta G^2(1)_{EM} = .79$, $p = .37$; $\Delta G^2(1)_{ED} = .31$, $p = .58$; $\Delta G^2(1)_{SD} = .38$, $p = .54$; $I_{da} = I_{db}$: $\Delta G^2(1)_{EM} = .05$, $p = .82$; $\Delta G^2(1)_{ED} = 1.86$, $p = .17$; $\Delta G^2(1)_{SD} = 1.14$, $p = .29$; $D_{sa} = D_{sb}$:

$\Delta G^2(1)_{EM} = .65$, $p = .42$; $\Delta G^2(1)_{ED} = 1.39$, $p = .24$; $\Delta G^2(1)_{SD} = 3.63$, $p = .06$; $D_{da} = D_{db}$: $\Delta G^2(1)_{EM} = .83$, $p = .36$; $\Delta G^2(1)_{ED} = .42$, $p = .52$; $\Delta G^2(1)_{SD} = 3.51$, $p = .06$; $P_{sak} = P_{sbk}$, $P_{dak} = P_{dbk}$, $P_{sau} = P_{sbu}$, and $P_{dau} = P_{dbu}$: $\Delta G^2(2)$'s $= 0$, $p = 1$.

The second assumption test was whether the probability of new item identification could be set equal to the probability of old item recognition for any of the source combinations, $I_{dp} = I_n$. When the probability of new item identification was set equal to the probability of spoken item recognition, we found a significant difference in each language group: $I_n = I_{da} = I_{db}$, $\Delta G^2(1)_{EM} = 10.44$, $p < .01$; $\Delta G^2(1)_{ED} = 7.60$, $p = .01$; $\Delta G^2(1)_{SD} = 25.92$, $p < .01$. However, this assumption was supported for the same probabilities between new item identification and listened item identification. The discrimination of relevant person (p) was set equal in each direction item recognition conditions ($\Delta G^2(1)_{EM} =.60$, $p = .44$; $\Delta G^2(1)_{ED} = 0$, $p = 1$; $\Delta G^2(1)_{SD} = 0$, $p = 1$). Thus, the model was set as follows: $I_n = I_{sa} = I_{sb}$ and $I_{da} = I_{db}$.

The third assumption test was whether the probability of remembering listened items could be set equal to the probability of remembering spoken items at a direction identification test phase: $D_{sa} = D_{sb} = D_{da} = D_{db}$. When we tested whether the probability of the direction identification for listened items could be set equal to the probability of the direction identification for spoken items for both confederate A and confederate B, $D_{sa} = D_{sb} = D_{da} = D_{db}$. The model fitted with this assumption, $\Delta G^2(1)_{EM} < .01$, $p = 1$; $\Delta G^2(1)_{ED} = 0$, $p = 1$; $\Delta G^2(1)_{SD} = 0$, $p = 1$.

Our fourth assumption test was whether guessing parameters could be set equal across conditions. We tested whether the probability of guessing confederate A for listened items could equal the probability of guessing confederate A for spoken items, $G_{sak} = G_{dak}$. This assumption was integrated in the MPT model, $\Delta G^2(1)_{EM} = .51$, $p = .48$; $\Delta G^2(1)_{ED} = 3.06$, $p = .08$; $\Delta G^2(1)_{SD} =$

.12, p = .73. Lastly, we compared probabilities of guessing one dimension for recognized old items with those for unrecognized old items ($G_s = T; G_{lu} = T_s; G_{tu} = T_d$). Those assumptions also fitted to the MPT model and were incorporated ($\Delta G^2(3)_{EM}$ = 1.33, p = .72; $\Delta G^2(3)_{ED}$ = 2.49, p = .48; $\Delta G^2(3)_{SD}$ = 6.10, p = .11).

In summary, through the assumption tests, we set the following equations to conduct further analyses: $I_n = I_{sa} = I_{sb}$, $I_{da} = I_{db}$, $D_{sa} = D_{sb} = D_{da} = D_{db}$, $P_{sak} = P_{sbk}$, $P_{dak} = P_{dbk}$, $P_{sau} = P_{sbu}$, $P_{dau} = P_{dbu}$, $G_{dak} = G_{sak}$, $G_s = T$, $G_{lu} = T_s$, $G_{tu} = T_d$.

2.2.3.3 Within Language Group Results in MPT Model

Item memory was significantly better for spoken items than listened items in all language groups ($I_{sp} = I_{dp}$ was significant: $\Delta G^2(1)_{EM}$ = 374.24, p < .01; $\Delta G^2(1)_{ED}$ = 311.38, p < .01; $\Delta G^2(1)_{SD}$ = 409.42, p < .01). When direction identification performance was analyzed in each language group ($D_{sp} = D_{dp}$), Spanish-dominant bilinguals identified the correct direction better for correctly recognized spoken trials compared with correctly recognized listened trials ($\Delta G^2(1)_{SD}$ = 5.18, p = .02), but no differences in monolinguals and English-dominant bilinguals ($\Delta G^2(1)_{EM}$ = .22, p = .64; $\Delta G^2(1)_{ED}$ = .86, p = .35). Person identification performance was significantly better for correctly recognized listened trials compared with correctly recognized spoken trials in all language groups ($P_{spk} = P_{dpk}$: $\Delta G^2(1)_{EM}$ = 424.44, p < .01; $\Delta G^2(1)_{ED}$ = 466.58, p < .01; $\Delta G^2(1)_{SD}$ = 484.94, p < .01). In addition, the person identification performance was significantly better for listened trials than spoken trials even when the direction of information transfer was not remembered ($P_{spu} = P_{dpu}$: $\Delta G^2(1)_{EM}$ = 5.12, p = .02; $\Delta G^2(1)_{ED}$ = 3.84, p =.05; $\Delta G^2(1)_{SD}$ = 11.36, p < .01).

2.2.3.4 Group Comparison Results in MPT Model

Item memory performance was analyzed first. The group comparison test showed that English-dominant bilinguals had a greater probability of accurately identifying listened items as old compared with monolinguals ($\Delta G^2(1)_{EMED}$ = 5.89, p = .02), but no other language group differences were observed ($\Delta G^2(1)_{EMSD}$ = .53, p = .47; $\Delta G^2(1)_{EDSD}$ = 2.83, p = .09). For spoken condition items, Spanish-dominant bilinguals showed a greater probability of accurately identifying spoken items as old than monolinguals ($\Delta G^2(1)_{EMSD}$ = 5.84, p = .02), but no other language group differences were observed ($\Delta G^2(1)_{EMED}$ = 1.03, p = .31; $\Delta G^2(1)_{EDSD}$ = 1.85, p = .17). Bilinguals had a greater response bias toward guessing *old* for unrecognized items and unidentified new items compared with monolinguals ($\Delta G^2(1)_{EMED}$ = 7.60, p = .01; $\Delta G^2(1)_{EMSD}$ = 6.52, p = .01), but there was no difference in response bias across bilingual groups ($\Delta G^2(1)_{EDSD}$ = .07, p = .79).

In the direction identification performance, there were no language group differences in identifying the correct direction for correctly remembered old items ($\Delta G^2(1)_{EMED}$ = 3.03, p = .08; $\Delta G^2(1)_{EMSD}$ = 1.06, p = .30; $\Delta G^2(1)_{EDSD}$ = .40, p = .53). There was also no significant difference in response bias toward guessing a particular direction of information transfer across the language groups ($\Delta G^2(1)_{EMED}$ = .11, p = .74; $\Delta G^2(1)_{EMSD}$ =.91, p = .34; $\Delta G^2(1)_{EDSD}$ = .35, p = .55).

We also examined the person identification performance across the language groups. For correctly recognized listened trials, English-dominant bilinguals showed a greater probability of identifying the correct confederate compared with monolinguals ($\Delta G^2(1)_{EMED}$ = 4.01, p = .045), but no other language group differences were observed ($\Delta G^2(1)_{EMSD}$ = .21, p = .65; $\Delta G^2(1)_{EDSD}$ = 2.33, p = .13). For correctly recognized spoken trials, the probability of identifying the correct confederate was greater for English-dominant bilinguals than Spanish-dominant bilinguals ($\Delta G^2(1)_{EDSD}$ = 5.30, p = .02), but no other language group differences were observed ($\Delta G^2(1)_{EMED}$ = 2.76, p = .10; $\Delta G^2(1)_{EMSD}$ = .24, p = .62). When the direction of information transfer was not remembered, there were no language group differences in either listened or spoken trials [Listened items: $\Delta G^2(1)_{EMED}$ < .01, p = 1; $\Delta G^2(1)_{EMSD}$ = .55, p = .46; $\Delta G^2(1)_{EDSD}$ = .44, p = .51; Spoken items: $\Delta G^2(1)_{EMED}$ < .01, p = 1; $\Delta G^2(1)_{EMSD}$ = .39, p = .53; $\Delta G^2(1)_{EDSD}$ = .40, p = .53].

Furthermore, there was no difference in response bias toward guessing a particular confederate across the language groups when the direction of information transfer was remembered ($\Delta G^2(1)_{EMED}$ = .24, p = .62; $\Delta G^2(1)_{EMSD}$ = .34, p = .56; $\Delta G^2(1)_{EDSD}$ < .01, p = 1) or when items were guessed as *listened* ($\Delta G^2(1)_{EMED}$ =.07, p = .79; $\Delta G^2(1)_{EMSD}$ < .01, p = 1; $\Delta G^2(1)_{EDSD}$ = .08, p = .78). However, English-dominant bilinguals were more likely than Spanish-dominant bilinguals to guess confederate A was their listener than confederate B when they guessed items were spoken ($\Delta G^2(1)_{EDSD}$ = 4.00, p = .046). There was no response bias difference between monolinguals and bilinguals; $\Delta G^2(1)_{EMED}$ = .69, p = .41; $\Delta G^2(1)_{EMSD}$ = 1.27, p = .26).

Table 6: Parameter Estimate and 95% Confidence Interval (CI) in the Multinomial Processing Tree Model of Each Language Group.

	Language Group					
	Monolinguals		English Dominant		Spanish Dominant	
Parameter	Estimate	CI	Estimate	CI	Estimate	CI
$I_{dp}^{Listened} = I_n$	.68	.66, .70	.72	.70, .74	.691	.67, .71
I_{dp}^{Spoken}	.93	.92, .95	.94	.93, .95	.95	.94, .96
D_{dp}	.90	.89, .92	.93	.91, .94	.92	.90, .94
$P_{dpk}^{Listened}$	.82	.78, .86	.87	.84, .90	.83	.79, .87
P_{dpk}^{Spoken}	.08	.02, .14	.15	.09, .20	.06	.01, .12
$P_{dpu}^{Listened}$	.57	.38, .76	.57	.33, .81	.68	.45, .91
P_{dpu}^{Spoken}	.13	.22, .47	.13	.24, .50	.00	-.38, .38
G_{dak}	.52	.49, .55	.51	.48, .54	.51	.48, .53
G_s	.24	.17, .31	.26	.18, .33	.29	.21, .36
$G_{lu} = T_s$	.46	.36, .56	.44	.35, .53	.46	.37, .56
$G_{tu} = T_d$	.56	.42, .69	.63	.51, .76	.45	.33, .57
G_o	.10	.08, .12	.15	.12, .18	.15	.12, .17

Note. $I_{dp}^{Listened}$ = probability of identifying previously listened items as old; I_n = probability of identifying non-presented items as new ($I_{dp}^{Listened}$ and I_n were set equal in each language group); I_{dp}^{Spoken} = probability of identifying previously spoken items as old; D_{dp} = probability of identifying correct direction of information transfer for recognized old items; $P_{dpk}^{Listened}$ = probability of identifying correct confederate for correctly remembered listened items; P_{dpk}^{Spoken} = probability of identifying correct confederate for correctly remembered spoken items; $P_{dpu}^{Listened}$ = probability of identifying correct confederate in listened conditions for recognized old items but no recollect of direction of information transfer; P_{dpu}^{Spoken} = probability of identifying correct confederate in spoken conditions for recognized old items but no recollect of direction of information transfer; G_{dak} = probability of guessing confederate A for recognized old items given recollection of correct direction of information transfer; G_s = probability of guessing listened trials for recognized old items; G_{lu} = probability of guessing confederate A for old items guessed as listened items; T_s = probability of guessing person A for unrecognized items and unidentified non-presented items given assignment to listened trials (G_{lu} and T_s were set equal in each language group); G_{tu} = probability of guessing confederate A for old items guessed as spoken items; T_d = probability of guessing confederate A for unrecognized items and unidentified non-presented items given assignment to spoken trials (G_{tu} and T_d were set equal in each language group); G_o = probability of guessing an item as old.

2.1 Discussion

The purpose of Experiment 1 was to understand the possible effects of bilingualism or bilingual proficiency on item memory and source/destination memory processes and the mechanisms of such contextual memory. First, in the signal detection theory analysis, item memory performance did not differ across the language groups. However, we found a language proficiency effect within bilinguals. Bilinguals with higher English proficiency showed *greater* item recognition performance than bilinguals with lower English proficiency. This finding stands in contrast to the results of previous studies in which higher language proficiency resulted in *worse* item recognition performance than lower language proficiency (Francis & Gutiérrez, 2012; Francis & Strobach, 2013). The different patterns of results may be due to differences in item stimuli. The prior studies of recognition memory in bilinguals used isolated words at encoding, whereas the current study used sentences. Thus, the current study required sentence comprehension rather than simple word comprehension, which requires greater cognitive resources at encoding. Therefore, under conditions with higher cognitive demand, bilinguals with higher language proficiency may have benefited from remembering whether items had been presented. Furthermore, the MPT model approach demonstrated language group differences in item memory. For listened item conditions, English-dominant bilinguals were more likely than monolinguals to remember that an item had been presented. For spoken item conditions, Spanish-dominant bilinguals were more likely than monolinguals to remember that an item had been presented. These results suggest that bilinguals have greater probability of remembering items compared to monolinguals.

Secondly, we examined source and destination memory performance in bilinguals. As expected, we found a source memory advantage over destination memory in bilinguals and monolinguals, suggesting that the speaker's information is better remembered than the listener's information which is consistent with previous studies (e.g., Gopie & MacLeod, 2009; Fischer et al., 2015). Furthermore, Experiment 1 demonstrated an important finding on bilingual source/destination memory processing and this finding provided evidence in favor of the attention hypothesis. Consistent with the previous study (Francis et al., 2019), source memory performance did not differ for L1 and L2. The result suggests that the source of the information is associated with the episodic information at the conceptual level. However, we found a bilingual language effect on destination memory performance such that bilinguals with higher English proficiency better identified the correct destination of the information compared to bilinguals with lower English proficiency. In particular, the MPT model analysis suggests that the L1 advantage in destination memory is more likely to occur when the direction of information transfer is correctly remembered.

These results support the attention hypothesis, which assumes that the availability of attentional resources at encoding is key to remembering the contextual information. Self-generation requires greater cognitive demands compared to simply listening, and furthermore, generating the information in L2 is a more cognitively demanding task compared to in L1. That is, in the current study, destination memory trials in L2 required more cognitive resources than the other conditions, and the task with greater cognitive demand led to the worst destination memory performance. As previous studies suggested, the tasks with more cognitive demands decreased attentional resources at encoding, resulting in worse contextual memory, particularly destination memory (Lindner et al., 2015). Thus, the bilingual language proficiency effect supports the attention hypothesis.

The current study examined the relationship between item memory and contextual memory. In prior research, findings regarding the item-source memory associations have been mixed. Some studies found a negative correlation between the two types of memory performance such that more accurate item memory performance was associated with less accurate source memory performance (e.g., Jurica & Shimamura, 1999). The explanation of this finding is that item and context information encoding requires different types of memory process and the different processes compete for cognitive resources. In other words, when greater cognitive resources are used to encode item information, only limited cognitive resources would be available to process its context information. However, other studies showed a positive correlation such that more accurate item memory was associated with more accurate source memory (e.g., Koehler et al., 2001; Geghman & Multhaup, 2004; Kinjo & Snodgrass, 2000; Riefer et al., 2007). One explanation of this phenomenon was that processes of item and source memory overlap, and stronger item encoding facilitates a stronger representation of all aspects of the event and helps with binding of content and context information, particularly when item encoding process becomes deeper and more elaborative.

Experiment 1 results showed a positive correlation between item and source memory, supporting the second explanation. We found that item memory in listened conditions was positively correlated with source memory performance regardless of memory for the direction of information transfer. The overall item memory performance also showed the positive correlation. However, interestingly, such a correlation was not observed under spoken conditions, indicating that memory performance for self-generated items was not correlated with the strength of memory for the targeted contextual information. This is consistent with the finding from a previous study where the self-referential encoding did not facilitate remembering non-targeted contextual information, although such encoding benefited from remembering targeted contextual information (Lawrence & Chai, 2021). Thus, the Experiment 1 results suggest that stronger item encoding process may facilitate a stronger representation of relevant contextual information and help to make stronger item-context associations, but the item's destination may be processed as *non-targeted* contextual information at encoding.

Lastly, we examined how the direction of information transfer was involved with content-context associations through the MPT model results. We proposed three possible models to represent content-context association processing (Figure 6). Model A assumes that the direction of information transfer is completely independent from contextual memory. If one of the memories is associated with the other, then we will exclude Model A. Model B and C assume that the direction of information transfer is hierarchically associated with person memory. If person memory needs to be remembered prior to the direction of information transfer, Model B needs to be excluded from our potential model. Whereas, if the direction of information transfer needs to be remembered prior to the person information, then Model C would be excluded.

The results of the MPT analysis of Experiment 1 showed that the direction identification performance was greater than the person identification performance. Thus, we excluded Model C from further consideration. We now consider Models A and B. The MPT model showed that participants remembered the source of the information with a probability of 84% when direction of information was remembered, whereas participants remembered the source with a probability of 60% when they did not remember the direction of information. Thus, 60% of the time, the source of information was able to be retrieved even with a failure to remember the direction of information transfer, but the source memory was 24% more likely to be remembered if the direction of information transfer is remembered. Regarding the destination memory, when the direction of information was retained, the destination of the information transfer was remembered with a probability of 9.7%. The probability of remembering the destination of the information was lowered by only 1% when the direction of information was not available. Thus, the probability of remembering the destination was not linked to remembering the direction of information transfer. These results suggest that the source and destination memory are somewhat associated with the direction of information transfer although these two types memories are not completely hierarchical. Therefore, the results of Experiment 1 suggest a new model, Model A2, which shows another link between the direction of information node and the contextual information node in Model A.

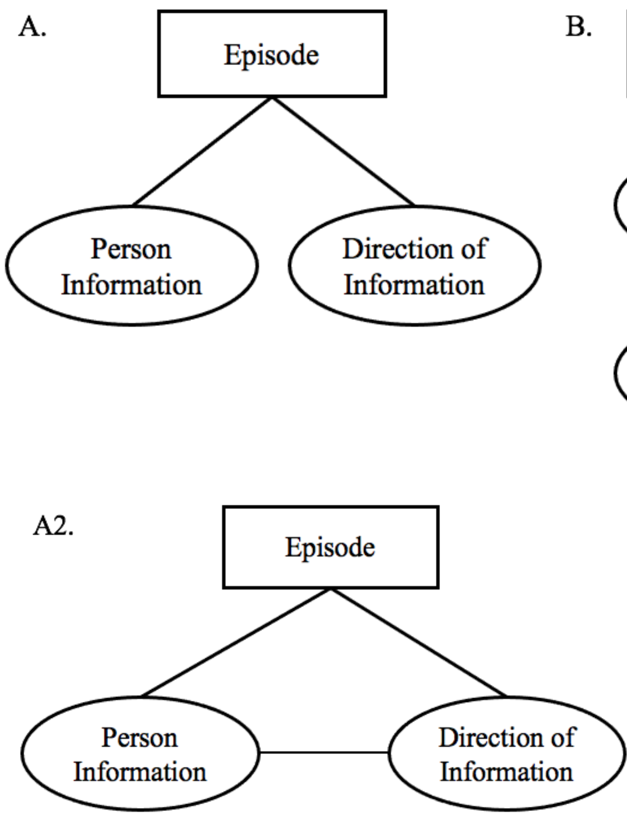

Figure 6. Possible Models and New Proposed Model.
Note. These are possible models for the relationships between the direction of information transfer and person information. Model A represents the independence of the two processes. Model B represents the dependency of the person information process on the direction of information transfer. Model C represents the dependency of the direction of information transfer on the person information. Model A2 is an extension of Model A and represents no hierarchy between the two processes although the two processes interact with each other.

Chapter 3: Experiment 2

Experiment 1 showed results consistent with prior literature, such that the production of self-generated sentences led to worse memory for information-person associations compared with exposure to someone's personal fact. That is, self-referential encoding benefitted item memory and memory for the source of the information (speaker), but memory for the destination of the information (listener) was not benefitted at all. In Experiment 1, the direction identification decision on the final test was always made prior to the person identification decision, and it is possible that this ordering gave an advantage to memory for directions relative to sources and destinations. Therefore, in Experiment 2, direction and person information were asked simultaneously at test such that participants were asked to choose who was an appropriate speaker (input direction and source of information) and who was an appropriate listener (output direction and destination of information).

In Experiment 2, we investigated whether and to what degree observational processes influenced forming information-person associations. In other words, the present experiment tested whether someone else's "source" and "destination" of the information were processed in the same way as one's own "source" and "destination" of the information. Therefore, in Experiment 2, participants were asked to simply observe others' conversations and remember what they observed so that no self-referential encoding processes were involved in forming information-person associations. It was hypothesized that there would be no difference between source and destination memory performance if the attention hypothesis is supported. This is because it is possible to allocate one's attention to both speaker and listener equivalently, specifically because prior to the experiment, participants were instructed that they were to remember relevant speakers and listeners on a future memory test. However, if the source of the information requires greater cognitive resources and is more strongly tied to the content information than the destination of the information, then we hypothesized a source memory advantage over destination memory in this simple observation process.

We hypothesized bilingualism-related effects as well. Experiment 2 utilized a more difficult task than Experiment 1, because participants were asked to learn a greater number of items, keep track of more confederates, and to process source and destination memory simultaneously at encoding. If the attention hypothesis is supported, bilinguals will outperform monolinguals because of their greater attentional control, which would suggest that bilinguals use attentional resources more efficiently than monolinguals. The increased task difficulty and better attentional control may lead to a bilingual advantage on memory for content-context associations.

Effects of language proficiency were also hypothesized. Bilinguals' less proficient language may be more episodically distinctive, because bilinguals are exposed to fewer conversations in L2 than in L1. According to the source-of-activation-confusion theory, item and source memory performance are better when the episode is more distinctive. Thus, we expected more accurate source retrieval for bilinguals processing in L2 relative to bilinguals processing in L1.

3.1 METHODS

3.1.1 Participants

Participants were 144 undergraduate students at the University of Texas at El Paso (48 men, 96 women). None of the participants in Experiment 2 had participated in Experiment 1. They received either course credit or $5 per 30 minutes for research participation. The median age was 20, and 86.8% of participants reported Hispanic ethnicity. There were fourteen participants who completed at least part of the computerized study but were excluded from data analyses. Out of fourteen participants, eight participants were excluded because more than half of old trial items were responded as new items which left too few items to conduct identification analyses. The other six participants were excluded because of technical difficulties. Replacements were made for all excluded participants to preserve counterbalancing.

Table 5: Participant Characteristics in Experiment 2.

Characteristic	English Monolinguals (N=48)	English-Spanish Bilinguals (N=48)	Spanish-English Bilinguals (N=48)
Median Age	20.0	20.0	20.0
Hispanic	66.7%	95.8%	97.9%
English Picture Vocabulary[a]	17.9 (5.9)	15.9 (4.2)	10.2 (2.4)
English Verbal Analogies[a]	20.0 (8.3)	18.9 (8.0)	14.1 (7.1)
English Oral Language[a]	18.8 (6.9)	17.4 (6.2)	10.9 (2.3)
Spanish Picture Vocabulary[a]	2.8 (1.0)	10.2 (2.1)	12.5 (2.0)
Spanish Verbal Analogies[a]	5.0 (1.2)	15.1 (8.6)	21.4 (9.5)
Spanish Oral Language[a]	3.2 (1.4)	11.2 (2.9)	14.0 (3.7)
Median Parental Education	Graduated College	Some College	Graduated College

[a]Scores indicate mean age-equivalency levels for performance on the WMLS-R (Woodcock et al., 2005).

3.1.2 Materials and Design

Experiment 2 formed a 3 (language group) x 2 (direction of information transfer) x 6 (confederate conversation pair) mixed design with four additional new-item control trials for test tasks. Three language groups were formed in Experiment 2: English-monolinguals, English-dominant bilinguals, and Spanish-dominant bilinguals. All participants completed the same task. The direction of information transfer was either a speaker (source of information) or a listener (destination of information). Four confederates were prepared, and all possible pairs were created. See Table 6 for all the experimental sets. The language assessments, criteria for inclusion, and the language and demographic background questionnaires were the same as in Experiment 1.

Table 6: Possible Confederate Pairs.

Confederate Conversation Pairs	Speaker (Source of Information)		Listener (Destination of Information)
Confederate A – Confederate B	Confederate A	→	Confederate B
	Confederate B	→	Confederate A
Confederate A – Confederate C	Confederate A	→	Confederate C
	Confederate C	→	Confederate A
Confederate A – Confederate D	Confederate A	→	Confederate D
	Confederate D	→	Confederate A
Confederate B – Confederate C	Confederate B	→	Confederate C
	Confederate C	→	Confederate B
Confederate B – Confederate D	Confederate B	→	Confederate D
	Confederate D	→	Confederate B
Confederate C – Confederate D	Confederate C	→	Confederate D
	Confederate D	→	Confederate C

3.1.3 Stimuli

Stimuli consisted of 160 experimental sentences and 4 practice sentences. 120 stimuli were the same as in Experiment 1, and we created 40 new sentence stimuli. 120 stimuli were randomly selected as experimental stimuli, and 40 were as new-control stimuli. The sentences were randomly assigned to 16 sets of 10, and the 16 sets were rotated through the 16 experimental conditions (4 sets of them were new-item conditions at test) across participants using a Latin square to control for specific item effects. Four female confederates were prepared to record video stimuli (two of them were the same as in Experiment 1). Three types of videos were recorded for the study phases by each female confederate: 1) Confederate introducing herself, 2) Confederate listening to another confederate's response, and 3) Confederate telling a sentence to another confederate. Half of the video stimuli were spoken by the left person; the others were by the right person. The facial pictures of the four female confederates were displayed prior to practice and at test.

3.1.4 Apparatus

The same apparatus as in Experiment 1 were used.

3.1.5 Procedure

The procedure before the main, computerized experiment was same as in Experiment 1. After all the assessments and questionnaires were completed, participants were instructed about the summary of the study. They were first asked to watch four short introduction videos where four women (the confederates: Ashley, Bethany, Carolina, and Diana) introduced themselves. After the videos, the names and facial pictures of the confederates were displayed on the computer, and participants were given time to remember their names and faces. Then, participants were asked to complete four practice videos where two confederates randomly picked and had conversations. After each practice video, an experimenter told the names of the speaker and listener to ensure participants remembered all the confederates' names and faces. After completing the practice trials, participants were asked to complete the study phase.

Study Phase. See Figure 7.1 for the study phase. This was a self-paced study, and therefore, all visual stimuli stayed on the computer screen until participants pressed a spacebar. Participants were asked to watch video stimuli one at time where one female confederate told a sentence to another female confederate. This is, a source condition and a destination condition were provided to participants at the same time. The source of information was the speaker who said a sentence; the destination of information was the listener who heard the sentence. A written, spoken sentence was displayed at the bottom of the screen. After each video, participants were asked to press a spacebar to move to the next trial. The trials in different conditions were randomly intermixed. This phase continued until participants completed all 120 experimental trials.

Test Phase. See Figure 7.2 for the test phase. All 120 experimental sentences and 40 new sentences were presented in a random order at test. Up to three different subtest screens were presented for each stimulus, and participants were instructed to press either four keys to respond test questions: "z", "v", "m" or "/" keys. Before moving to the actual memory test, participants were asked to complete three practice test trials with an experimenter. A sentence appeared on the top of the screen, and a memory question appeared on the bottom of the screen. The first question was whether the displayed sentence was presented at the study, and participants were instructed to choose a corresponding "Yes" or "No" key: a "z" key to indicate yes and a "/" key to indicate no. When participants identified a sentence as a new item (a non-presented item), the test advanced to the next sentence. When participants identified a sentence as an old item (a presented item), two follow-up identification tests were administered regardless of whether the this response was correct or incorrect. First, the facial pictures and names of all four confederates were displayed with the sentence and question, and participants were asked to remember who said the displayed sentence. Participants were instructed to press a "z" key to indicate Ashley, a "v" key to indicate Bethany, a "m" key to indicate Carolina, and a "/" key to indicate Diana. After they responded with a corresponding key, the last question "who listened to the sentence?" appeared on the screen with the sentence, facial pictures and names. After participants selected their response, the next item was displayed on the screen. This procedure was repeated until participants complete all 160 test trials.

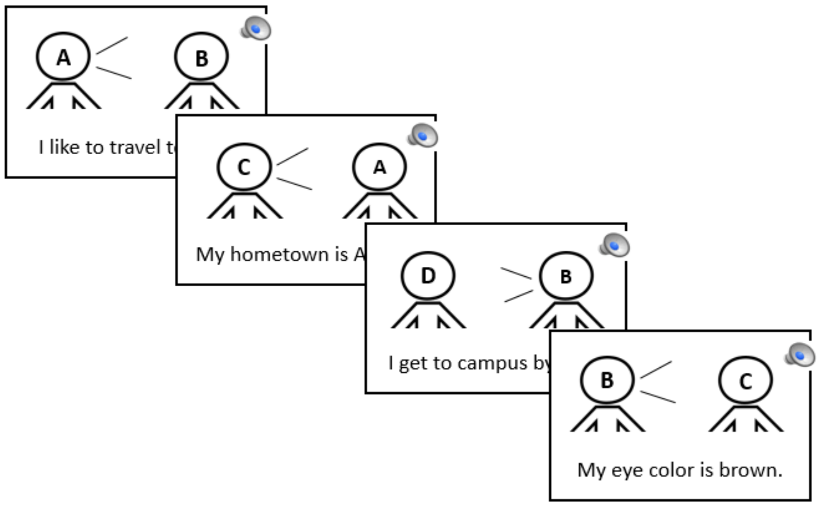

Figure 7.1. Study Phase in Experiment 2.

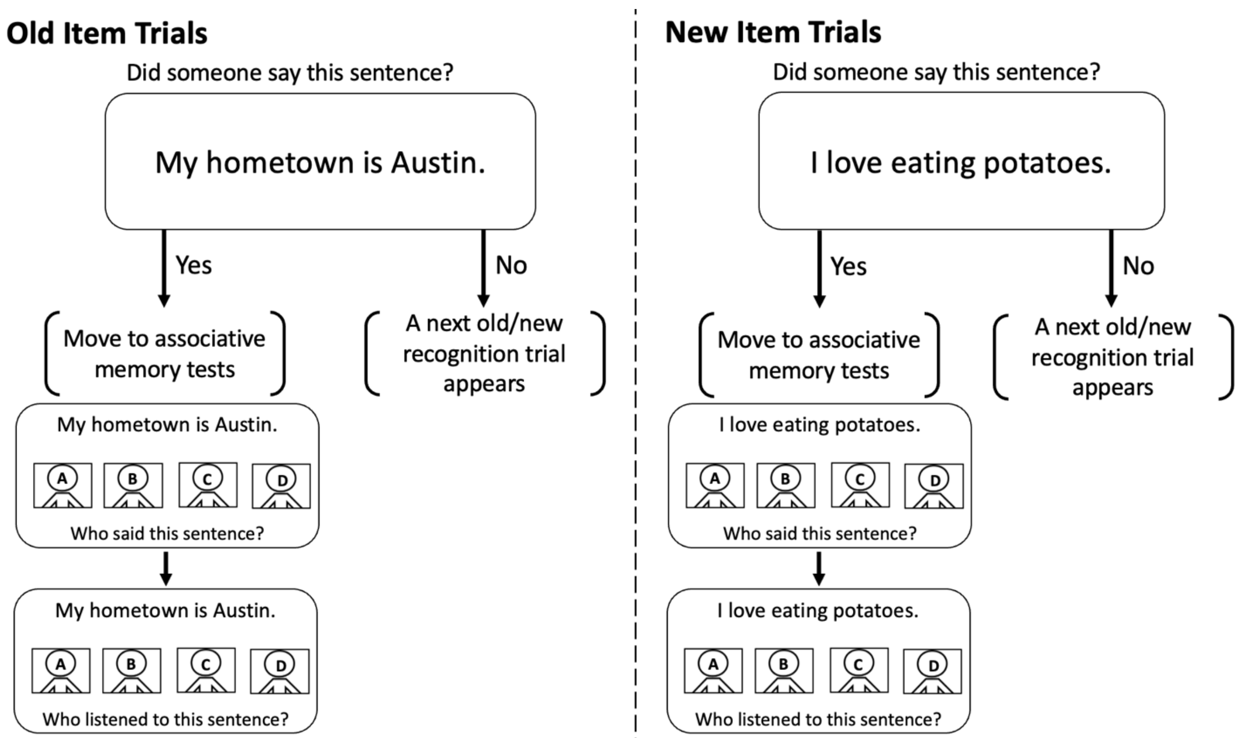

Figure 7.2. Test Phase in Experiment 2.

3.1 RESULTS

3.2.1 Approach to Analysis

Experiment 2 required different types of analyses from Experiment 1 because of the different experimental designs. We first analyzed item memory performance in each language group using signal detection theory. The signal detection measure d' for each participant was computed in the same way as in Experiment 1. Next, we distributed all direction-person identification responses into seven subcategories (Code 1 to Code 7). We conducted ANOVAs on the proportions of particular codes in each language group to investigate the degree to which memory for the direction of information transfer was related to memory for contextual information. Lastly, we conducted a group comparison analysis to investigate whether bilinguals more accurately remembered information-person associations relative to monolinguals.

3.2.2 Item Recognition Accuracy

Item recognition accuracy was defined in the same way as in Experiment 1. As shown in Figure 8, item recognition memory performance did not differ across language groups [monolinguals vs. ED: $F(1, 141) = 2.73$, $MSE = 1$, $p = .101$, $\eta^2_p = .019$; monolinguals vs. SD: $F < 1$; ED vs. SD: $F(1, 141) = 1.27$, $MSE = .465$, $p = .262$, $\eta^2_p = .009$]. Hit rates were significantly higher for English-dominant bilinguals than monolinguals ($F(1, 141) = 6.25$, $MSE = .075$, $p = .014$, $\eta^2_p = .042$). Spanish-dominant bilinguals also showed numerically higher hit rates than monolinguals, although it was not a significant difference ($F(1, 141) = 3.33$, $MSE = .04$, $p = .070$, $\eta^2_p = .023$). No difference on hit rates was observed across the two bilingual groups ($F < 1$). False alarm rates did not differ across language groups ($F < 1$). Thus, bilinguals were more likely to identify previously studied sentences correctly compared to monolinguals although overall item memory performance was the same across language groups when they simply observed others' conversations.

English and Spanish proficiency levels were incorporated into the item memory analysis. Monolinguals showed a positive correlation between English proficiency level and false alarm rates, indicating that monolinguals with higher English proficiency levels were more likely to respond incorrectly that they had previously encountered a new sentence. However, there were no such correlations for bilinguals. In addition, there were no correlations of proficiency with discrimination d' or hit rates in either language group.

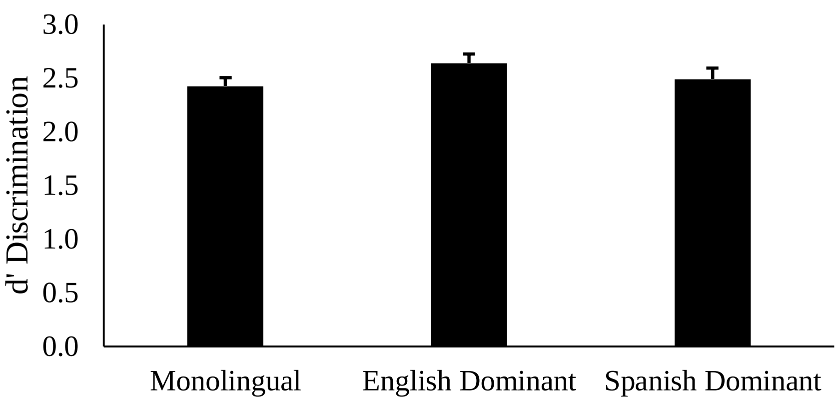

Figure 8. Item Memory Accuracy in Experiment 2.
Note. Error bars indicate standard errors of the mean.

3.2.3 Coding

To conduct analyses on memory for direction and person information, we classified participants' responses into 7 coding categories (see Table 7). Code 1 refers to complete source and destination memory (both direction and person information is retrieved correctly). In Code 2, direction of information transfer was not remembered although who was involved in the conversation was remembered correctly. In Code 3, only the speaker information was remembered correctly. In Code 4, only the listener information was remembered correctly. In Code 5, the source of the information was remembered but not the direction of information transfer or the destination of the information. In Code 6, the destination of the information was remembered but not the direction of information or the source of the information. In Code 7, neither direction nor person information was remembered.

Table 7: Summary of Coding Categories.

Coding Category	**Possible Responses** Example: Person A told Person B (A→B)	**Direction/Person Memory**
Code1	A → B	Complete source and destination memory with correct direction memory
Code 2	B → A	Complete source and destination memory with in correct direction memory
Code 3	A → C or A → D	Correct source memory with correct direction memory
Code 4	C → B or D → B	Correct destination memory with correct direction memory
Code 5	C → A or D → A	Correct source memory with incorrect direction memory
Code 6	B → C or B → D	Correct destination memory with incorrect direction memory
Code 7	C → D or D → C	No source and destination memory

Note. Letters prior to arrows represent speakers (source of information). Letters after arrows represent listeners (destination of information). The column of possible responses lists possible responses participants can make when they make decision about items which Confederate A told to Confederate B.

3.2.3.1 Category Comparison

A summary of the proportions of direction/person identification memory performance in each language group is provided in Table 8. A comparison of response rates for Codes 1 and 2 demonstrated that if participants remembered the two people correctly (both the source and destination of the information), they also remembered the direction of information correctly approximately 90% of the time. The response rate for Code 3 (source memory performance without the destination of the information) was eight times higher than the response rate for Code 4 (destination memory performance without the source of the information) in all language groups, indicating that source memory was better remembered than destination memory, which was consistent with the results of Experiment 1 (monolinguals: $F(1, 47) = 443$, $MSE = 1.83$, $p < .01$; ED: $F(1, 47) = 760$, $MSE = 2.59$, $p < .01$; SD: $F(1, 47) = 423$, $MSE = 2.28$, $p < .01$). Overall bilinguals showed the same pattern as well (bilingual: $F(1, 47) = 1104$, $MSE = 4.86$, $p < .01$). Additionally, when they did not remember the direction of information transfer, monolinguals and Spanish-dominant bilinguals were more likely to remember the source of the information better than the destination of the information, as shown by comparing Codes 5 and 6 (monolinguals: $F(1, 47) = 6.23$, $MSE = .003$, $p = .016$; SD: $F(1, 47) = 19.98$, $MSE = .005$, $p < .01$). Overall bilinguals showed the same result ($F(1, 47) = 11.31$, $MSE = .005$, $p < .01$) although English-dominant bilinguals did not show the pattern ($F < 1$). This might be because English-dominant bilinguals remembered the direction of information transfer better than the other language groups, and not many responses were assigned to Code 5 in comparison to monolinguals and Spanish-dominant. Overall, the results of the coding analysis suggested a source memory advantage over destination memory both with and without memory for the direction of information transfer.

Further analyses involved systematically combining some of the codes. Response rates for Codes 1 and 3 were combined in order to represent the proportion of correctly remembering a speaker as a speaker (source memory with correct direction information). Similarly, response rates for Codes 1 and 4 were combined to represent the proportion of correctly remembering a listener as a listener (destination memory with correct direction information). Combined response rates for Codes 2 and 5 represented the proportion of remembering a speaker as a listener (the correct source of the information without direction information); Combined response rates for Codes 2 and 6 represented the proportion of remembering a listener as a speaker (the correct destination of the information without direction information).

Table 8: Summary of Memory Performance in Each Language Group in Experiment 2.

	Language Group		
	English Monolingual	English Dominant	Spanish Dominant
Item Memory			
Hit Rate	.704 (.015)	.760 (.015)	.745 (.016)
False Alarm Rate	.041 (.006)	.045 (.007)	.053 (.008)
Discrimination d’	2.66 (.076)	2.63 (.085)	2.49 (.100)
Direction and Person Memory (e.g., A told something to B)			
(Code 1: A→B) Direction: + Person: Source +, Destination +	.181 (.009)	.221 (.010)	.210 (.011)
(Code 2: B→A) Direction: – Person: Source +, Destination +	.025 (.003)	.024 (.003)	.025 (.002)
(Code 3: A→C or A→D) Direction: Partially + Person: Source +, Destination –	.321 (.012)	.362 (.011)	.346 (.013)
(Code 4: C→B or D→B) Direction: Partially + Person: Source –, Destination +	.044 (.003)	.033 (.002)	.039 (.004)
(Code 5: C→A or D→A) Direction: – Person: Source +, Destination –	.054 (.004)	.044 (.003)	.053 (.004)
(Code 6: B→C or B→D) Direction: – Person: Source –, Destination +	.044 (.004)	.039 (.004)	.038 (.003)
(Code 7: C→D or D→C) Direction: – Person: Source –, Destination –	.036 (.004)	.037 (.003)	.034 (.003)

Note. + indicates that type of memory was remembered. – indicates that type of memory wasn’t remembered. Values in parentheses are standard errors. For direction and person memory codes, miss trials are excluded, because they do not provide information about direction or person memory. Therefore, the proportions of trials across codes sum to the hit rate rather than to 1.

We investigated how the direction/person identification performance was correlated with item memory performance in each language group (see Table 9). All language groups showed positive correlations of source and destination memory with item memory performance. The results indicate that people who better remembered whether they encountered sentences before were more likely to remember the source and destination of information than those with lower item memory performance. We also investigated how English and Spanish proficiency levels were associated with direction/person identification performance. Monolinguals showed a negative correlation between Code 1 response rates and English proficiency levels, indicating that monolinguals with higher English proficiency levels were less likely to remember complete source and destination memory compared to those with lower English proficiency. However, this pattern was not observed in bilinguals. Furthermore, the analysis demonstrated that source and destination memory performance (combined response rates for Code 1 and 3 and Code 1 and 4) were not correlated with language proficiency levels in monolinguals nor bilinguals.

Table 9: Correlation of Source/Destination Memory Performance with Item Memory d' and Language Proficiency Levels.

	Language Group			
	English Monolingual	English Dominant	Spanish Dominant	All Bilinguals
Overall Source Memory (Code: 1, 2, 3, 5)				
Item Memory d'	r = .710**	r = .710**	r = .798**	r = .760**
English Proficiency	r = -.211	r = -.118	r = -.008	r = .000
Spanish Proficiency	--	r = -.177	r = .138	r = -.041
Source Memory with Direction of Information (Code: 1, 3)				
Item Memory d'	r = .741**	r = .744**	r = .757**	r = .755**
English Proficiency	r = -.250^{M}	r = -.081	r = -.057	r = .018
Spanish Proficiency	--	r = -.202	r = .094	r = -.082
Overall Destination Memory (Code: 1, 2, 4, 6)				
Item Memory d'	r = .539**	r = .419**	r = .552**	r = .498**
English Proficiency	r = .149	r = .046	r = .168	r = .115
Spanish Proficiency	--	r = -.229	r = .280	r = .025
Destination Memory with Direction of Information (Code: 1, 4)				
Item Memory d'	r = .732**	r = .565*	r = .633**	r = .601**
English Proficiency	r = -.269^{M}	r = .008	r = .061	r = .047
Spanish Proficiency	--	r = -.230	r = .266^{M}	r = .011

^{M} $p < .1$, * $p < .05$, ** $p < .01$

Note. The all bilingual group is combined between the English-dominant and Spanish-dominant groups.

3.2.3.2 Group Comparison of Direction/Person Identification Accuracy

The last analysis was conducted to examine to what degree bilingualism was associated with remembering contextual information. We first investigated whether language group differences were observed in different code response performance. Bilinguals remembered both source and destination memory with the correct direction of information transfer more accurately than monolinguals (Code 1) [monolinguals vs. ED: $F(1, 141) = 7.80$, $MSE = .039$, $p < .01$, $\eta^2_p = .052$; monolinguals vs. SD: $F(1, 141) = 4.60$, $MSE = .023$, $p = .034$, $\eta^2_p = .032$]. However, there was no difference between English-dominant and Spanish-dominant bilinguals ($F < 1$). The Code 3 response rate was higher for English-dominant bilinguals than monolinguals, $F(1, 141) = 5.86$, $MSE = .041$, $p = .017$, $\eta^2_p = .040$, indicating that English-dominant bilinguals remembered the source of the information more accurately than monolinguals when the direction of information was correctly remembered. However, no other language group differences were observed [monolinguals vs. SD: $F(1, 141) = 2.43$, $MSE = .017$, $p = .121$, $\eta^2_p = .017$; ED vs. SD: $F < 1$]. English-dominant bilinguals also responded more with Code 5 than monolinguals did, $F(1, 141) = 4.00$, $MSE = .004$, $p = .047$, $\eta^2_p = .028$, indicating that the source of the information was better remembered for English-dominant bilinguals than monolinguals when the direction of information transfer was not remembered. No other language group differences were observed ($Fs < 1$). Furthermore, no other language group differences were observed for the other codes. These results suggest that English-dominant bilinguals remembered the source of the information better than monolinguals regardless of remembering the direction of information transfer, although the destination of the information was remembered at the same level across the language groups.

3.2.3.3 Group Comparison with Combined Code Analyses

We combined response rates of Code 1, 2, 3 and 5 to present overall source memory. We found a bilingual advantage over monolinguals on overall source memory performance [monolinguals vs. ED: $F(1, 141) = 7.93$, $MSE = .119$, $p < .01$, $\eta^2_p = .053$; monolinguals vs. SD: $F(1, 141) = 4.67$, $MSE = .070$, $p = .032$, $\eta^2_p = .032$] (see Figure 9). There was no difference between the bilingual groups ($F < 1$). Combined Code 1 and 3 response rates indicated source memory performance with remembering the direction of information was more accurate for bilinguals than monolinguals [monolinguals vs. ED: $F(1, 141) = 9.00$, $MSE = .162$, $p < .01$, $\eta^2_p = .060$; monolinguals vs. SD: $F(1, 141) = 4.17$, $MSE = .075$, $p = .043$, $\eta^2_p = .029$]. There was no difference between English-dominant and Spanish-dominant bilinguals ($F < 1$). On the other hand, source memory performance without remembering direction information (combined Code 2 and 5) was more accurate for monolinguals than English-dominant bilinguals, $F(1, 141) = 4.00$, $MSE = .004$, $p = .047$, $\eta^2_p = .028$, but there were no other language group differences [monolinguals vs. SD: $F < 1$; ED vs. SD: $F(1, 141) = 2.00$, $MSE = .002$, $p = .160$, $\eta^2_p = .014$]. We also tested the language group differences on destination memory performance. Overall destination performance was competed by combining Code 1, 2, 4, and 6. Unlike source memory performance, there was no language group difference on overall destination memory performance [monolinguals vs. ED: $F(1, 141) = 3.25$, $MSE = .013$, $p = .075$, $\eta^2_p = .023$; monolinguals vs. SD: $F(1, 141) = 2.00$, $MSE = .008$, $p = .160$, $\eta^2_p = .014$; ED vs. SD: $F < 1$]. However, the bilingual advantage was observed when participants remembered the direction of information transfer for the destination person (combined Code 1 and 4) [monolinguals vs. ED: $F(1, 141) = 5.50$, $MSE = .022$, $p = .020$, $\eta^2_p = .038$; monolinguals vs. SD: $F(1, 141) = 4.00$, $MSE = .016$, $p = .047$, $\eta^2_p = .028$] although no difference was observed between the bilingual groups ($F < 1$). There were no language group differences on destination memory performance without remembering the direction of information (combined Code 2 and 6 response rates) ($Fs < 1$).

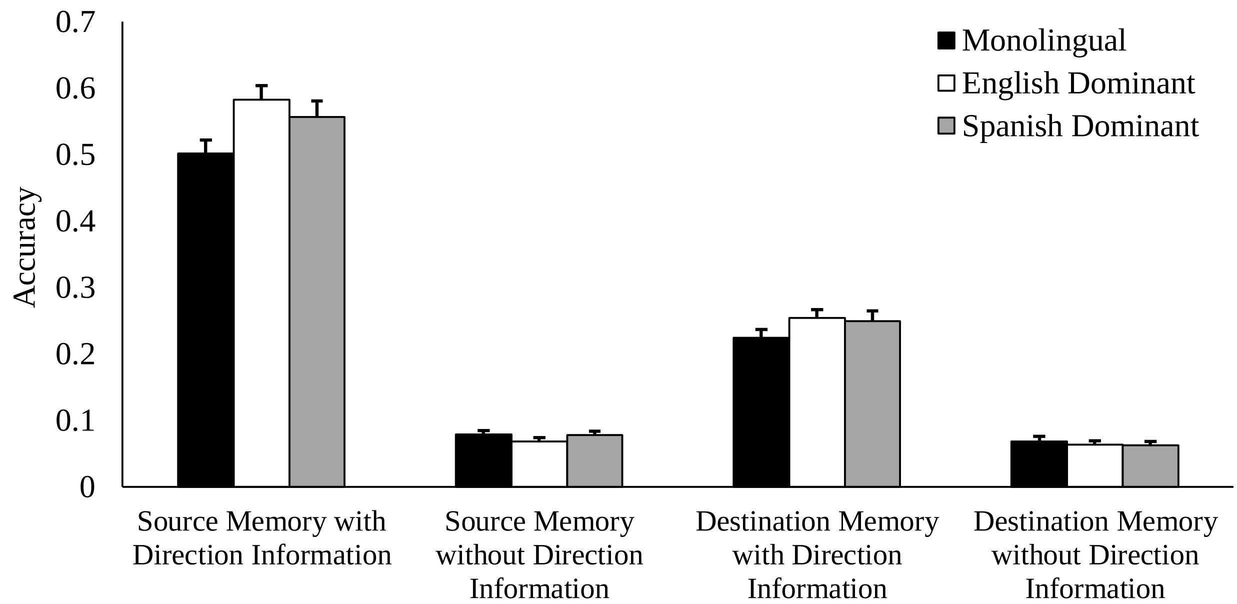

Figure 9. Contextual Memory Accuracy by Proportion.
Note. Error bars indicate standard errors of the mean.

3.1 Discussion

In Experiment 2, the self-reference process was excluded to better understand the mechanisms of source and destination memory in listening to conversations. First, item memory performance was examined to see the impact of bilingualism and language proficiency with complex materials. The result of Experiment 2 showed the same pattern of item results as in Experiment 1 such that the discrimination score on item memory did not differ across the language groups. The language proficiency levels did not impact item memory performance in either language group as well. These results suggest that the sentence encoding process by simple observation does not vary as a function of language proficiency, which is inconsistent with the results of the single-word encoding process studied in previous research.

Next, memory performance for sources and destinations in bilinguals was examined. Experiment 2 results showed differences between bilinguals and monolinguals in memory for contextual information. Complete accuracy (intact source and destination memory with a correct direction memory) was greater for bilinguals compared to monolinguals, indicating that bilinguals were able to process all the aspects of contextual information more accurately than monolinguals. In source recognition tasks, as a previous study showed (Francis et al., 2019), sources of the information were remembered more accurately by bilinguals than monolinguals. These findings support the explanation that bilinguals encode content-context association more efficiently than monolinguals. Furthermore, another conclusion that content-context associations are formed at the conceptual level is also supported because Experiment 2 showed no language proficiency effects on source memory. However, in contrast to source memory performance, there were no language group differences in overall destination memory performance. A possible explanation of the combined results is that the item information is more efficiently associated with contextual information at encoding for bilinguals than monolinguals, but the benefits to forming such associations disappears when the contextual information is not directly involved with the item information. The item information comes from the source, whereas the destination of the information is not directly related to the item itself. That is, these results suggest that bilinguals may form associations between item and contextual information more efficiently than monolinguals, but the efficiency would not be applied for processing contextual information which is not directly involved with the item information.

We compared source and destination memory performance to understand how attentional resources were used to process the source and destination of the information when both types of contextual information were given to people externally and simultaneously. We found a source memory advantage over destination memory in all of the language groups, suggesting that sources are better remembered than destinations of the information even when both sources and destinations are presented externally. In other words, the result provides additional support to the findings that self-generation at encoding is not the main factor underlying the less accurate memory for destinations relative to sources. Furthermore, the finding suggests that people tend to allocate their attentional resources toward processing the source of the information instead of equally distributing the attentional resources between source and destination processes. One possible explanation of why greater resources are used for the source memory encoding than the destination memory encoding is that the source information comes from someone along with the item information, and therefore, it involves with both visual (person's face) and auditory (person's voice) processing. Whereas the destination information is only visual processing. That is, greater cognitive resources are required to process the source information compared to the destination information, resulting in stronger representation for sources than destinations. Therefore, Experiment 2 supports the attention hypothesis.

Experiment 2 examined how item memory performance was correlated with contextual memory performance because some studies suggest an item-source trade-off hypothesis, assuming that increase of item memory lowers source memory (e.g., Jurica & Shimamura, 1999) although other studies suggest deeper item encoding process facilitates a stronger memory for contextual information (e.g., Koehler et al., 2001; Riefer et al., 2007). The current experiment showed a positive correlation between item memory and contextual memory in all the language groups regardless of memory for the direction of information transfer, indicating that higher item memory was associated with better memories for source and destination information no matter whether they remembered the direction of information transfer. Therefore, the results lend additional support to the existing evidence that a deeper and stronger item encoding process facilitates a stronger process of contextual information and therefore the association between item and context information becomes stronger.

Lastly, the results of the response code analyses helped to understand how the direction of information transfer was related to content-context associations. First, we compared how response rates were different between remembering the direction and not remembering the direction. Complete contextual memory with the correct direction of information was about eight times as frequent as complete contextual memory with incorrect direction of the information, which suggests that the contextual information is much less likely to be retrieved without the direction memory. Therefore, Model C is excluded from our possible models because if Model C were an appropriate model, then the person information would be remembered accurately regardless of the availability of direction memory. Remembering only source memory was several times more likely with correct direction memory than with incorrect direction memory. This result suggests that the direction of information transfer is somewhat associated with source information. Unlike the source memory performance comparison, the rate of remembering only the destination did not differ for knowing the direction and not knowing the direction. This result indicates that remembering the destination was not associated with remembering the direction of information transfer.

These results of source and destination memory response rates led to another question of whether destination memory processing was associated with source memory processing because the results of Experiment 2 showed direction memory was more likely to be associated with memory for sources than with memory for destinations of information. Thus, source memory and destination memory may be independently processed. To approach this additional question, we compared the response rates of complete associations of source and destination memory with those of either source or destination memory intact memory. The response rates of complete source/destination associations (both correct or neither correct) were approximately 27%, whereas the response rates of either source or destination memory without the other were approximately 47%, indicating a negative association between correct source and correct destination responses. That is, source and destination memory may compete for attentional resources such that an increase on source memory leads to worse destination memory and vice versa, supporting the attention hypothesis. As results, Model A2 may be an appropriate model to describe the relationship between the direction information and contextual information, and within the contextual memory, source and destination memory may interact with each other.

Chapter 4: General Discussion

The purpose of the study was to investigate the processes of source and destination memory and how they might differ as a function of bilingual proficiency. In the first study to directly compare source and destination memory in a conversational setting (Gopie & MacLeod, 2009), destination memory was more vulnerable compared to source memory. Subsequent studies found converging evidence and stated that higher cognitive demands at encoding led to worse contextual memory, particularly destination memory (e.g., Lindner et al., 2015). However, it has been unclear to what degree bilingualism and language proficiency levels might influence source and destination memory and how the direction of information transfer impacts those memories. Therefore, the current study built on the work of previous studies of destination memory (Gopie & MacLeod, 2009; Fischer et al., 2015) and extended it to bilinguals to address the following questions: 1) whether language proficiency and bilingualism play an important role in memory for item, source and destination information, 2) how attentional resources are allocated in encoding sources and destinations, and 3) whether the direction of information transfer is independent from content-context associations.

4.1 Effects of Bilingualism and Language Proficiency on Item and Contextual Memory

The current study investigated the effects of bilingualism and language proficiency levels on item, source, and destination memory. Previous research with isolated words as stimuli found that item recognition in bilinguals was more accurate in the less proficient language relative to the more proficient language and monolingual performance (Francis & Gutiérrez, 2012; Francis & Strobach, 2013). These advantages have been explained using the weaker links hypothesis (Gollan et al., 2008; Gollan et al., 2005). Specifically, within either of their languages, bilinguals have fewer and weaker associations between words and concepts compared to monolinguals. Also, a bilingual's less proficient language is used less often than their dominant language. This less frequent usage would result in fewer content-context associations in the less proficient language. According to the source-of-activation confusion theory (Buchler & Reder, 2007), having a smaller number of content-context associations should benefit item recognition, because fewer associations indicate lower baseline familiarity levels for the words and therefore lead to fewer false alarms.

Based on the preceding logic, we expected that the same pattern of results would be seen in the current study even where people were exposed to more complex materials, sentences. Contrary to our expectations, the current study found no differences in item memory between monolinguals and bilinguals, whether they were actively involved in conversations or simply observed others' conversations. Furthermore, in the real interaction setting, bilinguals showed a positive correlation between English proficiency level and item memory, although the language proficiency effect did not persist in the observation setting. These findings suggest that the benefit of a smaller number of associations is limited to isolated word processing, and the benefit disappears in sentence processing. Furthermore, increasing cognitive demands at sentence encoding may flip the advantage in bilinguals such that the more proficient language leads to better item recognition than the less proficient language.

We also examined the impacts of bilingualism and language proficiency on source and destination memory processing. Prior bilingual research in source-monitoring tasks found a bilingual advantage over monolinguals and no language proficiency effects using isolated words (Francis et al., 2019). The conclusion was that content-context associations are formed at a conceptual level and bilinguals might form such associations more efficiently compared to monolinguals. The current study provided additional evidence for this research conclusion but also added additional components to the explanation. As prior research showed, bilinguals remembered the source of information more accurately than monolinguals, and source memory performance did not differ as a function of language proficiency levels when people observed others' conversations. However, in contrast to our prediction, the bilingual advantage disappeared when people were required to directly interact with others. A possible explanation of the findings is that content-context associations are formed at a conceptual level even when the content information is more complex; however, the efficiency of forming such associations in bilinguals may decrease when cognitive loads increase at encoding.

The current study found a bilingual advantage in destination memory performance as well. However, similar to results for source memory, this phenomenon was seen only when people were required to process externally provided content and context information. In self-referential encoding, not only did the bilingual advantage in destination memory disappear, but also there was an advantage for the dominant language over the non-dominant language. The findings may be explained by the combination of differences in cognitive processing at encoding and the availability of attentional resources. Self-generation encodings require greater cognitive/attentional resources (particularly L2 generation), and the greater cognitive demands at encoding leave only limited resources to process other relevant information. Therefore, the higher cognitive demands at encoding in generation processing decrease the efficiency of forming content-context associations in bilinguals and reduce the amount of remaining attentional resources to process the destination of the information. These findings of source and destination memory in bilinguals support the idea that content-context associations are formed at a conceptual level, but the current study suggests that the bilinguals use content-context associations more efficiently than monolinguals when encoding has low cognitive demands. Higher cognitive demands may eliminate the bilingual efficiency advantage.

4.2 Attention Hypothesis and The Use of Attentional Resources at Encoding

The current study included two different encoding situations, both actively involved conversations and simply observed conversations, to test the attention hypothesis and better understand how attentional resources are allocated at encoding. The attention hypothesis assumes that the availability of attentional resources at encoding is key to remembering contextual information, such that greater attentional resources lead to better contextual memory. In addition, in the high cognitive demand conditions, destination memory performance may be more markedly impaired compared to source memory (Lindner et al., 2005). The results of the current study support the attention hypothesis. As discussed earlier, greater attentional resources are used in sentence processing in L2, particularly L2 generation. The current study demonstrated that L2 self-generation conditions had less accurate destination memory compared to L1 self-generation conditions.

We hypothesized that source memory would be more accurate than destination memory in Experiment 1, because self-generation requires greater cognitive/attentional resources compared to simply listening. However, we also hypothesized that source and destination memory might be remembered equivalently when no self-generation is required because people are able to distribute attentional resources more freely. In contrast to our expectation, source memory was more accurate than destination memory in both real-interaction and observation settings in all language groups. The results indicate that attentional resources are more likely to be allocated toward processing sources of information rather than equally distributed between source and destination processes. Therefore, the finding suggests that self-generation at encoding is not the main factor to interrupt allocating attentional resources to process destinations of information relative to sources. A possible explanation of this unequal distribution of processing is related to the information representation at encoding. In processing a source of information, the information itself carries both visual and auditory representations. On the other hand, in processing a destination of information, only a visual representation is involved. That is, source memory processing may require greater cognitive/attentional resources compared to destination memory processing, resulting in limited remaining resources to process destinations of the information. Thus, the current study provides additional evidence to support the attention hypothesis.

We also investigated the relationship between item memory and contextual memory. Prior research suggests that deeper item memory processing leads to worse memory for sources of the information (Jurica & Shimamura, 1999). In contrast to this suggestion, other studies suggest the opposite pattern, such that deeper item memory processing leads to a stronger memory for sources of the information (e.g., Koehler et al., 2001; Riefer et al., 2007). The results of the current study showed a positive correlation between item memory and source/destination memory in both experiments, except in the destination conditions in Experiment 1. The findings suggest that deeper and stronger item encoding processes are more likely to lead to stronger processing of contextual information, resulting in forming stronger item-contextual associations. These results also support the attention hypothesis. However, a correlation of item-context associative memory may disappear when encoding is too cognitively demanding, as with self-generation processing.

4.3 The Relationship between The Direction of Information Transfer and Contextual Information

A key difference between source and destination memory is the direction of information transfer: source memory is memory for where the information comes from, whereas destination memory is memory for where the information was given. In the current study, we attempted to understand whether the direction of information transfer is independent from contextual memory. The current study excludes the idea that person information must be retrieved in order to retrieve the direction of information. This is because direction memory was more accurate than person identification memory in Experiment 1 and complete contextual memory was greater when the direction of information was remembered in Experiment 2.

The results of source and destination memory performance with correct direction memory and incorrect direction memory led to another question of whether source memory is associated with destination memory. This question came up because the current study found better memory for sources with correct direction memory than with incorrect direction memory, although destination memory was impacted very little by direction memory. To examine this question, we used the combined code analysis from Experiment 2. The response rates for consistent source and destination accuracy (both correct or neither correct) were lower than the response rates for inconsistent source or destination memory accuracy. That is, source and destination memory are negatively associated, and better memory for one is associated with worse memory for the other. This finding supports the attention hypothesis.

4.4 Source-of-activation Confusion and Fuzzy-trace Theories

Based on the findings, we considered whether the source-of-activation confusion theory and/or fuzzy-trace theories are appropriate to explain source and destination memory processes in bilingualism. The SAC model (Buchler & Reder, 2007; Diana & Reder, 2006) is a dual-process model, meaning that recognition process involves both familiarity based on the activation of semantic nodes and recollection based on the activation of episodic nodes. Both processes are activated in decision making, but the reliance level differs for item and source recognition processes: item recognition relies more on the familiarity process, whereas source recognition relies more on the recollection process than item recognition tasks do (Johnson et al., 1993; Mitchell & Johnson, 2009). This is because in item recognition, some items are new and thus the familiarity process is helpful to distinguish between experienced items and non-experienced items. In contrast, in source recognition, all the items are previously exposed and thus the familiarity process is not helpful - specific contextual information must be retrieved to make decisions.

According to the SAC model, experience levels influence the familiarity process such that baseline familiarity levels are lower when fewer memories for presented items are available, resulting in fewer false alarms (Buchler & Reder, 2007). Prior bilingual research extended this model to bilingualism, concluding that the L2 advantage in item recognition was because L2 words have fewer episodic experiences and are less familiar relative to L1 words (Francis & Strobach, 2013; Francis & Gutiérrez, 2012). Therefore, if the SAC is supported in recognition of sentences, it is hypothesized that bilinguals would have more accurate item memory than monolinguals because bilinguals have less experience in each language relative to monolinguals. Also, it is hypothesized that bilinguals would have more accurate item recognition in L2 than in L1 due to less experience in L2. Contrary to our expectation, there was no language group difference or language proficiency effect in item recognition in either the direct-interaction setting or the observational setting. This finding suggests that the SAC theory may not apply for sentence memory.

Another theory that has the potential to explain both source and destination memory processes is the FTT framework (Reyna & Brainerd, 1995). FTT proposes that the two types of memory representations, gist and verbatim. The gist representation is a meaning-based representation, while verbatim representation is a surface-level representation. It is also known that memory durability differs for gist and verbatim representations: gist memory has higher durability, whereas verbatim memory is more vulnerable (Brainerd & Reyna, 2002). Therefore, people rely more on gist memory than verbatim memory.

The current study attempted to apply the FTT framework into bilingualism. According to FTT, both gist and verbatim memory traces are processed in making memory decisions, but the relative reliance on these two types of traces varies based on expertise (e.g., Reyna, 2004; Reyna & Lloyd, 2006; Reyna et al., 2014). It has been thought that the reliance on gist representations increases and the reliance on verbatim representations decreases when people have more experience on relevant tasks/information. That is, experts are more likely to make their decisions based on meanings/concepts of the event instead of details of the event. The idea of expertise is extended to language proficiency in bilinguals. Monolinguals are more expert in one language compared with bilinguals, and furthermore, bilinguals are more expert in L1 than in L2. Thus, the gist reliance level is greater for monolinguals than bilinguals and greater for L1 than L2. Also, in the current study, gist representations would contain topics of conversations (concepts of the information), whereas verbatim representations would contain other characteristics of the encoding episodes including confederates' facial information. That is, gist memory is more helpful than verbatim memory in item recognition tasks. It is hypothesized that monolinguals would outperform bilinguals. In contrast, people have to rely on verbatim memory in person identification tasks because all confederates may be stored in the same (or similar) category such as young unfamiliar female. That is, if FTT is supported for contextual memory in communication, bilinguals would outperform monolinguals and L2 would outperform L1.

Contrary to our expectation, the current study showed no language group/proficiency differences in item recognition tasks. One possible explanation of these unexpected results is the availability of sentence stimuli during encoding. In the current study, all sentence stimuli stayed on the computer screen during encoding to reduce participants' cognitive load. In contrast to item recognition performance, person identification performance supported FTT. Bilinguals who would rely less on gist representations outperformed monolinguals who would rely more on gist representations. Furthermore, monolinguals demonstrated the negative correlation between language proficiency levels and source/destination memory performance. The results provide additional evidence that language experts tend to rely more on gist memory than verbatim memory, resulting in worse source and destination memory. However, we did not see the same pattern within bilinguals. Bilinguals' language proficiency levels were not correlated with source/destination memory performance. This may be because contextual information may be associated with corresponding item information at a conceptual level and bilinguals share concepts between their two languages. The findings of the current study suggest that FTT has a potential to apply to source and destination memory processes and extend the theory to language proficiency. However, it needs some modification for bilingual memory processes to explain how two languages would influence the gist and verbatim memory representations.

4.5 Real-World Implications

The current study has real-world implications because there are many situations where source and destination memory are relevant in daily life. It seems that generation and speaking facilitate remembering the topic of information more than simple listening. This may be because sentence generation leads to deeper information processing. However, we found that generation processes led to worse memory for person information. Destination information was less accurate than source information, suggesting that greater effort may be required to remember to whom the information is provided when one speaks. Furthermore, the current study has shown a novel, interesting finding that the less accurate destination memory compared to source memory persists even in an observational setting. That is, regardless of whether one speaks or listens to someone else speak, information about the relevant listeners is less likely to be remembered. This finding has implications for the legal setting. Eyewitness research has been conducted to understand under what conditions people may (in)correctly remember information about relevant incidents. However, it is also significant to know how likely/accurately one remembers what a person did or said to whom during the relevant incident, and answering this question requires both source and destination memory. The results suggest that memory for the person who said something will be more reliable than memory for the person to whom the speech was directed.

The current study revealed that source and destination memory processes compete for attentional resources, and limited resources were available for destination memory compared to source memory. That is, increasing attentional resources at encoding would facilitate destination memory. However, it still remains unknown how a person decides whether the information has or has not been provided to a particular person yet. For example, if one is required to send meeting information to people later, but the next day the person may not remember whether the email has been sent. Addressing this question would help to understand how decision making regarding contextual information is carried out in everyday life and would give an idea of how to improve destination memory. Thus, this would be an interesting topic for future research.

4.6 Conclusion

The effects of bilingualism, language proficiency, and self-generation were examined in item recognition, direction identification, and person identification memory tasks. The current study showed a source memory advantage over destination memory in both real-interaction and observational settings. This finding suggests that processing sources of information is prioritized over processing destinations of information, even in a situation where it is possible to distribute attentional resources between sources and destinations equally. That is, people focus more on speakers and less on listeners.

In summary, the current study provided additional evidence in favor of the attention hypothesis but also provided initial evidence of a bilingualism effect on content-context associations. We found that increasing cognitive demands at encoding led to less accurate contextual memory. In fact, stronger item memory was associated with stronger context memory. In contrast, source memory and destination memory were negatively associated. Thus, source and destination memory processes compete for attentional resources at encoding. Regarding the bilingual aspects of the study, we found no language proficiency effects on source or destination memory performance in either experiment. Thus, item information may be linked to contextual information at a conceptual level because language proficiency does not influence the strength of such associative memory. Interestingly, bilinguals remember content-context associations more accurately than monolinguals in the observational setting, but the bilingual advantage disappears in the real-interaction setting. This may be because associative memories are formed more efficiently in bilinguals compared to monolinguals, but this efficiency advantage may be eliminated under encoding with high cognitive load.

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